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Hip Pain and Mobility Deficits—Hip Osteoarthritis: Revision 2017

Clinical Practice Guidelines Linked to the International Classification of Functioning, Disability and Health From the Orthopaedic Section of the American Physical Therapy Association

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Summary of Recommendations*

DIAGNOSIS/CLASSIFICATION

2017 Recommendation

A Clinicians should use the following criteria to classify adults over the age of 50 years into the International Statistical Classification of Diseases and Related Health Problems (ICD) category of coxarthrosis and the associated International Classification of Functioning, Disability and Health (ICF) impairment-based category of hip pain (**b28016 Pain in joints**) and mobility deficits (**b7100 Mobility of a single joint**): moderate anterior or lateral hip pain during weight-bearing activities, morning stiffness less than 1 hour in duration after wakening, hip internal rotation range of motion less than 24° or internal rotation and hip flexion 15° less than the nonpainful side, and/or increased hip pain associated with passive hip internal rotation.

DIFFERENTIAL DIAGNOSIS

2017 Recommendation

F Clinicians should revise the diagnosis and change their plan of care, or refer the patient to the appropriate clinician, when the patient's history, reported activity limitations, or impairments of body function and structure are not consistent with those presented in the diagnosis/classification section of this guideline, or when the patient's symptoms are not diminishing with interventions aimed at normalization of the patient's impairments of body function.

EXAMINATION – OUTCOME MEASURES: ACTIVITY LIMITATION/SELF-REPORT MEASURES

2017 Recommendation

A Clinicians should use validated outcome measures that include domains of hip pain, body function impairment, activity limitation, and participation restriction to assess outcomes of treatment of hip osteoarthritis.

Measures to assess hip pain may include the Western Ontario and McMaster Universities Osteoarthritis Index (WOMAC) pain subscale, Brief Pain Inventory (BPI), pressure pain threshold (PPT), and pain visual analog scale (VAS).

Activity limitation and participation restriction outcome measures may include the WOMAC physical function subscale, the Hip disability and Osteoarthritis Outcome Score (HOOS), Lower Extremity Functional Scale (LEFS), and Harris Hip Score (HHS).

EXAMINATION – ACTIVITY LIMITATION/PHYSICAL PERFORMANCE MEASURES

2017 Recommendation

A To assess activity limitation, participation restrictions, and changes in the patient's level of function over the episode of care, clinicians should utilize reliable and valid physical performance measures, such as the 6-minute walk test, 30-second chair stand, stair measure, timed up-and-go test, self-paced walk, timed single-leg stance, 4-square step test, and step test.

A Clinicians should measure balance performance and activities that predict the risk of falls in adults with hip osteoarthritis, especially those with decreased physical function or a high risk of falls because of past history. Recommended balance tests for patients with osteoarthritis include the Berg Balance Scale, 4-square step test, and timed single-leg stance test.

F Clinicians should use published recommendations from the Academy of Geriatric Physical Therapy of the American Physical Therapy Association[6] to guide fall risk management in patients with hip osteoarthritis to assess and manage fall risk.

EXAMINATION – PHYSICAL IMPAIRMENT MEASURES

2017 Recommendation

A When examining a patient with hip pain/hip osteoarthritis over an episode of care, clinicians should document the flexion, abduction, and external rotation (FABER or Patrick's) test and passive hip range of motion and hip muscle strength, including internal rotation, external rotation, flexion, extension, abduction, and adduction.

INTERVENTIONS – PATIENT EDUCATION

2017 Recommendation

B Clinicians should provide patient education combined with exercise and/or manual therapy. Education should include teaching activity modification, exercise, supporting weight reduction when overweight, and methods of unloading the arthritic joints.

INTERVENTIONS – FUNCTIONAL, GAIT, AND BALANCE TRAINING

2017 Recommendation

C Clinicians should provide impairment-based functional, gait, and balance training, including the proper use of assistive devices (canes, crutches, walkers), to patients with hip osteoarthritis and activity limitations, balance impairment, and/or gait limitations when associated problems are observed and documented during the history or physical assessment of the patient.

C Clinicians should individualize prescription of therapeutic activities based on the patient's values, daily life participation, and functional activity needs.

INTERVENTIONS – MANUAL THERAPY

2017 Recommendation

A Clinicians should use manual therapy for patients with mild to moderate hip osteoarthritis and impairment of joint mobility, flexibility, and/or pain. Manual therapy may include thrust, nonthrust, and soft tissue mobilization. Doses and duration may range from 1 to 3 times per week over 6 to 12 weeks in patients with mild to moderate hip osteoarthritis. As hip motion improves, clinicians should add exercises including stretching and strengthening to augment and sustain gains in the patient's range of motion, flexibility, and strength.

Summary of Recommendations* *(continued)*

INTERVENTIONS – FLEXIBILITY, STRENGTHENING, AND ENDURANCE EXERCISES

2017 Recommendation

A Clinicians should use individualized flexibility, strengthening, and endurance exercises to address impairments in hip range of motion, specific muscle weaknesses, and limited thigh (hip) muscle flexibility. For group-based exercise programs, effort should be made to tailor exercises to address patients' most relevant physical impairments. Dosage and duration of treatment for effect should range from 1 to 5 times per week over 6 to 12 weeks in patients with mild to moderate hip osteoarthritis.

INTERVENTIONS – MODALITIES

2017 Recommendation

B Clinicians may use ultrasound (1 MHz; 1 W/cm^2 for 5 minutes each to the anterior, lateral, and posterior hip for a total of 10 treatments over a 2-week period) in addition to exercise and hot packs in the short-term management of pain and activity limitation in individuals with hip osteoarthritis.

INTERVENTIONS – BRACING

2017 Recommendation

F Clinicians should not use bracing as a first line of treatment. A brace may be used after exercise or manual therapies are unsuccessful in improving participation in activities that require turning/pivoting for patients with mild to moderate hip osteoarthritis, especially in those with bilateral hip osteoarthritis.

INTERVENTIONS – WEIGHT LOSS

2017 Recommendation

C In addition to providing exercise intervention, clinicians should collaborate with physicians, nutritionists, or dietitians to support weight reduction in individuals with hip osteoarthritis who are overweight or obese.

*These recommendations and clinical practice guidelines are based on the scientific literature published prior to April 2016. Please refer to our previously published guidelines on "Hip Pain and Mobility Deficits – Hip Osteoarthritis" for literature reviewed prior to 2009.

List of Abbreviations

ACR: American College of Rheumatology
APTA: American Physical Therapy Association
BMI: body mass index
BPI: Brief Pain Inventory
CI: confidence interval
CPG: clinical practice guideline
ER: external rotator or rotation
FABER: flexion, abduction, and external rotation
GREES: Group for the Respect of Ethics and Excellence in Science
HHD: handheld dynamometer
HHS: Harris Hip Score
HOOS: Hip disability and Osteoarthritis Outcome Score
ICC: intraclass correlation coefficient
ICD: International Classification of Diseases and Related Health Problems
ICF: International Classification of Functioning, Disability and Health
IR: internal rotator or rotation
ISS: ischial spine sign
JOSPT: *Journal of Orthopaedic & Sports Physical Therapy*
KL: Kellgren-Lawrence radiographic score
LEFS: Lower Extremity Functional Scale
LISH: Lequesne Index of Severity for Osteoarthritis of the Hip
MCID: minimal clinically important difference
MDC: minimal detectable change
MRI: magnetic resonance imaging
NSAID: nonsteroidal anti-inflammatory drug
OA: osteoarthritis
OR: odds ratio
PPT: pressure pain threshold
QOL: quality of life
RCT: randomized clinical trial
ROM: range of motion
RR: risk ratio
SCFE: slipped capital femoral epiphysis
SD: standard deviation
SEM: standard error of the measurement
SF-36: Medical Outcomes Study 36-Item Short-Form Health Survey
THA: total hip arthroplasty
TUG: timed up-and-go test
VAS: visual analog scale
WOMAC: Western Ontario and McMaster Universities Osteoarthritis Index

Introduction

AIM OF THE GUIDELINES

The Orthopaedic Section of the American Physical Therapy Association (APTA) has an ongoing effort to create evidence-based clinical practice guidelines (CPGs) for orthopaedic physical therapy management of patients with musculoskeletal impairments described in the World Health Organization's International Classification of Functioning, Disability and Health (ICF).[73]

The purposes of these clinical guidelines are to:

- Describe evidence-based physical therapy practice, including diagnosis, prognosis, intervention, and assessment of outcomes for musculoskeletal disorders commonly managed by orthopaedic physical therapists
- Classify and define common musculoskeletal conditions using the World Health Organization's terminology related to impairments of body function and body structure, activity limitations, and participation restrictions
- Identify interventions supported by current best evidence to address impairments of body function and structure, activity limitations, and participation restrictions associated with common musculoskeletal conditions
- Identify appropriate outcome measures to assess changes resulting from physical therapy interventions in body function and structure as well as in activity and participation of these individuals
- Provide a description to policy makers, using internationally accepted terminology, of the practice of orthopaedic physical therapists
- Provide information for payers and claims reviewers regarding the practice of orthopaedic physical therapy for common musculoskeletal conditions
- Create a reference publication for orthopaedic physical therapy clinicians, academic instructors, clinical instructors, students, interns, residents, and fellows regarding the best current practice of orthopaedic physical therapy

STATEMENT OF INTENT

These guidelines are not intended to be construed or to serve as a standard of medical care. Standards of care are determined on the basis of all clinical data available for an individual patient and are subject to change as scientific knowledge and technology advance and patterns of care evolve. These parameters of practice should be considered guidelines only. Adherence to them will not ensure a successful outcome in every patient, nor should they be construed as including all proper methods of care or excluding other acceptable methods of care aimed at the same results. The ultimate judgment regarding a particular clinical procedure or treatment plan must be made based on clinician experience and expertise in light of the clinical presentation of the patient, the available evidence, available diagnostic and treatment options, and the patient's values, expectations, and preferences. However, we suggest that significant departures from accepted guidelines should be documented in the patient's medical records at the time the relevant clinical decision is made.

Methods

Content experts were appointed by the Orthopaedic Section of the APTA to conduct a review of the literature and to develop an updated hip osteoarthritis (OA) CPG as indicated by the current state of the evidence in the field. The aims of the revision were to provide a concise summary of the evidence since publication in 2009 of the original guidelines, and to develop new recommendations or revise previously published recommendations to support evidence-based practice. The authors of this guideline revision worked with research librarians with expertise in systematic review to perform a systematic search for hip OA articles published since 2008 related to classification, examination, and intervention strategies, consistent with previous guideline development methods related to ICF classification. Briefly, the following databases were searched from 2008 to 2016: MEDLINE (PubMed; 2008-2016), CINAHL (EBSCO; 2008-date), PEDro (EBSCO; 2008-date), and the Cochrane Library (Wiley; 2008-date). See **APPENDIX A** for full search strategies and **APPENDIX B** for search dates and results (available at www.orthopt.org).

The authors declared relationships and developed a conflict management plan, which included submitting a conflict-of-interest form to the Orthopaedic Section of the APTA. Articles that were authored by a reviewer were assigned to an alternate reviewer. Funding was provided to the CPG development team for travel and expenses for CPG development training. The CPG development team maintained editorial independence.

Methods *(continued)*

Articles contributing to recommendations were reviewed based on specified inclusion and exclusion criteria, with the goal of identifying evidence relevant to physical therapist clinical decision making for adults with hip OA. The title and abstract of each article were reviewed independently by 2 members of the CPG development team for inclusion. See **APPENDIX C** for inclusion and exclusion criteria (available at www.orthopt.org). Full-text review was then similarly conducted to obtain the final set of articles for contribution to recommendations. The team leader (M.T.C.) provided the final decision for discrepancies that were not resolved by the review team. See **APPENDIX D** for a flow chart of articles and **APPENDIX E** for articles included in recommendations by topic (available at www.orthopt.org). For selected relevant topics that were not appropriate for the development of recommendations, such as incidence and imaging, articles were gathered, reviewed, and synthesized but were not subject to a formal systematic review process and were not included in the flow chart. Evidence tables for this CPG are available on the Clinical Practice Guidelines page of the Orthopaedic Section of the APTA website (www.orthopt.org).

This guideline was issued in 2017 based on the published literature up to 2016. This guideline will be considered for review in 2021, or sooner if new evidence becomes available. Any updates to the guideline in the interim period will be noted on the Orthopaedic Section of the APTA website (www.orthopt.org).

LEVELS OF EVIDENCE

Individual clinical research articles were graded according to criteria adapted from the Centre for Evidence-based Medicine (Oxford, UK) for diagnostic, prospective, and therapeutic studies.[52] In teams of 2, each reviewer independently assigned a level of evidence and evaluated the quality of each article using a critical appraisal tool. See **APPENDICES F** and **G** (available at www.orthopt.org) for a levels of evidence table and details on procedures used for assigning levels of evidence. The evidence update was organized from highest level of evidence to lowest level. An abbreviated version of the grading system is provided below.

I	Evidence obtained from high-quality diagnostic studies, prospective studies, or randomized controlled trials
II	Evidence obtained from lesser-quality diagnostic studies, prospective studies, or randomized controlled trials (eg, weaker diagnostic criteria and reference standards, improper randomization, no blinding, less than 80% follow-up)
III	Case-control studies or retrospective studies
IV	Case series
V	Expert opinion

GRADES OF EVIDENCE

The strength of the evidence supporting the recommendations was graded according to the previously established methods for the original guideline and those provided below. Each team developed recommendations based on the strength of evidence, including how directly the studies addressed the question of hip pain and hip OA. In developing their recommendations, the authors considered the strengths and limitations of the body of evidence and the health benefits, side effects, and risks of tests and interventions.

GRADES OF RECOMMENDATION BASED ON		STRENGTH OF EVIDENCE
A	Strong evidence	A preponderance of level I and/or level II studies support the recommendation. This must include at least 1 level I study
B	Moderate evidence	A single high-quality randomized controlled trial or a preponderance of level II studies support the recommendation
C	Weak evidence	A single level II study or a preponderance of level III and IV studies, including statements of consensus by content experts, support the recommendation
D	Conflicting evidence	Higher-quality studies conducted on this topic disagree with respect to their conclusions. The recommendation is based on these conflicting studies
E	Theoretical/ foundational evidence	A preponderance of evidence from animal or cadaver studies, from conceptual models/ principles, or from basic science/bench research supports this conclusion
F	Expert opinion	Best practice based on the clinical experience of the guidelines development team

GUIDELINE REVIEW PROCESS AND VALIDATION

Identified reviewers who are experts in hip OA management and rehabilitation reviewed the CPG draft for integrity, accuracy, and to ensure that it fully represents the current evidence for the condition. The guideline draft was also posted for public comment and review on www.orthopt.org, and a notification of this posting was sent to the members of the Orthopaedic Section of the APTA. In addition, a panel of consumer/patient representatives and external stakeholders, such as claims reviewers, medical coding experts, academic educa-

Methods *(continued)*

tors, clinical educators, physician specialists, and researchers, also reviewed the guideline. All comments, suggestions, and feedback from the expert reviewers, the public, and consumer/patient representatives were provided to the authors and editors for consideration and revisions. Guideline-development methods, policies, and implementation processes are reviewed at least yearly by the Orthopaedic Section of the APTA's ICF-based Clinical Practice Guideline Advisory Panel, including consumer/patient representatives, external stakeholders, and experts in physical therapy practice guideline methodology.

DISSEMINATION AND IMPLEMENTATION TOOLS

In addition to publishing these guidelines in the *Journal of Orthopaedic & Sports Physical Therapy* (*JOSPT*), these guidelines will be posted on CPG areas of both the *JOSPT* and Orthopaedic Section of the APTA websites, which are free-access website areas, and submitted to be available as free access on the Agency for Healthcare Research and Quality website (www.guideline.gov). The implementation tools planned to be available for patients, clinicians, educators, payers, policy makers, and researchers, and the associated implementation strategies, are:

TOOL	STRATEGY
"Perspectives for Patients" and/or "Perspectives for Practice"	Patient-oriented guideline summary available on www.jospt.org and www.orthopt.org
Mobile app of guideline-based exercises for patients/clients and health care practitioners	Marketing and distribution of app using www.orthopt.org and www.jospt.org
Clinician's quick-reference guide	Summary of guideline recommendations available on www.orthopt.org
Read-for-credit continuing education units	Continuing education units available for physical therapists and athletic trainers through *JOSPT*
Webinars: educational offering for health care practitioners	Guideline-based instruction available for practitioners on www.orthopt.org
Mobile and web-based app of guideline for training of health care practitioners	Marketing and distribution of app using www.orthopt.org and www.jospt.org
Physical Therapy National Outcomes Data Registry	Support the ongoing usage of data registry for common musculoskeletal conditions of the hip
Logical Observation Identifiers Names and Codes mapping	Publication of minimal data sets and their corresponding Logical Observation Identifiers Names and Codes for the hip region on www.orthopt.org
Non-English versions of the guidelines and guideline implementation tools	Development and distribution of translated guidelines and tools to *JOSPT*'s international partners and global audience via www.jospt.org

CLASSIFICATION

The primary International Classification of Diseases 10th Revision (ICD-10) code and condition associated with hip pain and mobility deficits is **M16.1 Primary coxarthrosis, unilateral**. In the ICD, the term OA is used as a synonym for arthrosis or osteoarthrosis. Other, secondary codes associated with hip OA are **M16.0 Primary coxarthrosis, bilateral**; **M16.2 Coxarthrosis resulting from dysplasia, bilateral**; **M16.3 Dysplastic coxarthrosis, unilateral**; **M16.4 Posttraumatic coxarthrosis, bilateral**; **M16.5 Posttraumatic coxarthrosis, unilateral**; **M16.7 Secondary coxarthrosis, not otherwise specified**; **M25.65 Stiffness in hip**; and **M25.55 Pain in hip**.

The primary ICF body function codes associated with the above-noted primary ICD-10 conditions are the sensory functions related to pain and the movement-related functions related to joint mobility. These body function codes are **b2816 Pain in joints** and **b7100 Mobility of a single joint**.

The primary ICF body structure codes associated with hip pain and mobility deficits are **s75001 Hip joint**, **s7402 Muscles of the pelvic region**, and **s7403 Ligaments and fascia of the pelvic region**.

The primary ICF activities and participation codes associated with hip pain and mobility deficits are: **d4154 Maintaining a standing position**, **d4500 Walking short distances**, and **d4501 Walking long distances**.

A comprehensive list of codes was published in the previous guideline.[17]

ORGANIZATION OF THE GUIDELINE

For each topic, the summary recommendation and grade of evidence from the 2009 guideline are presented, followed by a synthesis of the recent literature with the corresponding evidence levels. Each topic concludes with the 2017 summary recommendation and its updated grade of evidence.

CLINICAL GUIDELINES

Impairment/Function-Based Diagnosis

PREVALENCE

2009 Summary

Hip pain associated with OA is the most common cause of hip pain in older adults. Prevalence studies have shown that the rates for adult hip OA range from 0.4% to 27%.

EVIDENCE UPDATE

III In a systematic review assessing age- and sex-specific epidemiological data for hip and knee OA, the global age-standardized prevalence of hip OA was 0.85% (95% confidence interval [CI]: 0.74%, 1.02%). Prevalence was higher for females than males.[19] In a case-control study examining the prevalence of hip OA among 978 individuals in the United States, the prevalence was estimated at 19.6% (95% CI: 16.7%, 23.0%). Men showed a higher prevalence of radiographic hip OA. No difference in symptomatic hip OA prevalence was observed between men and women.[39] In a study examining the prevalence of OA in 7126 residents of rural China, the prevalence of symptomatic hip OA was estimated at 0.6%.[77]

2017 Summary

Osteoarthritis is the most common cause of hip pain in older adults (older than 50 years of age). Prevalence rates for adult hip OA range from 0.4% to 27%. The reported prevalence of hip OA continues to show great variability, with men showing higher prevalence of radiographic hip OA.

PATHOANATOMICAL FEATURES

2009 Summary

Clinicians should assess for impairments in mobility of the hip joint and the strength of the surrounding muscles, especially the hip abductor muscles, when a patient presents with hip pain.

EVIDENCE UPDATE

III Acetabular retroversion is associated with the development of hip OA.[42] External rotation (ER) of the hemi-pelvis is often noted with acetabular retroversion and can be identified on radiographs by noting a protrusion of the ischial spine into the pelvis on that side, called the ischial spine sign (ISS).[32,36,66]

IV Cartilage defects and bone marrow lesions in the anterior and central superolateral regions of the joint may represent early structural damage in the development of hip OA. Patients with hip OA also have less femoral-head cartilage volume and a higher prevalence of cartilage defects and bone marrow lesions.[67]

2017 Summary

Early articular changes observed on imaging may help identify individuals who have not been clinically diagnosed with hip OA. In patients with hip pain, there is some evidence that the presence of acetabular retroversion is related to the development of hip OA.

CLINICAL COURSE

Evidence Update

IV French et al,[23] in a secondary analysis of 131 patients meeting the American College of Rheumatology (ACR) criteria for hip OA, were unable to identify variables that predicted treatment success for patients with hip OA. Independent variables included age, sex, body mass index (BMI), duration of symptoms, comorbidities, treatment adherence, baseline pain with activity, baseline Western Ontario and McMaster Universities Osteoarthritis Index (WOMAC) physical function subscale score, baseline Hospital Anxiety and Depression Scale score, baseline aggregate range of motion (ROM), and treatment adherence.

2009 and 2017 Summary

Total hip arthroplasty (THA) is the most common surgical procedure for end-stage hip OA. Despite the success of THA and knee arthroplasty over the last 3 decades, consensus on criteria for the timing of surgery has not been established. However, the Group for the Respect of Ethics and Excellence in Science (GREES) suggests that nonsurgical intervention has failed if a patient has not experienced a reduction in symptoms, such as a 20% to 25% improvement on the WOMAC pain subscale, and has progressive loss of joint space of between 0.3 and 0.7 mm per year. The rate of hip OA progression varies from patient to patient, thus therapists should monitor the clinical course of hip OA (ROM and strength) and baseline hip pain, Kellgren-Lawrence (KL) grades, joint space width, and outcome score.[75]

RISK FACTORS

2009 Recommendation

A Clinicians should consider age, hip developmental disorders, and previous hip joint injury as risk factors for hip OA.

EVIDENCE UPDATE

I In hip OA,[31] lower range of hip internal rotation (IR) and hip flexion is associated with hip osteophytes, morning stiffness, male sex, higher BMI, and hip pain. An increase in BMI is related to increased risk of hip OA of similar magnitude for men and women (risk ratio [RR] = 1.11; 95% CI: 1.07, 1.16).[33]

III Living in a community with a high poverty level is independently associated with radiographic OA in 1 or both hips. Low education attainment is independently associated with symptomatic OA of 1 or both hips (odds ratio [OR] = 1.44).[18] People with high bone mass and hip OA have a higher prevalence of osteophytosis and excessive bone formation than those with less bone mass (osteophytosis OR = 2.12; 95% CI: 1.61, 2.79 and subchondral sclerosis OR = 2.78; 95% CI: 1.49, 5.18).[28,29] A genetic predisposition to end-stage hip OA exhibited an increased level of clinical OA signs in some individuals.[55,56]

2017 Summary

Age, history of hip developmental disorders, previous hip joint injury, reduced hip ROM (especially hip IR), presence of osteophytes, lower socioeconomic status, higher bone mass, and higher BMI are risk factors for developing hip OA.

NATURAL HISTORY

2009 Summary

The natural history of hip OA is not completely understood. Many different factors contribute to this. Arthritic changes occurring both inside and outside of the hip joint result in loss of joint space and the development of osteophytes, subchondral sclerosis, and cysts. Joint ROM is reduced and muscle weakness develops around the joint with OA progression.

EVIDENCE UPDATE

III Degenerative hip changes occur most rapidly in those with developmental dysplasia of the hip. Cam deformities and acetabular dysplasia are associated with developing hip OA more rapidly.[25,43,46] The extent of cam deformity is related to the presence of hip OA in early adulthood; in 121 patients with stable slipped capital femoral epiphysis (SCFE), 96 had signs of femoroacetabular impingement (FAI) and all 121 had some radiographic signs of hip OA.[14]

2017 Summary

The natural history of hip OA is not completely understood. Arthritic changes occur both inside and outside of the hip joint, resulting in loss of joint space, development of osteophytes, and subchondral sclerosis and cysts. Joint ROM is reduced and muscle weakness develops around the joint with a progression of OA. Degenerative hip changes develop more frequently in those with developmental dysplasia as compared to those with structurally normal hips. Those with cam deformities develop hip OA more rapidly. Cam deformities that develop after SCFE are related to the development of early hip OA.

DIAGNOSIS/CLASSIFICATION

2009 Recommendation

A Moderate lateral or anterior hip pain during weight bearing, in adults over the age of 50 years, with morning stiffness less than 1 hour, with limited hip IR and hip flexion by more than 15°, and when comparing the painful to the nonpainful side constitute useful clinical findings to classify a patient with hip pain into the International Statistical Classification of Diseases and Related Health Problems (ICD) category of unilateral coxarthrosis and the associated International Classification of Functioning, Disability and Health (ICF) impairment-based category of hip pain (**b2816 Pain in joints**) and mobility deficits (**b7100 Mobility of a single joint**).

EVIDENCE UPDATE

II Using the ACR definition of clinical hip OA, the criteria for hip IR should be revised from less than 15° to less than 24°.[31] Patients with hip pain often do not have radiographic evidence of hip OA (eg, osteophytes, joint space narrowing, etc), and many people with radiographic evidence of hip OA do not have hip pain.[40]

2017 Recommendation

A Clinicians should use the following criteria to classify adults over the age of 50 years into the International Statistical Classification of Diseases and Related Health Problems (ICD) category of coxarthrosis and the associated International Classification of Functioning, Disability and Health (ICF) impairment-based category of hip pain (**b28016 Pain in joints**) and mobility deficits (**b7100 Mobility of a single joint**): moderate anterior or lateral hip pain during weight-bearing activities, morning stiffness less than 1 hour in duration after wakening, hip internal rotation range of motion less than 24° or internal rotation and hip flexion 15° less than the nonpainful side, and/or increased hip pain associated with passive hip internal rotation.

DIFFERENTIAL DIAGNOSIS

2009 and 2017 Recommendation

F Clinicians should revise the diagnosis and change their plan of care, or refer the patient to the appropriate clinician, when the patient's history, reported activity limitations, or impairments of body function and structure are not consistent with those presented in the diagnosis/classification section of this guideline, or when the patient's symptoms are not diminishing with interventions aimed at normalization of the patient's impairments of body function.

IMAGING STUDIES

2009 and 2017 Summary

Plain-film radiography is the most often used method when radiographically diagnosing and assessing the progression of hip OA. Radiographs are used to look for the amount of joint space narrowing, the presence of osteophytes, and subchondral sclerosis or cysts. Research on imaging methods, using magnetic resonance imaging (MRI) and ultrasound, that can identify prearthritic changes is still under way. Much of the imaging research has looked at how hip dysplasia or FAI may predispose hips to OA; however, results to date are not conclusive.

CLINICAL GUIDELINES

Examination

OUTCOME MEASURES: ACTIVITY LIMITATION – SELF-REPORT MEASURES

2009 Recommendation

A Clinicians should use validated outcome measures, such as the WOMAC, the Lower Extremity Functional Scale (LEFS), and the Harris Hip Score (HHS), before and after interventions intended to alleviate impairments of body function and structure, activity limitations, and participation restrictions associated with hip OA.

Evidence Update

I Adults with hip OA have decreased physical function that can affect balance. In a prospective study of 79 individuals with hip OA, falls efficacy (individuals' belief in their ability and skill to successfully perform a task and avoid a fall) was measured using 2 questionnaires, and the results showed that falls efficacy independently predicted balance performance as measured by the last 9 items of the Berg Balance Scale.[5]

II The 40-item Hip disability and Osteoarthritis Outcome Score (HOOS) is a reliable and valid measure of pain, symptoms, physical function (daily living and sports/recreation), and quality of life (QOL) in patients with hip disability and OA.[30,49,68] The HOOS activities of daily living subscale consists of the WOMAC physical function subscale items.[49] The short version of the HOOS[20] consists of 5 items, including sitting, descending stairs, getting in/out of a bath or shower, twisting/pivoting on loaded leg, and running.[20,63]

II In a prospective study of 57 patients with hip OA and 100 patients with FAI, the construct validity of a German version of the WOMAC was evaluated.[59] The results of the study support the validity of using a reduced 12-item version of the WOMAC for assessing patients with FAI and OA; items removed from the physical function subscale were "bending to the floor," "putting on socks," "lying in bed," "getting off/on toilet," "heavy domestic duties," and "light domestic duties." The item "pain with sitting/lying" was removed from the pain subscale.[59]

III The Brief Pain Inventory (BPI) measures 4 dimensions of pain intensity (now, average, worst, and least). A prospective study[37] of 224 patients with hip OA identified established cut points for pain levels: mild, 1 to 4; moderate, greater than 4 to 6; severe, greater than 6 to 10. The BPI has also been shown to have good internal consistency (Cronbach α>.80), construct validity, and responsiveness in a prospective study of 250 patients with hip OA.[38]

III Hyperalgesia has been associated with central pain sensitization and chronic conditions such as OA, and there is growing interest in its potential to inform clinical decision making and research.[64] Although hyperalgesia may occur in response to mechanical, thermal, or chemical stimuli, the literature is most well developed in the area of mechanical hyperalgesia.[4] A mechanical pressure algometer is commonly used to measure pressure pain threshold (PPT), defined as the minimal amount of pressure at which the sensation of pressure first changes to a sensation of pain. Typically, PPTs are measured in a variety of body locations, and low values in locations away from the primary painful site are used as an indicator of central pain sensitization. Emerging research has demonstrated a strong negative correlation between PPT and pain severity in patients with hip OA.[76] Wylde et al[76] found a strong negative correlation between PPT measured at the forearm and pain severity as measured by the WOMAC pain subscale in 254 patients with hip OA. Those with low PPT values had high pain severity (P<.001). Aranda-Villalobos et al[3] found a similar negative correlation between PPT measured at the second metacarpal, gluteus medius, vastus lateralis, vastus medialis, and anterior tibialis and pain assessed with a visual analog scale (VAS) in 40 adults with hip OA. Goode et al[26] investigated hip radiographs, self-reported hip pain, and PPT from the upper trapezius in 1550 individuals aged 45 years and older. They found a significant association between PPT and self-reported hip pain, but no significant association between PPT and the presence or severity of radiographic hip OA. These findings suggest that PPT may be a useful indicator of pain processing associated with hip OA.

2017 Recommendation

A Clinicians should use validated outcome measures that include domains of hip pain, body function impairment, activity limitation, and participation restriction to assess outcomes of treatment of hip osteoarthritis.

Measures to assess hip pain may include the Western Ontario and McMaster Universities Osteoarthritis Index (WOMAC) pain subscale, Brief Pain Inventory (BPI), pressure pain threshold (PPT), and pain visual analog scale (VAS).

Activity limitation and participation restriction outcome measures may include the WOMAC physical function subscale, the Hip disability and Osteoarthritis Outcome Score (HOOS), Lower Extremity Functional Scale (LEFS), and Harris Hip Score (HHS).

ACTIVITY LIMITATION/PHYSICAL PERFORMANCE MEASURES

2009 Recommendation

A Clinicians should utilize easily reproducible physical performance measures, such as the 6-minute walk, self-paced walk, stair measure, and timed up-and-go tests, to assess activity limitation and participation restrictions associated with their patient's hip pain and to assess the changes in the patient's level of function over the episode of care.

Evidence Update

I Reliability and measurement error were determined for 4 balance tests in 30 people with hip OA: the 4-square step, step, timed single-leg stance, and functional reach tests. Interrater reliability for all tests was sufficient, with intraclass correlation coefficients (ICCs) greater than or equal to 0.85, except for the functional reach test (ICC = 0.62-0.72). Intrarater reliability was sufficient for the step test performed on the side of the involved hip and the timed single-leg stance test on the other side (ICC = 0.91), with low measurement error. However, the timed single-leg stance test demonstrated a ceiling effect, indicating potential problems measuring outcomes for higher-functioning patients.[16]

30-Second Chair-Stand Test[9]

I
- ICF category: activity limitation: changing basic body position
- Description: the number of full sit-to-stand repetitions completed in 30 seconds

- Measurement method: a standard/folding chair is placed with the back against the wall. The clinician should demonstrate the movements and ask the patient to complete a practice trial. Then, the patient begins, seated on the chair with feet shoulder-width apart and flat on the floor and arms crossed at the chest. The patient rises to a full stance and repeats as many as possible in the time allotted. The clinician records the total number of completed chair stands (full rise back to seated position) in 30 seconds
- Nature of variable: continuous
- Units of measurement: the completed number of chair stands
- Measurement properties: in a cohort of 37 adults with hip OA, based on ACR clinical diagnostic criteria[9]
  - Intrarater reliability: ICC = 0.88
  - Minimal detectable change: MDC_{90}, 3.5
  - Standard error of the measurement: SEM, 1.5
  - Mean ± SD, 12.6 ± 3.4 in week 1 and 13.5 ± 3.5 in week 2

4-Square Step Test[16]

I
- ICF category: measurement of activity limitation: moving within the home
- Description: assesses how well a person can manage moving in different directions

- Measurement method: 4 canes are placed with handles out at 90° angles to form 4 squares. After demonstration from clinician and a practice trial, the participant begins by standing in square 1 (always facing square 2 throughout the test) and stepping forward with both feet into square 2, then side steps right into square 3, and steps back into square 4, then returns to square 1 with a side step to the left. The sequence is then reversed back to the starting position (squares 1, 4, 3, 2, and back to 1). Both sequences are completed as quickly as possible
- Nature of variable: continuous
- Units of measurement: seconds
- Measurement properties: in a cohort of 30 adults with hip OA, based on the ACR clinical diagnostic criteria[16]
- Interrater reliability
  - ICC = 0.86 (95% CI: 0.72, 0.93)
  - MDC_{90}, 1.80 (95% CI: 1.53, 2.42)
  - SEM, 0.77 (95% CI: 0.65, 1.04)
  - Mean ± SD, 8.97 ± 2.32
- Intrarater reliability (1-week interval)
  - ICC = 0.83 (95% CI: 0.57, 0.93)
  - MDC_{90}, 2.00 (95% CI: 1.58, 2.72)
  - SEM, 0.86 (95% CI: 0.68, 1.17)
  - Mean ± SD, 9.07 ± 2.35

Step Test[16]

I
- ICF category: activity limitation: climbing; moving the whole body upward or downward, such as climbing steps

- Description: determine how many steps a person can complete while standing on the painful hip, assessing a participant's standing balance
- Method of measurement: after demonstration by the clinician and 1 practice trial, the participant steps up onto and then off of a 15-cm step while maintaining stance on the painful leg on a 5-cm-wide cardboard template that is used as a starting marker and placed on the floor in front of the step. The other leg is then moved up onto the step, then back down to the floor (the stepping foot must be placed flat on the step and then back down flat on the ground to count as a completed step). The test is performed for 15 seconds, and full steps are counted without the patient moving his or her stance leg from the starting position

(overbalancing). The test may also be performed on the other leg
- Nature of variable: continuous
- Units of measurement: number of steps
- Measurement properties: in a cohort of 30 adults with hip OA, based on clinical diagnostic criteria established by the ACR[39]
- Intertester reliability for standing on the side of the painful hip
  - ICC = 0.94 (95% CI: 0.88, 0.97)
  - MDC_{90}, 3.0 (95% CI: 1.97, 3.33)
  - SEM, 1.06 (95% CI: 0.85, 1.43)
  - Mean ± SD, 14.63 ± 4.63
- Intrarater reliability for standing on the side of the painful hip
  - ICC = 0.91 (95% CI: 0.77, 0.96)
  - MDC_{90}, 3.0 (95% CI: 2.52, 4.34)
  - SEM, 1.37 (95% CI: 1.08, 1.86)
  - Mean ± SD, 14.71 ± 4.74

Timed Single-Leg Stance[16]

I
- ICF category: activity limitation: maintaining and shifting center of gravity
- Description: assesses static balance

- Measurement method: after demonstration by the clinician and 1 practice trial, the patient places hands on hips and stands on 1 leg, with the knee of the nonstance leg flexed so the foot is behind the patient and the nonstance hip is in a neutral position. While focusing on a stationary target 1 to 3 m ahead, the patient stands on 1 leg for as long as possible, up to 30 seconds. The test is completed when the patient touches the stance leg, removes hands from hip, or if the stance leg touches the nonstance leg. The longer of 2 trials on each leg, to the nearest 0.1 second, is recorded
- Nature of variable: continuous
- Units of measurement: seconds
- Measurement properties: in a cohort of 30 adults with hip OA, based on clinical diagnostic criteria established by the ACR[16]
- Interrater reliability for standing on the side of the painful hip
  - ICC = 0.89 (95% CI: 0.78, 0.95)
  - MDC_{90}, 8.08 (95% CI: 6.44, 10.87)
  - SEM, 3.46 (95% CI: 2.76, 4.66)
  - Mean ± SD, 21.26 ± 10.30
- Intrarater reliability for standing on the side of the painful hip
  - ICC = 0.82 (95% CI: 0.64, 0.91)
  - MDC_{90}, 10.78 (95% CI: 8.52, 14.67)
  - SEM, 4.62 (95% CI: 3.65, 6.29)
  - Mean ± SD, 20.63 ± 10.39

2017 Recommendation

A To assess activity limitation, participation restrictions, and changes in the patient's level of function over the episode of care, clinicians should utilize reliable and valid physical performance measures, such as the 6-minute walk test, 30-second chair stand, stair measure, timed up-and-go test, self-paced walk, timed single-leg stance, 4-square step test, and step test.

A Clinicians should measure balance performance and activities that predict the risk of falls in adults with hip osteoarthritis, especially those with decreased physical function or a high risk of falls because of past history. Recommended balance tests for patients with osteoarthritis include the Berg Balance Scale, 4-square step test, and timed single-leg stance test.

F Clinicians should use published recommendations from the Academy of Geriatric Physical Therapy of the American Physical Therapy Association[6] to guide fall risk management in patients with hip osteoarthritis to assess and manage fall risk.

PHYSICAL IMPAIRMENT MEASURES

2009 Recommendation

Recommended impairment measures and their properties are provided in the 2009 CPG.[17]

Evidence Update

Hip ROM

I
- ICF category: impairment of body function: mobility of a single joint
- Description: active and passive hip motion are measured in prone, supine, and sitting. Although assessing ROM for supine hip flexion, prone hip IR, and sidelying hip abduction is most important, occasionally clinicians may need to assess other hip motions. The therapist may ask the patient to rate the amount of pain experienced during movement on a 0-to-10 numeric pain-rating scale (NPRS) to assess hip joint irritability and to guide intervention choice

- Nature of variable: continuous (ROM) and ordinal (pain)
- Unit of measurement: degrees and 0-to-10 NPRS rating
- Measurement properties: limited ROM is associated with high levels of disability in patients with hip OA.[58] Pua et al[58] found both excellent intrarater and interrater reliability for hip passive ROM when testing 22 patients with clinical and radiographic evidence of hip OA. Measurement properties for passive hip ROM are provided below[58]

	Reliability: ICC (95% CI)	SEM	MDC_{90}
Flexion	0.97 (0.93, 0.99)	3.5°	8.2°
Extension: knee flexed	0.86 (0.67, 0.94)	4.5°	10.5°
Extension: knee unconstrained	0.89 (0.72, 0.95)	4.7°	11.0°
Abduction	0.94 (0.86, 0.98)	3.2°	7.3°
IR	0.93 (0.83, 0.97)	3.4°	7.8°
ER	0.96 (0.91, 0.99)	3.1°	7.1°

- Measurement method: hip IR can be measured in prone or sitting, with goniometer placement being the same for both.[58] The patient is positioned with the knee flexed to 90°. The movement arm of the goniometer is placed along the center of the tibia, while the stationary arm is placed along a vertical plane. When using a bubble goniometer, the distal end of the goniometer is placed 5 cm proximal to the lateral malleolus along the shaft of the fibula. Use of a stabilization belt is preferable to prevent movement of the pelvis. Being careful to control tibiofemoral joint motion, the lower leg is actively or passively moved into IR and measured when a firm end feel is appreciated or the pelvis begins to move.[58] Hip ER can be measured in prone or sitting, and goniometer placement is the same. The patient is positioned with the knee flexed to 90°. The movement arm of the goniometer is placed along the center of the tibia, while the stationary arm is placed along a vertical plane. When using a bubble goniometer, the distal end of the goniometer is placed along the shaft of the tibia 5 cm above the medial malleolus. Use of a belt is preferable to stabilize and prevent movement of the pelvis.[58] Hip flexion is measured with the patient in supine. A strap can be placed across the contralateral thigh to stabilize the pelvis. The stationary arm of the goniometer is aligned along the long axis of the trunk, while the movement arm is aligned parallel with the femur. When using a bubble inclinometer, the inclinometer is zeroed on a horizontal surface and then placed parallel to the femur.[58] Hip abduction is measured in the supine position (passive) or in sidelying (active). The stationary arm of the goniometer is placed so as to connect an imaginary line from the left and right anterior superior iliac spines. The movement arm is parallel along the thigh. The hip is abducted until a firm end feel is noted or the pelvis begins to move. For active abduction, the procedure is the same; however, stabilization of the pelvis is created by body weight. Hip extension is measured with the patient in the supine position and hip joint positioned at the edge of the treatment table. Both hips are fully flexed until there is adequate hip flexion to produce a flattened lumbar spine (Thomas test position); then, the measured hip is slowly extended. Hip extension is measured as the angle between the femur and the horizontal surface. The stationary arm of the goniometer is along the horizontal surface and the movement arm along the thigh.[58] An alternative position is to have the patient lie prone and actively or passively extend the hip. Goniometer position is the same as above

Hip Muscle Strength

I

- ICF category: impairment of body function: strength of a single joint
- Description: the amount of muscle strength in hip muscles measured in different positions
- Measurement method: hip IR is tested with the patient seated in a chair or prone, with the knee flexed to 90°. In prone, the pelvis should be stabilized to prevent movement during the test. Resistance is manually applied at the medial distal femur and lateral lower leg. When using a handheld dynamometer (HHD), the device is placed 5 cm above the lateral malleolus. Hip ER is tested with the patient prone and the knee flexed to 90°. In prone, the pelvis should be stabilized to prevent movement during the test. Resistance is manually applied at the lateral distal femur and medial lower leg. When using an HHD, the device is placed 5 cm above the medial malleolus. Hip flexors are tested with the patient seated in a chair or supine, with the knee flexed to 90° (while seated) or extended fully (supine), stabilizing the pelvis as necessary. An HHD is placed 5 cm proximal to the superior pole of the patella (sitting) or 5 cm proximal to the ankle joint (supine). Hip abductors are measured with the patient in supine or sidelying by placing an HHD 5 cm proximal to the lateral femoral condyle to isolate action of the hip joint. Pua et al[58] measured hip extensor strength with the patient in the supine position, the uninvolved thigh stabilized, and the measured hip placed in 20° of hip flexion, suspended by a strap attached to a force transducer. An alternative method is to measure using the same position, but with an HHD positioned 5 cm proximal to the ankle on the Achilles tendon. This test may also be performed in the prone position
- Nature of variable: continuous
- Unit of measurement: Newtons, kilograms, or pounds
- Measurement properties: limited strength is associated with high levels of disability in patients with hip OA.[58] Pua et al[58] found both excellent intrarater and interrater reliability for hip muscle strength when testing 22 patients with clinical and radiographic evidence of hip OA. Tests of isometric muscle strength should be performed for the hip abductors, IRs, ERs, flexors, adductors, and extensors. Bieler et al[9] also measured hip muscle strength in patients with hip OA and found similar results. Measurement properties for hip muscle strength are provided below.[58]

	Reliability: ICC (95% CI)	SEM	MDC_{90}
Flexors	0.87 (0.69, 0.95)	10.9 Nm	25.3 Nm
Extensors	0.97 (0.92, 0.99)	13.3 Nm	30.8 Nm
Abductors	0.84 (0.55, 0.94)	12.1 Nm	28.0 Nm
Internal rotators	0.98 (0.94, 0.99)	3.7 Nm	8.5 Nm
External rotators	0.98 (0.96, 0.99)	3.2 Nm	7.4 Nm

Pressure Pain Threshold

III

- ICF category: impairment of body function: pain hyperalgesia
- Description: a measure of pressure/tenderness taken over the hip joint and in areas away from the hip joint
- Measurement method: place the rubber disc of the algometer on the site of choice and apply pressure until the patient indicates that the sensation of pressure has changed to pain. Record the value indicated on the strain gauge. Always begin with the algometer on 0 kg/cm^2. Change the location on the skin slightly and repeat 2 more times. Allow 30 seconds between trials. Record the average of the 3 trials. Sites to test include the upper trapezius, gluteus medius, second metacarpal, vastus medialis or lateralis, and anterior tibialis. Test both sides
- Nature of variable: continuous
- Units of measure: kilograms per square centimeter
- Measurement properties: the interrater reliability of pressure algometry has been found to be high in healthy individuals, with an ICC of 0.91 (95% CI: 0.82, 0.97).[15] Construct validity has been demonstrated, with high correlations between force-plate readings and algometer readings (r = 0.99).[41] Values of PPTs (kilopascals) reported by Maquet et al,[48] obtained from healthy male and female adults, ranged from 190 to 350 kPa (1.94-3.57 kg/cm^2), depending on the site tested. Abnormal tenderness is defined as a PPT that is 2 kg/cm^2 lower than a normal sensitive corresponding point.[22] Values of PPT suggestive of hyperalgesia for individuals with hip OA have not been published.

2017 Recommendation

A

When examining a patient with hip pain/hip osteoarthritis over an episode of care, clinicians should document the flexion, abduction, and external rotation (FABER or Patrick's) test and passive hip range of motion and hip muscle strength, including internal rotation, external rotation, flexion, extension, abduction, and adduction.

BEST-PRACTICE POINT

Essential Data Elements

Clinicians should use the following measures, at least at baseline and at 1 follow-up time point, for all patients with hip OA to support standardization for quality improvement in clinical care and research:

Activity Limitation – Self-Report Measures

- WOMAC physical function subscale

Activity Limitation – Physical Performance Measures

- 6-minute walk test
- 30-second chair-stand test
- Timed up-and-go test
- Stair measure

Physical Impairment Measures

- Hip ROM and muscle strength for the following:
  - IR
  - ER
  - Flexion
  - Extension
  - Abduction
  - Adduction
- Pain
  - NPRS
- Joint irritability
  - FABER test

CLINICAL GUIDELINES

Interventions

ANTI-INFLAMMATORY AGENTS

2009 and 2017 Summary

Nonsteroidal anti-inflammatory drugs (NSAIDs), COX-2 inhibitors, and steroid injections are effective treatments for relief of symptoms in patients with hip OA. Some evidence suggests that NSAIDs may increase the progression of hip OA by decreasing glycosaminoglycan synthesis; however, data are not conclusive. Clinicians should be aware of the incidence of serious gastrointestinal side effects associated with the use of oral NSAIDs.

ALTERNATIVE/COMPLEMENTARY MEDICATION

2009 Summary

There is some evidence to support the short-term use of injectable viscosupplementation with hyaluronic acid into the hip joint of patients with hip OA. Despite a paucity of evidence, the use of injectable synthetic hyaluronic acid (hyaluronan) into the hip joint has been shown to be an elective treatment for symptomatic hip OA. Evidence also shows that injectable hyaluronan works best in mild to moderate hip OA, especially when nonsurgical therapy has failed. A recent published meta-analysis suggests the benefit of hyaluronan for the treatment of hip OA, but so far it is only approved by the Federal Drug Administration for the knee. More controlled studies are needed to show its effectiveness in patients with hip OA.

Evidence Update

I Rozendaal et al[60] studied 222 patients with hip OA treated with glucosamine or placebo once daily for 2 years. No differences were noted after 2 years in joint space on radiographs or in WOMAC physical function score.[60,61] Wandel et al[72] conducted a meta-analysis of glucosamine and/or chondroitin on joint pain and joint space in patients with hip or knee OA. Pain was not improved, nor did glucosamine have an effect on joint space narrowing. The efficacy of intra-articular hyaluronic acid in treating hip OA has still not been established in high-quality randomized clinical trials (RCTs).[47]

2017 Summary

There is insufficient evidence to support the use of supplements such as glucosamine, chondroitin, hyaluronic acid (injectable), or similar substances for the treatment of hip OA.

PATIENT EDUCATION

2009 Recommendation

B Clinicians should consider the use of patient education to teach activity modification, exercise, weight reduction when overweight, and methods of unloading the arthritic joints.

Evidence Update

I Svege et al[65] conducted a 6-year follow-up study of a previous RCT of 109 patients in which participants were randomized to 2 groups: exercise plus patient education and patient education only (control group). Exercise plus patient education had a protective effect against hip arthroplasty compared with patient education only (hazard ratio = 0.56; 95% CI: 0.32, 0.96). Results showed that exercise therapy plus education and education only were associated with 6-year cumulative survival of the native hip of 41% and 25%, respectively ($P = .034$).[65]

I Fernandes et al[21] enrolled 109 patients with mild to moderate hip OA and compared patient education versus patient education plus exercise at 16 months. The WOMAC physical function scores had improved significantly for the education-plus-exercise group (from an initial score of 21.1 to 15.1), but did not exceed the minimal clinically important difference (MCID) for the outcome measure, while those receiving only patient education improved minimally (from 23.6 to 22.8).

I Poulsen et al[57] compared patient education only, patient education plus manual therapy, and minimal (control) intervention (continue medication usage, minimal education on stretching) groups. At 6 weeks, significant differences were found in all HOOS subscales, favoring patient education plus manual therapy versus the minimal (control) intervention group. At 6 weeks, 76.5% of patients in the education-plus-manual therapy group improved, versus 22.2% in the patient-education group and 12.5% in the control group. No overall difference was found between groups for mean pain severity. At 12 months, no differences were noted among groups for pain, HOOS scores, and ROM.

II Voorn et al[71] observed 29 patients referred to an outpatient orthopaedic clinic with hip OA who were given tailored management advice and a fol-

low-up phone call by a physical therapist and/or a nurse practitioner to assess whether education was effective in changing their QOL after 10 weeks. Significant improvement was found in the HOOS subscale for sports, the Intermittent and Constant Osteoarthritis Pain questionnaire score, the Medical Outcomes Study 36-Item Short-Form Health Survey (SF-36) physical functioning subscale score, and the EuroQol-5 dimensions score.

2017 Recommendation

B Clinicians should provide patient education combined with exercise and/or manual therapy. Education should include teaching activity modification, exercise, supporting weight reduction when overweight, and methods of unloading the arthritic joints.

FUNCTIONAL, GAIT, AND BALANCE TRAINING

2009 Recommendation

C Functional gait and balance training, including the use of assistive devices such as canes, crutches, and walkers, can be used in patients with hip OA to improve function associated with weight-bearing activities.

Evidence Update

III Bossen et al[10] conducted an RCT of patients with self-reported hip OA, comparing a self-paced physical activity intervention individualized based on favorite recreational activity to a wait-list control group. At 3 months, the intervention group demonstrated greater improvement in HOOS physical function score (6.5/100 points) and global rating of change. At 12 months, the intervention group showed higher levels of self-reported physical activity, but no difference in HOOS physical function score or global rating of change, compared to the control group.

2017 Recommendation

C Clinicians should provide impairment-based functional, gait, and balance training, including the proper use of assistive devices (canes, crutches, walkers), to patients with hip osteoarthritis and activity limitations, balance impairment, and/or gait limitations when associated problems are observed and documented during the history or physical assessment of the patient.

C Clinicians should individualize prescription of therapeutic activities based on the patient's values, daily life participation, and functional activity needs.

MANUAL THERAPY

2009 Recommendation

B Clinicians should consider the use of manual therapy procedures to provide short-term pain relief and improve hip mobility and function in patients with mild hip OA.

Evidence Update

I Abbott et al[1] conducted an RCT of 4 groups: usual care plus manual therapy, usual care plus exercise therapy, usual care plus manual and exercise therapy, or usual care in 206 patients with hip or knee OA. Results for hip and knee OA were similar and were therefore combined. Each intervention group demonstrated statistically significant improvement at 1 year. The WOMAC composite score improvement was greater than the MCID of 28 points for the usual care-plus-manual therapy and the usual care-plus-exercise therapy groups. The magnitude of improvement in WOMAC composite score was greater for usual care plus manual therapy than for the other 2 intervention groups.

I Bennell et al[7] completed an RCT of 102 patients with mild, moderate, and severe hip OA confirmed by radiographs, comparing education/advice, manual therapy, home exercise, and gait aid if needed to a sham intervention consisting of inactive ultrasound. The protocol included hip thrust mobilization/manipulation and deep tissue massage in the thigh/hip region. More than half of the sample had moderate to severe hip OA (KL radiographic score grades 3-4), with significantly reduced total hip rotation (mean, 42°) and long duration of hip OA symptoms (intervention group, 36 months; sham group, 30 months). After 13 weeks, there were no between-group differences for pain or function. Mild adverse events were reported by 41% in the active groups versus 14% in the sham group, including hip pain (33%) and spinal stiffness (4%), with 1 in 3 active participants reporting increased hip pain. This study shows that a multimodal physical therapy intervention, including education and advice, manual therapy, and home exercise, in people who have radiographic evidence of moderate/severe hip OA, limited hip rotation, and a long duration of hip pain will not likely have better success with reduction in pain or improvement in function than a sham intervention using inert ultrasound gel.

I Beselga et al[8] performed an RCT of 40 patients to test the effect of a single session of mobilization-with-movement techniques, compared to a sham treatment, on pain, hip ROM, and function. Compared to the sham group, the mobilization-with-movement group had decreased pain (2/10 points), increased hip flexion (12.2°) and IR (4.4°), and clinically significant improvement in the

40-m self-paced walk test by 11.2 seconds. The intervention was performed by a single physical therapist, which reduces the external validity of the study.

I Brantingham et al[13] conducted an RCT comparing manipulative therapy and stretching versus a "full kinetic chain" approach in 111 patients with mild to moderate hip OA (based on ACR criteria, with KL grades ranging from 0 to 3). The manipulative group received high-velocity hip traction and stretching of thigh muscles. The "full kinetic chain" group received manipulative therapy and stretching to the hip plus soft tissue mobilization and manipulation to the low back and ipsilateral knee, ankle, and foot at the discretion of the practitioner. Results indicated that applying manual therapy distal to the hip (knee, ankle, or foot) offers no additional benefit.

I French et al[23] completed an RCT comparing the effects of exercise therapy, exercise plus manual therapy, and no therapy in the management of 131 patients with hip OA based on ACR criteria. Manual therapy included grade II and III mobilizations performed for the 2 most restricted movements. Exercise and exercise-plus-manual therapy groups showed statistically significant improvement in WOMAC physical function score, aggregate ROM, and global rating of change at 9 weeks compared to no therapy. There were no significant differences in mean WOMAC physical function or pain score found between exercise therapy and exercise plus manual therapy.

I The 2012 review by Brantingham et al[11] on the effectiveness of manipulative interventions throughout the lower extremity found fair evidence for benefit of manual therapy in hip OA using a range of measures. This review included 5 case series that provided lower-level support for manual therapy for hip OA.

II Pinto et al[53] conducted an economic evaluation of the RCT conducted by Abbott et al[1] of patients who met the ACR criteria for hip OA using 1-year outcomes. Manual therapy, exercise therapy, and combined manual and exercise therapy provided gains in quality-adjusted life-years compared to usual medical care. From the societal perspective, manual therapy was cost saving compared to usual care, and exercise therapy was cost-effective. Using either exercise or manual therapy was more cost-effective than the combination of the 2. The 1-year time frame is an important limitation of this study because gains sustained over time would increase cost-effectiveness.

II Poulsen et al[57] completed an RCT of 118 patients with hip OA assigned to 3 groups: (1) patient education, (2) patient education plus manual therapy, and (3) control: home stretching. At 6 weeks, no significant differences were found between the groups for mean pain severity. Comparing pairwise change in pain, the education-plus-manual therapy group showed reduction in pain versus the control group (effect size, 0.92) and the education group. No difference was noted between the education and control groups. All HOOS subscale scores showed improvement for the patient education-plus-manual therapy group compared to the control group. For hip ROM, no differences were found.

II Peter et al[51] provided an update to the Dutch CPG for hip OA, adding manual therapy to exercise as a level II recommendation for pain and reversible joint mobility limitation. Manual therapy, according to the guidelines, includes manipulation, manual traction, and muscle stretching. The CPG recommends adding manual therapy when hip joint mobility is limited as a preparation for exercise.

III Wright et al[74] completed a secondary analysis of data from a previous study of 70 patients with clinical diagnosis of hip OA to determine whether within-session changes in pain, function, and well-being after manual hip traction predicted outcomes at 9 weeks and whether this differed for those who received manual therapy and those who did not. Within-session changes for the group receiving manual hip traction and manual therapy were not associated with 9-week change in pain and function based on the WOMAC pain and function subscale scores and a global rating of change score.

IV Brantingham et al[12] conducted a prospective single-group, pretest/posttest study of 18 participants with hip OA based on ACR criteria. Treatment included axial manipulation to the hip combined with manipulative therapy to the spine, knee, ankle, or foot. Results included reduced hip pain and improved function, as evidenced by lower composite WOMAC scores, HHS, and improved hip flexion ROM that were sustained for up to 3 months.

IV Hando et al[27] performed a case series of 27 patients with mild to severe hip OA based on ACR criteria. Treatment included ten 30-minute sessions over 8 weeks for preselected manual therapy (muscle stretching, nonthrust and thrust manipulation) and therapeutic exercise as a home program. After 8 weeks, the HHS improved an average of 20.4 points (100-point scale) and the NPRS was reduced by an average of 2.3 (0-10) points.

2017 Recommendation

A Clinicians should use manual therapy for patients with mild to moderate hip osteoarthritis and impairment of joint mobility, flexibility, and/or pain. Manual therapy may include thrust, nonthrust, and soft tissue

mobilization. Doses and duration may range from 1 to 3 times per week over 6 to 12 weeks in patients with mild to moderate hip osteoarthritis. As hip motion improves, clinicians should add exercises, including stretching and strengthening to augment and sustain gains in the patient's range of motion, flexibility, and strength.

FLEXIBILITY, STRENGTHENING, AND ENDURANCE EXERCISES

2009 Recommendation

B Clinicians should consider the use of flexibility, strengthening, and endurance exercises in patients with hip OA.

Evidence Update

I Abbott et al[1] conducted an RCT of usual medical care versus manual therapy and/or exercise therapy in addition to usual medical care in 206 patients with hip or knee OA. Results for hip and knee OA were similar and therefore combined. Each intervention group demonstrated statistically significant improvement at 1 year. The WOMAC composite score improvement was greater than the MCID of 28 points for the usual care-plus-manual therapy and usual care-plus-exercise therapy groups. The magnitude of improvement in the WOMAC composite score was smaller for usual care plus exercise than for usual care plus manual therapy.

I Krauß et al[45] performed an RCT comparing exercise therapy, ultrasound, and a control group in 218 patients with ACR clinical diagnosis of hip OA. The WOMAC showed significant differences between the ultrasound and exercise groups for pain reduction (5.1) and physical function (5.5). The WOMAC showed that the exercise group had significant improvement in pain reduction (7.4) and physical function (6.4) compared to the control group. The WOMAC stiffness subscale was not different between the groups.

I Villadsen et al[69] performed a secondary analysis of an RCT comparing the effects of an 8-week neuromuscular exercise and education program versus an education-only group on activity in 84 patients scheduled for THA. The exercise-plus-education group had significant improvement in the HOOS activities of daily living subscale compared to the education group (7.3 points; effect size, 0.63). The HOOS pain, sport and recreation function, and joint-related QOL subscale scores, as well as chair stands and the 20-m self-paced walk, all significantly improved in the exercise-plus-education group.

I The RCT by Juhakoski et al[35] investigated short- and long-term effects (2 years) of exercise on pain and function in 120 people with an ACR clinical diagnosis of hip OA and a KL score greater than 1. The control group received usual care consisting of medication (NSAIDs and analgesics) and physical therapy (thermal modalities, transcutaneous electrical nerve stimulation, electrical stimulation, and acupuncture). The intervention group received usual care plus 12 supervised group exercise sessions plus a booster session at 1 year. No differences were found between groups for WOMAC pain and physical function scores and SF-36 physical component summary score at 2 years. There was statistically significant improvement in the WOMAC physical function score (7 points) for the intervention group at 6 and 18 months compared to the usual-care group. The exercise program was standardized, and intensity was not adjusted individually.

I In their RCT, Pisters et al[54] compared the effect at 5 years of usual exercise and exercise plus behavioral graded activity. Usual exercise followed the Dutch guideline[70] for hip OA (hip muscle strengthening, aerobic capacity, function, and gait, with focus on limitation of activities and restrictions on participation), including advice, and encouraged coping strategies. Behavioral graded activity consisted of a tailored exercise program using operant conditioning. A difference was found at 3 and 9 months for reduction of pain and improved physical function in favor of behavioral graded activity. At 60 months, both groups showed improvement, but no differences were found between groups. Behavioral graded activity also reduced the likelihood of joint replacement surgery and improved exercise adherence.

I Bennell et al[7] randomized 102 patients with hip OA and compared a physical therapy intervention consisting of manual therapy to the hip and spine, deep tissue massage, stretching, strengthening of the hip and leg, functional balance, gait drills, home exercises, and education and advice for 12 weeks to a sham intervention consisting of inactive ultrasound. Differences between groups for pain and function were not significant, except at week 13 in the active group, with improvement noted in the balance step test.

II Fukumoto et al[24] randomized 46 women diagnosed with hip OA based on the Japanese Orthopaedic Association classification system to assess the difference between high-velocity and low-velocity resistance exercise programs at 8 weeks. Women were stratified into groups by age and hip OA severity. Both training approaches reduced hip pain and improved function (HHS), but did not demonstrate improvements beyond the MDCs for isometric strength, muscle power, clinical assessment, muscle mass, and composition. The results support the use of exercise in patients with hip OA, but indicate no preference for high- versus low-velocity resistive exercise.

III Ageberg et al[2] prospectively followed a group of 38 patients with severe hip OA based on pain, disability, and radiographic findings. Patients received up to 20 individualized goal-based interventions that consisted of neuromuscular training exercises. The HOOS scores for pain, symptom, activities of daily living, sport, and QOL had improvements of 6.1, 4.7, 5.0, 6.9, and 7.1 points (0-100) from baseline scores. Improvements found in this study of an individual approach to exercise should be confirmed in controlled studies.

III Paans et al[50] studied the effect of an 8-month combined exercise and weight-loss program in a prospective cohort of 35 patients with hip OA. Significant improvements were found at 3 months for WOMAC physical function and WOMAC pain and stiffness scores, pain VAS, SF-36 physical component summary score, body mass, and body fat. At 8 months, improvements were found for WOMAC physical function (33%), WOMAC pain and stiffness, SF-36, pain VAS, 6-minute and 20-m walk tests, and body mass and body fat. Adherence rates to exercise and diet components were 94% and 82%, respectively.

III Jigami et al[34] provided land-based and aquatic exercises to 2 groups of 36 patients. One group exercised weekly and the other group exercised biweekly, each for a total of 10 sessions. Muscle strength improved in the weekly group only (hip flexors, +5.7 kg; extensors, +5.8 kg; abductors, +4.3 kg). Both groups improved in the timed up-and-go test and timed 1-leg standing with eyes open test.

2017 Recommendation

A Clinicians should use individualized flexibility, strengthening, and endurance exercises to address impairments in hip range of motion, specific muscle weaknesses, and limited thigh (hip) muscle flexibility. For group-based exercise programs, effort should be made to tailor exercises to address patients' most relevant physical impairments. Dosage and duration of treatment for effect should range from 1 to 5 times per week over 6 to 12 weeks in patients with mild to moderate hip osteoarthritis.

MODALITIES

2009

No recommendation.

Evidence Update

I Köybaşi et al[44] completed an RCT exploring the effects of ultrasound in 45 patients (mean age, 65.3 years) with primary hip OA and a KL score of 2 or 3 based on radiographs. Patients were randomized into 3 groups: (1) exercise and hot packs; (2) exercise, hot packs, and sham ultrasound; (3) exercise, hot packs, and ultrasound (1 MHz continuous; 1 W/cm^2 with 5-cm head size). Ultrasound was administered for 5 minutes to the anterior, posterior, and lateral hip for 10 treatments total. After 10 treatments, all 3 groups showed significant improvement in pain intensity, WOMAC total scores, and 15-minute timed walk. Only the improvements for the exercise-plus-ultrasound and hot packs (group 3) group remained significant at 1 and 3 months after completion of treatment. Ultrasound may be beneficial for short-term pain reduction in patients with hip OA.

2017 Recommendation

B Clinicians may use ultrasound (1 MHz; 1 W/cm^2 for 5 minutes each to the anterior, lateral, and posterior hip for a total of 10 treatments over a 2-week period) in addition to exercise and hot packs in the short-term management of pain and activity limitation in individuals with hip osteoarthritis.

BRACING

2009

No recommendation.

Evidence Update

IV Sato et al[62] explored the effects of using an S-form hip brace in a cross-sectional survey of 16 patients (15 females) with mild hip OA, with an "on versus off" brace design. Two types of braces were studied, unilateral and bilateral, with usage depending on unilateral versus bilateral hip OA. Using the unilateral brace, the mean timed up-and-go test time when turning and rounding a cone with the unbraced leg, inside of the cone but not outside, showed improvements at 3 months, which were maintained at 12 months. Improvements were found in the timed up-and-go test at 6 or 12 months for the bilateral hip brace. The HHS improved in 9 out of 10 hips at 1 month. Economic cost and the demands of daily wear are drawbacks.

2017 Recommendation

F Clinicians should not use bracing as a first line of treatment. A brace may be used after exercise or manual therapies are unsuccessful in improving participation in activities that require turning/pivoting for patients with mild to moderate hip osteoarthritis, especially in those with bilateral hip osteoarthritis.

WEIGHT LOSS

2009 Recommendation

No recommendation.

Evidence Update

III Paans et al[50] investigated the effect of exercise and dietary guidance for weight loss on function in a cohort study with hip OA, with the following inclusion criteria: ACR hip OA criteria, 25 years of age or older, overweight (BMI, greater than 25 kg/m^2), or obese (BMI, greater than 30 kg/m^2). Significant decreases in body mass and body fat were found at 8 months (5% and 3.3%, respectively). Self-reported WOMAC physical function subscale scores also improved after 3 and 8 months, by 11% and 17%, respectively. The WOMAC pain subscale score decreased by 24.8% at 8 months. Walking distance on the 6-minute walk test improved by 11.6%.

2017 Recommendation

C In addition to providing exercise intervention, clinicians should collaborate with physicians, nutritionists, or dietitians to support weight reduction in individuals with hip osteoarthritis who are overweight or obese.

A model to guide clinical decisions regarding examination and treatment planning for individuals with hip pain and mobility deficits—hip osteoarthritis is depicted in the **FIGURE**.

Key Clinical Findings of Hip Pain and Mobility Deficits—Hip OA

- Moderate anterior or lateral hip pain during weight-bearing activities
- Morning stiffness less than 1 hour in duration after wakening
- Hip IR ROM less than 24°
- IR and hip flexion 15° less than the nonpainful side
- Increased hip pain associated with passive hip IR
- Absence of history, activity limitations, and/or impairments inconsistent with hip OA

Measures to Assess Level of Functioning, Presence of Associated Physical Impairments to Address With Treatment, and Response to Treatment*

Activity/Participation Measures (A)
- LEFS
- WOMAC
- BPI
- HOOS
- HHS
- Pain VAS
- Berg Balance Scale
- Timed up-and-go test
- Stair measure
- Self-paced walk test
- 4-square step test
- Step test
- Timed single-leg stance
- 30-second chair stand
- 6-minute walk test

Impairment Measures
- FABER test (A)
- Scour test (A)
- Hip flexion ROM (A)
- Hip IR ROM (A)
- Hip ER ROM (A)
- Hip extension ROM (A)
- Hip abduction/gluteus medius strength and motor control (A)
- Hip extension/gluteus maximus strength and motor control (A)
- Pain at rest: current level of pain (0-10, 0 best) (F)
- Pain at best: lowest level of pain in recent 24 hours (0-10, 0 best) (F)
- Pain at worst: highest level of pain in recent 24 hours (0-10, 0 best) (F)
- Pain frequency: percent of time in pain in recent 24 hours (0%-100% of time, 0% best) (F)

Figure continues on page A21.

FIGURE. Hip pain and mobility deficits—hip osteoarthritis examination/intervention guidelines decision-making model. *Letters in parentheses reflect the grade of evidence on which the recommendation for each item is based: (A) strong evidence; (B) moderate evidence; (C) weak evidence; (D) conflicting evidence; (E) theoretical/foundational evidence; (F) expert opinion.

Interventions

Note: Interventions should be tailored to address the specific hip OA-related impairments and limitations identified on examination.

Flexibility, Strengthening, and Endurance Exercises (A)
- Dosage: 1 to 5 times per week over 6 to 12 weeks for mild to moderate hip OA
- Hip capsule, fascia, and muscle stretching, including extension, flexion, IR, ER, abduction, and horizontal adduction, with attention to hip flexors and ERs
- Strengthening of hip abductors, ERs, extensors

Manual Therapy (A)
- Soft tissue mobilization of areas of soft tissue restriction, such as iliacus, hip ERs, posterior gluteus medius, quadratus femoris, and gluteus maximus
- Joint mobilizations to improve identified restrictions in joint mobility, such as hip distraction mobilizations, posterior glides, anterior glides, and distraction mobilizations with movement

Functional, Gait, and Balance Training (C)
- Balance, functional, and gait training to address identified limitations
- Proper use of assistive devices (canes, crutches, walkers)
- Individualized exercise prescription based on patient values, needs, and activities

Patient Education Combined With Exercise (B)
- Address weight-bearing activity modification as appropriate
- Provide exercises to address identified impairments and to support weight reduction as appropriate
- Discuss unloading the arthritic joints as appropriate

Weight Loss (C)
- Refer and collaborate as needed to physicians, nutritionists, or dietitians to support weight management plan

Modalities (B)
- Ultrasound may be used in addition to exercise for short-term pain and activity limitation management for up to 2 weeks

Revise Diagnosis, Change Plan of Care, or Refer to Appropriate Clinicians

- When the patient's symptoms do not diminish after targeted interventions within expected time frame, as identified in the tailored treatment plan

FIGURE (CONTINUED). Hip pain and mobility deficits—hip osteoarthritis examination/intervention guidelines decision-making model.

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APPENDIX A

SEARCH STRATEGIES FOR ALL DATABASES SEARCHED

Assessment

PubMed

((Questionnaires [mesh]) OR (womac[tiab] OR hoos[tiab] OR mactar[tiab] OR lish[tiab] OR oakhqol[tiab] OR "walk test"[tiab] OR "stair measure"[tiab] OR "timed up and go"[tiab] OR "lower extremity functional scale"[tiab] OR lefs[tiab] OR "harris hip score"[tiab] OR "faber test"[tiab] OR "scour test"[tiab] OR "sit to stand test"[tiab] OR "step test"[tiab] OR "stance test"[tiab] OR "stair climb"[tiab] OR "performance-based"[tiab] OR Questionnaire [tiab] OR Questionnaires[tiab] OR Instrument[tiab] OR Instruments[tiab] OR Scale[tiab] OR Scales[tiab] OR Measurement[tiab] OR Measurements[tiab] OR Index[tiab] OR Indices[tiab] OR Score[tiab] OR Scores[tiab]) ((diagnosis[sh] OR "Diagnosis"[Mesh])) OR (radiograph*[tiab] OR radiologic*[tiab] OR diagnos*[tiab] OR misdiagnos*[tiab] OR ultrasonography[tiab] OR sonography[tiab] OR ultrasound*[tiab] OR sonogram*[tiab] OR CT[tiab] OR tomography[tiab] OR xray[tiab] OR x-ray[tiab] OR mri[tiab] OR imaging[tiab] OR examination[tiab] OR exam[tiab] OR evaluat*[tiab] OR classif*[tiab] OR specificity[tiab] OR kellgren*[tiab] OR mankin[tiab]) ("osteoarthritis, hip"[mesh]) OR ((hip[mesh] OR "hip joint"[mesh] OR hip[tiab] OR hips[tiab]) AND (osteoarthritis[mesh:noexp] OR osteoarthr*[tiab]

Cochrane Library

((CT or radiograph* or radiologic* or diagnos* or misdiagnos* or ultrasonography or sonography or ultrasound* or sonogram* or tomography or xray or x-ray or mri or imaging or examination or exam or evaluat* or classif* or specificity or kellgren* or mankin:womac or hoos or mactar or lish or oakhqol or "walk test" or "stair measure" or "timed up and go" or "lower extremity functional scale" or lefs or "harris hip score" or "faber test" or "scour test" or "sit to stand test" or "step test" or "stance test" or "stair climb" or "performance-based" or Questionnaire or Questionnaires or Instrument or Instruments or Scale or Scales or Measurement or Measurements or Index or Indices or Score Scores)

CINAHL

((womac OR hoos OR mactar OR lish OR oakhqol OR "walk test" OR "stair measure "OR" timed up and go "OR" lower extremity functional scale "OR lefs OR "harris hip score"OR"faber test"OR"scour test"OR"sit to stand test"OR"step test "OR" stance test"OR"stair climb"OR"performance-based"OR Questionnaire OR Questionnaires OR Instrument ORInstruments OR Scale OR Scales ORMeasurement OR Measurements OR Index OR Indices OR Score Scores) ORAB (womac OR hoos OR mactar OR lish OR oakhqol OR"walk test"OR"stair measure"OR"timed up and go"OR"lower extremity functional scale"OR lefs OR"harris hip score"OR"faber test"OR"scour test"OR" sit to stand test" OR "step test"OR"stance test" OR "stair climb" OR "performance-based"OR Questionnaire OR Questionnaires OR Instrument ORInstruments OR Scale OR Scales OR Measurement OR Measurements OR Index OR Indices OR Score Scores

T1(radiograph* OR radiologic* OR diagnos* OR misdiagnos* OR ultrasonography ORsonography OR ultrasound* OR sonogram* OR tomography OR xray OR x-ray OR mri OR imaging OR examination OR exam ORevaluat* OR classif* OR specificity ORkellgren* OR mankin) ORAB (radiograph*OR radiologic* OR diagnos* OR misdiagnos* OR ultrasonography OR sonography ORultrasound* OR sonogram* OR tomography OR xray OR x-ray OR mri OR imaging OR examination OR exam OR evaluat* OR classif* OR specificity OR kellgren* OR mankin)

Intervention

PubMed

Search ((Combined Modality Therapy[mesh] OR Electric Stimulation Therapy[mesh] OR Electric Stimulation[mesh] OR Transcutaneous Electric Nerve Stimulation[mesh] OR Traction[mesh] OR Laser Therapy[mesh] OR Rehabilitation[mesh] OR rehabilitation[sh] OR Phototherapy[mesh] OR Lasers[mesh] OR Physical Therapy Modalities[mesh] OR Cryotherapy[mesh] OR Cryoanesthesia[mesh] OR Ice[mesh] OR Acupuncture Therapy[mesh] OR Acupuncture[mesh] OR modalit*[tiab] OR "electric stimulation"[tiab] OR "electrical stimulation"[tiab] OR electrotherapy[tiab] OR tens[tiab] OR"transcutaneous electric nerve stimulation"[tiab] OR electroacupuncture[tiab] OR acupuncture[tiab] OR needling[tiab] OR heat[tiab] OR cold[tiab] OR traction[tiab] OR laser[tiab] OR lasers[tiab] OR rehabilitation[tiab] OR "physical therapy"[tiab] OR "physical therapies"[tiab] OR physiotherap*[tiab] OR cryotherapy[tiab] OR hyperthermia[tiab] OR "vapocoolant spray"[tiab] OR cryoanesthesia[tiab] OR ice[tiab] OR faradic[tiab] OR traction[tiab] OR iontophoresis[tiab] ORphonophoresis[tiab] OR phototherapy[tiab] OR hydrotherapy[tiab] OR "li"light therapy"[tiab] OR diathermy[tiab] OR ultraviolet[tiab] OR infrared[tiab]))

Search (("Exercise Therapy"[Mesh] OR Exercise[mesh] OR "Self-Help Devices"[Mesh] OR "education" [Subheading] OR "Patient Education as Topic"[Mesh] OR crutches[Mesh] OR Canes[Mesh] OR Walkers[Mesh] OR "orthotic devices"[mesh] OR therapy[sh:noexp])) OR (exercis*[tiab] OR massag*[tiab] OR "manual therapy"[tiab] OR accupressure[tiab] OR manipulat*[tiab] OR "applied kinesiology"[tiab] OR stretching[tiab] OR stretch[tiab] OR stretches[tiab] OR "continuous passive movement"[tiab] OR "continuous passive motion"[tiab] OR plyometric[tiab] OR plyometrics[tiab] OR "resistance training"[tiab] OR "strength training"[tiab] OR strengthening[tiab] OR "weight-bearing"[tiab] OR weightbearing[tiab] OR "weight-lifting"[tiab] OR weightlifting[tiab] OR "physical conditioning"[tiab] OR education[tiab] OR balneotherapy[tiab] OR "aquatic therapy"[tiab] OR "pool therapy"[tiab] OR "water aerobics"[tiab] OR "water running"[tiab] OR "water training"[tiab] OR "gait aids"[tiab] OR "gait aid"[tiab] OR "gait training"[tiab] OR crutches[tiab] OR walker[tiab] OR

APPENDIX A

walkers[tiab] OR cane[tiab] OR canes[tiab] OR orthotic*[tiab] OR orthoses[tiab] OR orthosis[tiab] OR "activity modification"[tiab] OR "balance training"[tiab] OR "functional training"[tiab] OR "assistive devices"[tiab] OR "assistive device"[tiab] OR mobilization[tiab] OR mobilisation[tiab] OR "flexibility training"[tiab] OR "endurance training"[tiab] OR "proprioceptive neuromuscular facilitation"[tiab] OR "manual resistance"[tiab] OR "aerobic activity"[tiab]

("osteoarthritis, hip"[mesh]) OR ((hip[mesh] OR "hip joint"[mesh] OR hip[tiab] OR hips[tiab]) AND (osteoarthritis[mesh:noexp] OR osteoarthr*[tiab])))

Cochrane Library

((hip or hips) and osteoarthr*modalit* or "electric stimulation" or "electrical stimulation" or electrotherapy or tens or "transcutaneous electric nerve stimulation" or electroacupuncture or acupuncture or needling or heat or cold or traction or laser or lasers or rehabilitation or "physical therapy" or "physical therapies" or physiotherap* or cryotherapy or hyperthermia or "vapocoolant spray" or cryoanesthesia or ice or faradic or traction or iontophoresis or phonophoresis or phototherapy or hydrotherapy or "light therapy" or diathermy or ultraviolet or infrared; exercis* or massag* or "manual therapy" or accupressure or manipulat* or "applied kinesiology" or stretching or stretch or stretches or "continuous passive movement" or "continuous passive motion" or plyometric or plyometrics or "resistance training" or "strength training" or strengthening or "weight-bearing" or weightbearing or "weight-lifting" or weightlifting or "physical conditioning" or education or balneotherapy or "aquatic therapy" or "pool therapy" or "water aerobics" or "water running" or "water training" or "gait aids" or "gait aid" or "gait training" or crutches or walker or walkers or cane or canes or orthotic* or orthoses or orthosis or "activity modification" or "balance training" or "functional training" or "assistive devices" or "assistive device" or mobilization or mobilisation or "flexibility training" or "endurance training" or "proprioceptive neuromuscular facilitation" or "manual resistance" or "aerobic activity":ti,ab,kw)

CINAHL

((MH Exercise+ OR MH Assistive Technology Devices+ OR MW ED OR MH "Patient Education+ OR MH orthoses + OR MW TH) OR TI (exercise * OR massage* OR manual therapy OR accupressure OR manipulat* OR applied kinesiology OR stretching OR stretch OR stretches OR "continuous passive movement" OR "continuous passive motion" OR plyometric OR plyometrics OR resistance training OR strength training OR strengthening OR weight-bearing OR weightbearing OR weight-lifting OR weightlifting OR physical conditioning OR education OR balneotherapy OR aquatic therapy OR pool therapy OR water aerobics OR water running OR water training OR gait aids OR gait aide OR gait training OR crutches OR walker OR walkers OR cane OR canes OR orthotic* OR orthoses OR orthosis OR activity modification OR balance training OR functional training OR assistive devices OR assistive device OR mobilization OR mobilisation OR flexibility training OR endurance training OR proprioceptive neuromuscular facilitation OR manual resistance OR aerobic activity) OR AB (exercise * OR massage * OR manual therapy OR accupressure OR manipulate * OR applied kinesiology OR stretching OR stretch OR stretches OR "continuous passive movement" OR "continuous passive motion" OR plyometric OR plyometrics OR resistance training OR strength training OR strengthening OR weight-bearing OR weightbearing OR weight-lifting OR weightlifting OR physical conditioning OR education OR balneotherapy OR aquatic therapy OR pool therapy OR water aerobics OR water running OR water training OR gait aids OR gait aid OR gait training OR crutches OR Search modes - walker OR walkers OR cane OR canes OR orthotic* OR orthoses OR orthosis OR activity modification OR balance training OR functional training OR assistive devices OR assistive device OR mobilization OR mobilisation OR flexibility training OR endurance training OR proprioceptive neuromuscular facilitation OR manual resistance OR aerobic activity))

(MH "Combined Modality Therapy" OR MH Physical Therapy + OR MH Rehabilitation OR MW RH OR MH Traction OR MH Laser Therapy OR MH Ice OR MH Acupuncture+ OR MH Acupressure) OR TI (modalities * OR "electric stimulation" OR "electrical stimulation" OR electrotherapy OR tens OR "transcutaneous electric nerve stimulation" OR electroacupuncture OR acupuncture OR needling OR heat OR cold OR traction OR laser OR lasers OR rehabilitation OR "physical therapy" OR Physical therapies OR physiotherap* OR cryotherapy OR hyperthermia OR "vapocoolant spray" OR cryoanesthesia OR ice OR faradic OR traction OR iontophoresis OR phonophoresis OR phototherapy OR hydrotherapy OR "light therapy" OR diathermy OR ultraviolet OR infrared) OR AB (modalit * OR "electric stimulation" OR "electrical stimulation" OR electrotherapy OR tens OR "transcutaneous electric nerve stimulation" OR electroacupuncture OR acupuncture OR needling OR heat OR cold OR traction OR laser OR lasers OR rehabilitation OR "physical therapy" OR physical therapies OR physiotherap* OR cryotherapy OR hyperthermia OR "vapocoolant spray" OR cryoanesthesia OR ice OR faradic OR traction OR iontophoresis OR phonophoresis OR phototherapy OR hydrotherapy OR "light therapy" OR diathermy OR ultraviolet OR infrared)

PEDro

hip* AND osteoarthr*

body part: hip or thigh

APPENDIX B

SEARCH RESULTS
Assessment

Database/Platform	Time Covered	Date Conducted	Results, n
MEDLINE			
PubMed	2008-date	August 4, 2014	3464
PubMed	July 2014-date	April 8, 2016	100
CINAHL			
EBSCO	2008-July 2014	August 4, 2014	183
ESSCO	July 2014-date	April 8, 2016	47
Cochrane Library			
Wiley	Current as of August 4, 2014	August 4, 2014	412
Wiley	2014-date: DSR, issue 4 (April 2016); DARE, issue 2 (April 2015); CENTRAL, issue 3 (March 2016); HTA, issue 1 (January 2016)	April 8, 2016	258 (DSR, 13; other, 2; CENTRAL, 242; HTA, 1)
PEDro	2008-date	August 4, 2014	83
		April 8, 2016	29
Total		August 4, 2014	4142
With duplicates removed		August 4, 2014	3691
Total		April 8, 2016	1734
With duplicates removed		April 8, 2016	1589

Abbreviations: CENTRAL, Cochrane Central Register of Controlled Trials; DARE, Database of Abstracts of Reviews of Effects; DSR, Database of Systematic Reviews; HTA, Health Technology Assessment.

APPENDIX B

SEARCH RESULTS
Intervention

Database/Platform	Time Covered	Date Conducted	Results, n
MEDLINE			
PubMed	2008-July 2014	July 14, 2014	1057
PubMed	July 2014-date	March 11, 2016	431
CINAHL			
EBSCO	2008-date	July 14, 2014	445
ESSCO	2014-date	March 11, 2016	131
Cochrane Library			
Wiley	April 2014-July 2014: DSR, issue 7 (July 2014); DARE, issue 2 (April 2014); CENTRAL, issue 6 (June 2014); EED, issue 2 (April 2014)	July 14, 2014	204 (DSR, 13; DARE, 14; CENTRAL, 171; EED, 6)
Wiley	April 2015-March 2016: DSR, issue 3 (March 2016); DARE, issue 2 (April 2015); CENTRAL, issue 2 (February 2016); HTA, issue 1 (January 2016)	March 11, 2016	132 (DSR, 8; DARE, 3; CENTRAL, 120; HTA, 1)
PEDro	2008-date	July 15, 2014	81
		March 11, 2016	27
Total		July 15, 2014	1787
With duplicates removed		July 15, 2014	1297
Total		March 11, 2016	721
With duplicates removed		March 11, 2016	579

Abbreviations: CENTRAL, Cochrane Central Register of Controlled Trials; DARE, Database of Abstracts of Reviews of Effects; DSR, Database of Systematic Reviews; EED, NHS Economic Evaluation Database; HTA, Health Technology Assessment; NHS, National Health Service.

APPENDIX C

ARTICLE INCLUSION AND EXCLUSION CRITERIA

Inclusion Criteria

We included articles providing evidence of the following types: systematic reviews, meta-analyses, experimental, cohort, and cross-sectional studies reporting on:

- Must have diagnostic hip OA with either radiographic or clinical confirmation (using established criteria such as the ACR criteria)

AND

- Have at least a sample size of 15 or greater

AND

- If the study included both hip and knee OA, the results must be reported separately

OR

- Tests and measures for diagnosis and/or differential diagnosis of hip OA within the scope of physical therapy practice (including but not limited to lumbar spine, sacroiliac joint, hernia, and cancer)

OR

- Tests and methods for diagnosis and/or differential diagnosis of hip OA using imaging (including but not limited to ultrasound, plain-film radiography, and MRI)

OR

- Measurement properties of tests and measures specific to hip OA–related symptoms and outcomes (WOMAC, HHS, HOOS, Lequesne Index of Severity for Osteoarthritis of the Hip [LISH], Osteoarthritis Knee and Hip Quality of Life Questionnaire, American Academy of Orthopaedic Surgeons Hip and Knee Outcomes Questionnaire, Oxford hip and knee score, Lower Limb Core Scale, VAS, LEFS, SF-36, World Health Organization Disability Assessment Schedule [WHODAS], QOL)

OR

- Measurement properties of tests/measurements using data from a sample of patients with hip OA, including active and passive ROM; pain; manual muscle tests; muscle length measures; and special tests, including but not limited to the flexion, abduction, and external rotation (FABER), flexion, adduction, and internal rotation (FADIR), log roll, and scour tests

OR

- Measurement properties of tests and measures specific to hip OA–related functions, activity, and participation (including but not limited to the 6-minute walk test, self-paced walk test, stair measure, timed up-and-go test. Berg Balance Scale, 5-time sit-to-stand test, functional gait, 10-m walk test, and EQ-5D)

AND

- Interventions within the scope of the practice of physical therapy, including coordination training, functional training, gait training, balance training, modalities (including but not limited to heat, electrical stimulation, ultrasound, diathermy), manual therapy (including but not limited to manipulation, joint mobilization, soft tissue mobilization, massage), exercise (including but not limited to stretching/flexibility, proprioceptive neuromuscular facilitation, manual resistance, resistance/strength training, aerobic and endurance activities, community-based and self-management programs), assistive devices, and education

Exclusion Criteria

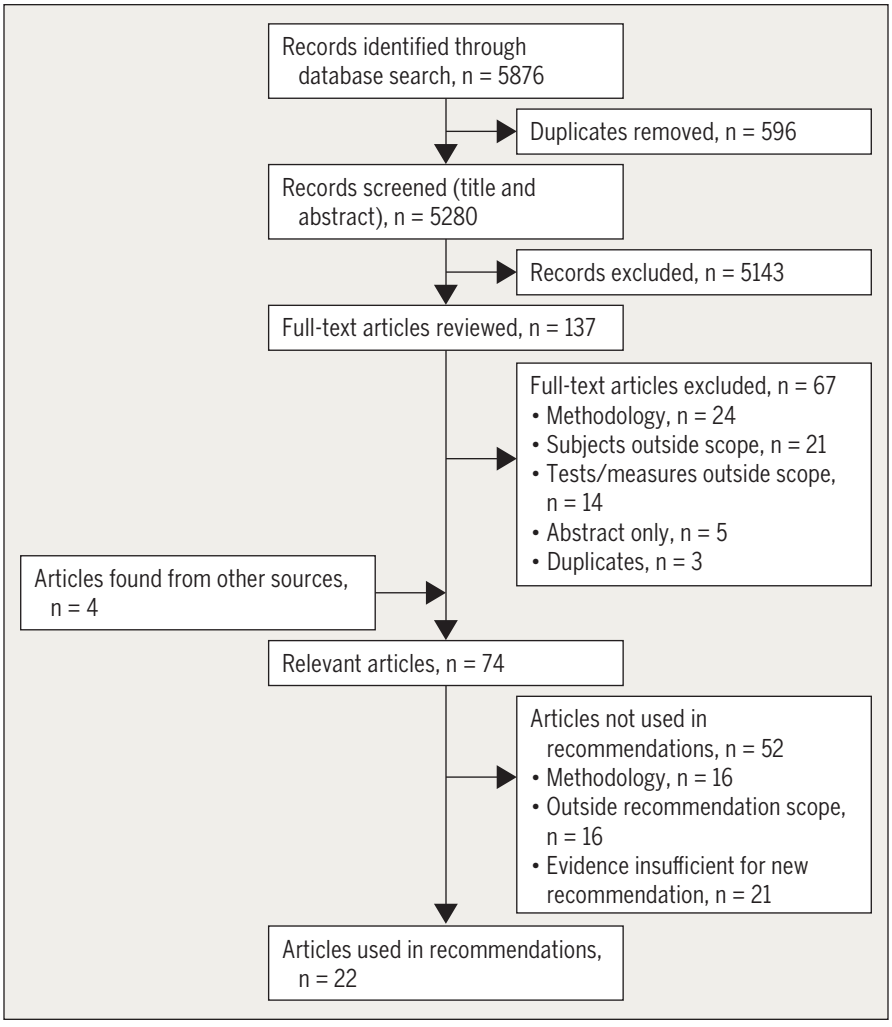
We excluded abstracts, press reports, editorial letters, and articles reporting on:

- Study protocols
- Animal studies
- Children (aged less than 18 years)
- Primary surgical studies
- Legg-Calve-Perthes disease
- Congenital hip dislocation
- SCFE
- Hip dysplasia
- FAI

APPENDIX D

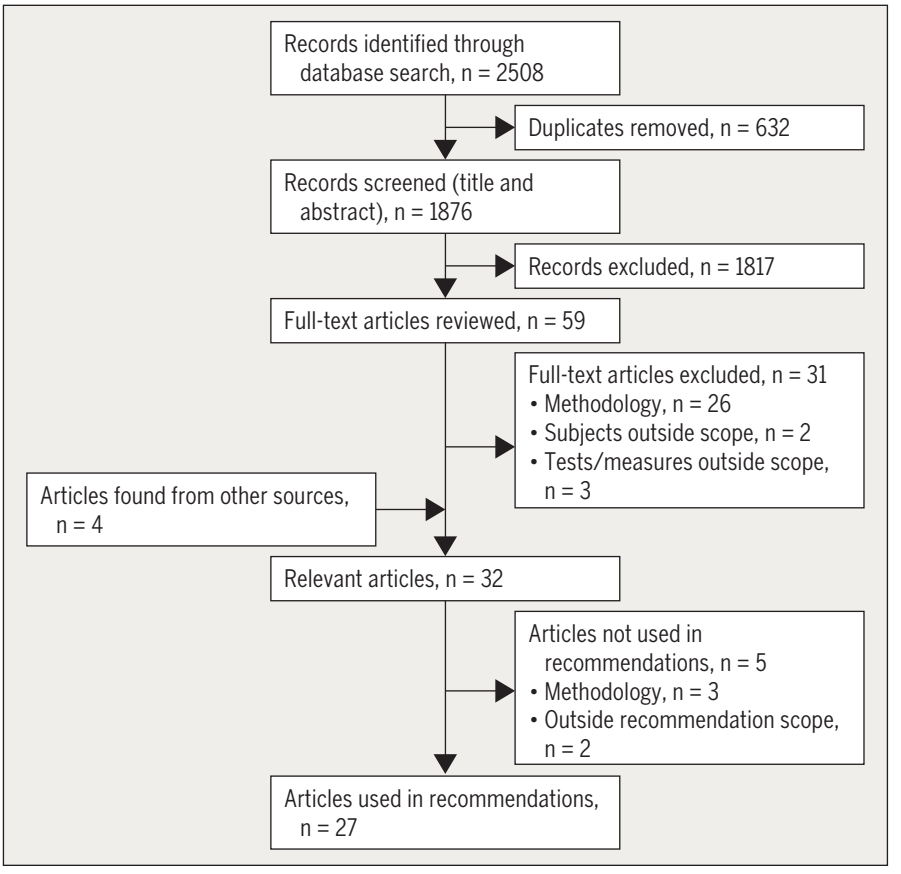
FLOW CHART OF ARTICLES

Assessment



APPENDIX D

FLOW CHART OF ARTICLES
Intervention



APPENDIX E

ARTICLES INCLUDED IN RECOMMENDATIONS BY TOPIC

Diagnosis/Classification

Holla JF, Steultjens MP, van der Leeden M, et al. Determinants of range of joint motion in patients with early symptomatic osteoarthritis of the hip and/or knee: an exploratory study in the CHECK cohort. *Osteoarthritis Cartilage*. 2011;19:411-419. https://doi.org/10.1016/j.joca.2011.01.013

Kim C, Nevitt MC, Niu J, et al. Association of hip pain with radiographic evidence of hip osteoarthritis: diagnostic test study. *BMJ*. 2015;351:h5983. https://doi.org/10.1136/bmj.h5983

Examination

Outcome Measures: Activity Limitations – Self-report Measures

Aranda-Villalobos P, Fernández-de-las-Peñas C, Navarro-Espigares JL, et al. Normalization of widespread pressure pain hypersensitivity after total hip replacement in patients with hip osteoarthritis is associated with clinical and functional improvements. *Arthritis Rheum*. 2013;65:1262-1270. https://doi.org/10.1002/art.37884

Arendt-Nielsen L, Graven-Nielsen T. Translational musculoskeletal pain research. *Best Pract Res Clin Rheumatol*. 2011;25:209-226. https://doi.org/10.1016/j.berh.2010.01.013

Arnold CM, Faulkner RA. Does falls-efficacy predict balance performance in older adults with hip osteoarthritis? *J Gerontol Nurs*. 2009;35:45-52.

Davis AM, Perruccio AV, Canizares M, et al. The development of a short measure of physical function for hip OA HOOS-Physical Function Shortform (HOOS-PS): an OARSI/OMERACT initiative. *Osteoarthritis Cartilage*. 2008;16:551-559. https://doi.org/10.1016/j.joca.2007.12.016

Goode AP, Shi XA, Gracely RH, Renner JB, Jordan JM. Associations between pressure-pain threshold, symptoms, and radiographic knee and hip osteoarthritis. *Arthritis Care Res (Hoboken)*. 2014;66:1513-1519. https://doi.org/10.1002/acr.22321

Hawker GA, Davis AM, French MR, et al. Development and preliminary psychometric testing of a new OA pain measure – an OARSI/OMERACT initiative. *Osteoarthritis Cartilage*. 2008;16:409-414. https://doi.org/10.1016/j.joca.2007.12.015

Kapstad H, Hanestad BR, Langeland N, Rustøen T, Stavem K. Cutpoints for mild, moderate and severe pain in patients with osteoarthritis of the hip or knee ready for joint replacement surgery. *BMC Musculoskelet Disord*. 2008;9:55. https://doi.org/10.1186/1471-2474-9-55

Kapstad H, Rokne B, Stavem K. Psychometric properties of the Brief Pain Inventory among patients with osteoarthritis undergoing total hip replacement surgery. *Health Qual Life Outcomes*. 2010;8:148. https://doi.org/10.1186/1477-7525-8-148

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APPENDIX F

LEVELS OF EVIDENCE TABLE*

Level	Intervention/Prevention	Pathoanatomic/Risk/ Clinical Course/Prognosis/ Differential Diagnosis	Diagnosis/Diagnostic Accuracy	Prevalence of Condition/Disorder	Exam/Outcomes
I	Systematic review of high-quality RCTs High-quality RCT†	Systematic review of prospective cohort studies High-quality prospective cohort study‡	Systematic review of high-quality diagnostic studies High-quality diagnostic study§ with validation	Systematic review, high-quality cross-sectional studies High-quality cross-sectional study‖	Systematic review of prospective cohort studies High-quality prospective cohort study
II	Systematic review of high-quality cohort studies High-quality cohort study‡ Outcomes study or ecological study Lower-quality RCT¶	Systematic review of retrospective cohort study Lower-quality prospective cohort study High-quality retrospective cohort study Consecutive cohort Outcomes study or ecological study	Systematic review of exploratory diagnostic studies or consecutive cohort studies High-quality exploratory diagnostic studies Consecutive retrospective cohort	Systematic review of studies that allows relevant estimate Lower-quality cross-sectional study	Systematic review of lower-quality prospective cohort studies Lower-quality prospective cohort study
III	Systematic reviews of case-control studies High-quality case-control study Lower-quality cohort study	Lower-quality retrospective cohort study High-quality cross-sectional case-control study	Lower-quality exploratory diagnostic studies Nonconsecutive retrospective cohort	Local nonrandom study	High-quality cross-sectional study
IV	Case series	Case series	Case-control study		Lower-quality cross-sectional study
V	Expert opinion	Expert opinion	Expert opinion	Expert opinion	Expert opinion

Abbreviation: RCT, randomized clinical trial.

Adapted from Phillips et al[52] (http://www.cebm.net/index.aspx?o=1025). See also* **APPENDIX G.

†*High quality includes RCTs with greater than 80% follow-up, blinding, and appropriate randomization procedures.*

‡*High-quality cohort study includes greater than 80% follow-up.*

§*High-quality diagnostic study includes consistently applied reference standard and blinding.*

‖*High-quality prevalence study is a cross-sectional study that uses a local and current random sample or censuses.*

¶*Weaker diagnostic criteria and reference standards, improper randomization, no blinding, and less than 80% follow-up may add bias and threats to validity.*

APPENDIX G

PROCEDURES FOR ASSIGNING LEVELS OF EVIDENCE

- Level of evidence is assigned based on the study design using the Levels of Evidence table (**APPENDIX F**), assuming high quality (eg, for intervention, randomized clinical trial starts at level I)
- Study quality is assessed using the critical appraisal tool, and the study is assigned 1 of 4 overall quality ratings based on the critical appraisal results
- Level of evidence assignment is adjusted based on the overall quality rating:
  - High quality (high confidence in the estimate/results): study remains at assigned level of evidence (eg, if the randomized clinical trial is rated high quality, its final assignment is level I). High quality should include:
    - Randomized clinical trial with greater than 80% follow-up, blinding, and appropriate randomization procedures
    - Cohort study includes greater than 80% follow-up
    - Diagnostic study includes consistently applied reference standard and blinding
    - Prevalence study is a cross-sectional study that uses a local and current random sample or censuses
  - Acceptable quality (the study does not meet requirements for high quality and weaknesses limit the confidence in the accuracy of the estimate): downgrade 1 level
    - Based on critical appraisal results
  - Low quality: the study has significant limitations that substantially limit confidence in the estimate: downgrade 2 levels
    - Based on critical appraisal results
  - Unacceptable quality: serious limitations—exclude from consideration in the guideline
    - Based on critical appraisal results

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CLINICAL UPDATE

WILEY

A clinical practice guideline for physical therapy in patients with hip or knee osteoarthritis

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Abstract

Objective: The purpose of this paper is to revise the 2010 Dutch guideline for physical therapy (PT) in patients with hip or knee osteoarthritis (OA), issued by the Royal Dutch Society for Physical Therapy (KNGF).

Method: This revised guideline was developed according to the Appraisal of Guidelines for Research and Evaluation (AGREE) and Guidelines International Network (G-I-N) standards. A multidisciplinary guideline panel formulated clinical questions based on perceived barriers to current care. A narrative or systematic literature review was undertaken in response to each clinical question. The panel formulated recommendations based on evidence and additional considerations, as described in the Grading of Recommendations Assessment, Development, and Evaluation (GRADE) Evidence-to-Decision framework.

Results: A comprehensive assessment should be based on the International Classification of Functioning Disability and Health (ICF) core set for OA, including the identification of OA-related red flags. Based on the assessment, four treatment profiles were distinguished: (1) education and instructions for unsupervised exercises, (2) education and short-term supervised exercise therapy, (3) education and longer term supervised exercise therapy, and (4) education and exercise therapy before and/or after total hip or knee surgery. Education included individualized information, advice, instructions, and self-management support. Exercise programs were tailored to individual OA-related issues, were adequately dosed, and were in line with public health recommendations for physical activity. Recommended measurement instruments included the Patient-Specific Complaints Instrument, the Numeric Pain Rating Scale, the Hip Disability and Osteoarthritis Outcome Score/the Knee Injury Osteoarthritis Outcome Score, and the Six Minute Walk Test.

Conclusion: An evidence-based PT guideline for the management of patients with hip or knee OA was developed. To improve quality of care for these patients, an extensive implementation strategy is necessary.

KEYWORDS

clinical practice guideline, exercise therapy, hip osteoarthritis, knee osteoarthritis, physical therapy, total hip arthroplasty, total knee arthroplasty

1 | INTRODUCTION

Osteoarthritis (OA) is the most common disorder of the musculoskeletal system, with hip and knee joints being among the most frequent localizations (Hunter & Bierma-Zeinstra, 2019). In 2010, of 291 conditions, hip and knee OAs were ranked as the 11th highest contributors to global disability in the Global Burden of Disease Study (Cross et al., 2014). The prevalence of OA is expected to rise in the future because of demographic developments and the increase in the occurrence of (serious) obesity and joint injuries (Cross et al., 2014; Hunter & Bierma-Zeinstra, 2019).

Primary care physical therapy (PT) is one of the cornerstones for the conservative management of hip or knee OA (Fernandes et al., 2013; Hochberg et al., 2012; McAlindon et al., 2014). The clinical effect of PT on pain and disability in hip or knee OA is substantial (Fransen et al., 2015; Fransen, McConnell, Hernandez-Molina, & Reichenbach, 2014), while its associated costs are low. In the Netherlands, costs related to primary care for hip or knee OA constitute 6% of the total costs for this condition (National Institute for Public Health and the Environment, 2017). Given its beneficial effects, PT has been advocated in multiple national and international guidelines and in recommendations for the management of hip or knee OA (Fernandes et al., 2013; Hochberg et al., 2012; McAlindon et al., 2014; National Health Care Institute, 2014; Peter et al., 2011).

A prerequisite for effective PT in hip or knee OA is appropriate delivery. Clinical practice guidelines (CPGs) can help to improve and sustain the quality of PT care. Since 1998, CPGs have been developed and implemented by the Royal Dutch Society for Physical Therapy (KNGF) (Hendriks et al., 2000). In 2016, the KNGF used a new methodology to develop their CPGs (Royal Dutch Society for Physical Therapy, 2019; Van der Wees & Irrgang, 2014) based on the AGREE II statement (Brouwers et al., 2010), the Guidelines International Network (G-I-N) standards (Qaseem et al., 2012), and the Grading of Recommendations Assessment, Development, and Evaluation (GRADE) methodology (Guyatt et al., 2008) and emphasized the importance of multidisciplinary collaboration in the developmental process. The most recent update of the KNGF guideline for hip or knee OA was undertaken in 2010 (Peter et al., 2011). The evidence base for PT in patients with OA has expanded, and new insights into the optimization of its delivery have emerged; therefore, a revision of the KNGF guideline was deemed necessary. Moreover, more detailed practical recommendations were required concerning the actual delivery of exercise therapy and concerning physical therapeutic interventions before and after total hip or knee arthroplasties. The purpose of this paper is to describe the development of the revised KNGF guideline for hip or knee OA and the resulting recommendations on physical therapeutic assessment and treatment.

2 | METHOD FOR GUIDELINE DEVELOPMENT

The revision of the 2008 guideline was undertaken using the guideline methodology developed by the KNGF (Royal Dutch Society for Physical Therapy, 2019; Van der Wees & Irrgang, 2014). The methodology consisted of the following phases: (1) preparation, (2) development, (3) review and authorization, and (4) dissemination and implementation. This paper focuses on the first three phases, which were undertaken from June 2016 to March 2018.

2.1 | Phase 1: Preparation

Between June and September 2016, three groups were formed: an author group, a guideline panel, and a review panel. The author group consisted of guideline experts and policy advisors with expertise in the methodological field and with research experience, a postdoctoral researcher and a professor in the field of PT and OA. Both the guideline and the review panels composed of physical therapists with clinical and research experience concerning OA, patient representatives, and other stakeholders (e.g., general practitioners and orthopedic surgeons; see Appendix A for all stakeholders). An independent expert on the topic of OA was appointed as chair of both the guideline and the review panels.

The barriers to assessment, treatment, and evaluation of patients with OA were identified using focus groups comprised physical therapists (n = 19) and patients (n = 10) and during the first meetings of the guideline and the review panels. The guideline panel subsequently identified barriers that were then prioritized and translated into clinical questions (Appendix B).

2.2 | Phase 2: Development

The development process was based on the principles of evidence-based medicine through a description of the best available evidence combined with clinical expertise and patient preferences (Sackett, Rosenberg, Gray, Haynes, & Richardson, 1996). For this purpose, the clinical questions were first adapted to form research questions, which were subsequently answered by means of systematic literature reviews for questions regarding therapeutic interventions and narrative literature reviews for all other questions.

Regarding therapeutic interventions, a systematic literature search of the PubMed, Embase, Web of Science, Cochrane Library, Central, EMCARE, and CINAHL databases was conducted on December 19, 2016, for questions concerning exercise therapy and on August 14, 2017, for questions concerning nonexercise therapy (Appendix C). This study included randomized controlled trials (RCTs) involving adults diagnosed with OA according to the American College of Rheumatology classification criteria (Altman et al., 1991, 1986) that described the posttreatment effect of the intervention of interest compared with the usual care. All outcomes of interest were defined in advance by the guideline panel and rated as critical (in terms of physical functioning) or important (in terms of pain and quality of life), based on their importance for decision making. The evidence was synthesized through providing estimates of the effects and the quality of the evidence for each outcome. The methods described by the

TABLE 1 Recommendations for exercise therapy and nonexercise therapeutic interventions

Clinical question 1

Is exercise therapy recommended for people with hip osteoarthritis (OA)?

Conclusions from the literature study

- Directly after the intervention, exercise therapy has a moderate effect on physical functioning in people with hip OA, compared with no exercise therapy (SMD, 0.32; 95% CI, 0.13–0.52). The quality of the evidence is moderate.
- Six months after the intervention, there is a small effect (SMD, 0.28; 95% CI, 0.10–0.45). The quality of the evidence is high.

Evidence-to-Decision

Based on the likelihood of the effects, the limited side effects, the demonstrated cost-effectiveness, and a high acceptability of exercise therapy, the guideline panel is of the opinion that the intervention can be strongly recommended.

Recommendation

Offer exercise therapy to all patients with hip OA in the conservative treatment phase, and make use of the frequency, intensity, time, and type (FITT) principles.

Clinical question 2

Is exercise therapy recommended for people with knee OA?

Conclusion from the literature study[a]

- Directly after the intervention, exercise therapy has a moderate effect on physical functioning in people with knee OA, compared with no exercise therapy (SMD, 0.54; 95% CI, 0.36–0.72). The quality of the evidence is moderate.
- Six months after the intervention, there is a moderate effect (SMD, 0.30; 95% CI, 0.13–0.47). The quality of the evidence is high.

Evidence-to-Decision

Based on the likelihood of the effects, the limited side effects, the demonstrated cost-effectiveness, and a high acceptability of exercise therapy, the guideline panel is of the opinion that the intervention can be strongly recommended.

Recommendation

Offer exercise therapy to all patients with OA of the knee in the conservative treatment phase, and make use of the FITT principles.

Clinical question 3

Is exercise therapy recommended prior to joint replacement surgery for hip OA?

Conclusion from the literature study

Preoperative exercise therapy has a moderate effect on physical functioning in people after a total hip replacement, compared with no preoperative exercise therapy (SMD, 0.32; 95% CI, 0.06–0.57). The quality of the evidence is moderate.

Evidence-to-Decision

Based on the reasonable likelihood of the effects, the limited side effects, and the likely acceptability of exercise therapy, the guideline panel is of the opinion that the intervention can be considered for specific patients.

Recommendation

- Consider offering exercise therapy in the preoperative phase if the patient has an increased risk of delayed recovery following OA-related hip joint replacement. Make use of the FITT principles.
- Consider limiting exercise therapy in the preoperative phase, teaching the patient exercises that he/she can independently perform, and monitoring how the exercises are performed if the risk of delayed postoperative recovery is not increased. Teach all patients to use a walking aid that will be needed in the postoperative phase.

Clinical question 4

Is exercise therapy recommended prior to joint replacement surgery for knee OA?

Conclusion from the literature study

Preoperative exercise therapy has a moderate effect on physical functioning in people after a total knee replacement, compared with no preoperative exercise therapy (SMD, 0.4; 95% CI, 0.09–0.62). The quality of the evidence is low.

Evidence-to-Decision

Based on the reasonable likelihood of the effects, the limited side effects, and the likely acceptability of exercise therapy, the guideline panel is of the opinion that the intervention can be considered for specific patients.

Recommendation

- Consider offering exercise therapy in the preoperative phase if the patient has an increased risk of delayed recovery following OA-related knee joint replacement. Make use of the FITT principles.
- Consider limiting exercise therapy in the preoperative phase to teaching the patient exercises that he/she can independently perform and monitor how the exercises are performed if the risk of delayed postoperative recovery is not increased. Teach all patients to use a walking aid that will be needed in the postoperative phase.

Clinical question 5

Is exercise therapy recommended after joint replacement surgery for hip OA?

Conclusion from the literature study

Postoperative exercise therapy has a moderate effect on physical functioning in people after a total hip replacement, compared with no preoperative exercise therapy (SMD, 0.37; 95% CI, 0.17–0.56). The quality of the evidence is high.

Evidence-to-Decision

Based on the high probability of the effects, the limited side-effects, and the likely acceptability of exercise therapy, the guideline panel is of the opinion that a weak recommendation can be given in favor of the intervention.

Recommendation

- Preferably offer exercise therapy in the postoperative phase following OA-related hip joint replacement if the patient has an increased risk of delayed recovery and/or if complications occur. Make use of the FITT principles.

(Continues)

TABLE 1 (Continued)

- Consider limiting exercise therapy in the postoperative phase to teaching the patient exercises that he/she can independently perform and monitor how the exercises are performed, if the risk of delayed postoperative recovery is not elevated and there are no postoperative complications.

Clinical question 6

Is exercise therapy recommended after joint replacement surgery for knee OA?

Conclusion from the literature study

Postoperative exercise therapy has a minor effect on physical functioning in people after a total knee replacement, compared with no preoperative exercise therapy (SMD, 0.18; 95% CI, 0.03–0.33). The quality of the evidence is high.

Evidence-to-Decision

Based on the high probability of the minor effects, the limited side effects, and the likely acceptability of exercise therapy, the guideline panel is of the opinion that the intervention can be considered for specific patients.

Recommendation

- Consider exercise therapy in the postoperative phase following OA-related knee joint replacement if the patient has an increased risk of delayed recovery and/or if complications occur. Make use of the FITT principles.
- Consider limiting exercise therapy in the postoperative phase to teaching (and monitoring the execution of) exercises that the patient can independently perform, if the risk of delayed postoperative recovery is not increased and there are no postoperative complications.

Clinical question 7

Are the following nonexercise therapeutic interventions recommended for people with hip or knee OA: continuous passive motion (CPM; after joint replacement surgery), pulsed electromagnetic field therapy, low-level laser therapy, massage, passive mobilizations, shock wave therapy, taping, TENS, thermotherapy, and ultrasound therapy?

Conclusion from the literature study

- Massage therapy has a small effect on the physical functioning of people with knee OA, compared with no massage therapy. The quality of the evidence is very low. Massage therapy also appears to have an effect on pain. The effect of massage therapy on people with hip OA is unknown.
- TENS treatment has no effect on the physical functioning of patients with knee OA compared with no treatment using TENS. The quality of the evidence is very low. However, TENS treatment does appear to have an effect on pain in patients with knee OA. The effect of TENS treatment for patients with hip OA is unknown.
- There are small effects, no effects, or unknown effects of CPM (after joint replacement surgery), pulsed electromagnetic field therapy, LLLT, passive mobilizations, shock wave, taping, thermotherapy, and ultrasound in patients with hip or knee OA, compared with no nonexercise therapeutic intervention. The quality of the evidence (where available) is low to very low.

Evidence-to-Decision

- Based on the large uncertainty concerning the effect, the duration of massage therapy that was examined (30–60 min) and the expected negligible added value of the intervention compared with standard care (i.e., exercise therapy and education/advice) and the value that some patients may attach to this intervention and the potential effect on pain (thereby possibly supporting the exercise therapy), the *guideline panel* is of the opinion that the intervention should be conditionally discouraged for patients with hip or knee OA.
- Based on the large uncertainty concerning the effect and the expected negligible added value of TENS therapy compared with standard care (i.e., exercise therapy and education/advice) and the potential effect on pain (thereby possibly supporting exercise therapy), the guideline panel is of the opinion that the intervention should be conditionally discouraged for patients with hip or knee OA. In addition, the *guideline panel* is of the opinion that TENS therapy should only be considered as a brief intervention to support exercise therapy, if exercise therapy is being hampered due to severe pain symptoms.
- Based on the large uncertainty concerning the effect and the expected negligible added value of CPM (after total joint replacement surgery), pulsed electromagnetic field therapy, LLLT, passive mobilizations, shock wave therapy, taping, thermotherapy, and ultrasound therapy compared with standard care (i.e., exercise therapy and education/advice), the guideline panel is of the opinion that these interventions should be strongly discouraged for patients with hip or knee OA.

Recommendation

- It is not recommended to offer massage therapy to patients with hip or knee OA.
- Preferably do not offer treatment with TENS therapy to patients with hip or knee OA. Consider the use of TENS only as a brief intervention for pain reduction to support exercise therapy if exercise therapy is being hampered due to severe pain symptoms.
- Do not offer CPM (after total joint replacement surgery), pulsed electromagnetic field therapy, LLLT, passive mobilizations, shock wave therapy, taping, thermotherapy, or ultrasound therapy to patients with hip or knee OA.

[a]Analysis was restricted to studies of sufficient size and good quality to prevent downgrading because of low quality studies.

Abbreviations: CI, confidence interval; CPM, continuous passive motion; FITT principles, frequency, intensity, type of exercises, and time duration; LLLT, low-level laser therapy; SMD, standard mean difference; TENS, transcutaneous electrical nerve stimulation.

GRADE group were used to assess the quality of the evidence (Guyatt et al., 2008). The quality of the evidence was classified as high, in the case of RCTs, and was downgraded to moderate, low, or very low, based on the risk of bias (assessed in accordance with the Cochrane risk of bias tool) (Higgins et al., 2011), inconsistency of results (studies showing clinical or statistical heterogeneity), indirectness of the evidence (the study population differed from the target population of our guideline), imprecision (a low number of studies or included patients, e.g., <300 patients or events), and publication bias.

When it was not possible to answer a clinical question using a systematic literature review (e.g., because of a lack of suitability for a systematic literature review or due to an absence of literature), the question was answered through a search of landmark papers,

textbooks, and existing sets of guidelines, recommendations, or clinical protocols, as suggested by the experts.

In four face-to-face meetings of the guideline panel and in one face-to-face and three digital meetings of the review group over an 18-month period, the results of the (systematic/narrative) literature reviews were presented. For therapeutic interventions, the recommendations were formulated based on the GRADE Evidence-to-Decision framework (Alonso-Coello et al., 2016), including a discussion on the balance between benefits and harms, the quality of the evidence, the values and preferences of patients and clinicians, and feasibility, equity, and acceptability of the recommendations. Discussions were structured using an Evidence-to-Decision form (Appendix D), leading to strong or conditional recommendations in favor of or against the intervention or to a neutral recommendation (Alonso-Coello et al., 2016).

2.3 | Phase 3: Review and authorization

The recommendations and underlying descriptions formed the basis of a draft guideline, which was externally reviewed by seven physical therapists and 14 stakeholder organizations participating in the guideline or review panels (Appendix A). Based on their comments, revisions were made to the draft guideline, which then resulted in the final document. All participating stakeholders were then requested to authorize this final version of the guideline (Royal Dutch Society for Physical Therapy, 2018a; Royal Dutch Society for Physical Therapy, 2018b).

3 | RESULTS

The main recommendations for assessment and treatment resulting from the guideline development process are summarized in Table 1. These recommendations and a summary of additional recommendations and underlying descriptions, as included in the guideline, are presented below.

3.1 | Assessment

A narrative literature search was conducted regarding the comprehensive assessment of patients with hip or knee OA. This assessment is performed using history taking including the identification of red and yellow flags, physical examination, and the application of measurement instruments and analysis. A treatment profile is then selected that best suits the patient's health status, needs, and preferences. The recommended content of the assessment was based on the International Classification of Functioning Disability and Health (ICF) core set for OA (Bossmann, Kirchberger, Glaessel, Stucki, & Cieza, 2011) and included aspects most relevant specifically for people with hip or knee OA, in the following areas: body structures and function, activities, participation, environmental factors, and personal factors.

3.1.1 | History taking

The guideline panel concluded that, aside from a comprehensive inventory of the patient's health status and the effects of the disease on a patient's life, based on the ICF core set for OA (Bossmann et al., 2011), it is important to determine the course of the condition, previous and current medical and nonmedical assessments, and/or treatment. History taking provides a physical therapist with a wider understanding of the presence of comorbidity and other factors influencing the course of disability in OA. Relevant history taking questions are presented in Table 2.

3.1.2 | Red flags

Aside from general red flags, a number of OA-specific clinical signs and symptoms can indicate severe pathology. Based on expert opinion, the guideline panel formulated a list of specific red flags for patients with OA or after total joint replacement because of OA (Table 3).

3.1.3 | Physical examination

The guideline panel concluded that, similar to history taking, physical examination should be based on the ICF core set for OA. Relevant points of attention during the physical examination are presented in Table 4. These include the use of clinical classification criteria for hip or knee OA to determine a clinical diagnosis of OA (Table 5) (Altman et al., 1991, 1986).

3.1.4 | Measurement instruments

Based on the ICF core set for OA, a limited number of corresponding measurement instruments for initial assessment and subsequent evaluation were selected, conditional on their reliability, validity, and feasibility. The recommended measurement instruments selected were a Numeric Rating Scale for pain (Salaffi, Stancati, Silvestri, Ciapetti, & Grassi, 2004), the Patient-Specific Complaints Instrument (Horn et al., 2012), the Hip Disability and Osteoarthritis Outcome Score activities of daily living (ADL) subscale (De Groot et al., 2007), the Knee Injury Osteoarthritis Outcome Score ADL subscale (De Groot, Favejee, Reijman, Verhaar, & Terwee, 2008), and/or the Six Minute Walk Test (Kennedy, Stratford, Wessel, Gollish, & Penney, 2005) (Figure 1). It is recommended that both a questionnaire and a performance test be used to evaluate physical functioning.

3.1.5 | Treatment profiles

A literature research was conducted regarding specific indications for PT in patients with hip or knee OA. In the absence of literature to

TABLE 2 Relevant questions for history taking

Central
• What is the patient's request for help? • What are the patient's expectations regarding therapy? • What are the patient's expectations concerning the course of the symptoms?
Functional and anatomical characteristics
• Does the patient complain of intermittent or constant pain, pain on exertion, or night and/or rest pain? • Where is the pain located, and how long has the patient experienced this pain? • Is the patient suffering from (severe) pain and swelling at rest? (potential red flag) • Was the pain onset sudden? (potential red flag for joint replacement surgery) • Does the patient feel pain in the calf when raising the foot? (potential red flag for patients who have recently had knee joint replacement surgery) • Does the patient experience morning stiffness in the affected joint and/or start-up joint stiffness? If so, for how long? • Are the movements of the hip and/or knee restricted, and if so, in which direction? • Does the patient have reduced muscle strength in the legs? If so, with which activities? (risk factor for occurrence and course) • Does the patient have a fever? (specific red flag for joint replacement surgery) • Is wound healing progressing favorably and without complications? (point of interest in the case of joint replacement surgery) • Was the onset of symptoms sudden or gradual? • Does the knee appear to be swollen? (local/diffuse; left/right comparison) (potential red flag, depending on severity and in combination with an increased skin temperature) • Is there an increased skin temperature? (potential red flag, depending on severity and combination with swelling) • In terms of hip joint problems, has the patient observed any groin swelling? (potential red flag) • Has the mobility of the joint changed?
Functional and anatomical characteristics
• Does the patient experience a sensation of “giving way” or instability? • Does the joint exhibit an abnormal position? (potential risk factor for occurrence) • Is there any history of surgery or trauma? (potential risk factor for occurrence) • Is the patient overweight/obese? (height/weight; a high BMI is a risk factor for occurrence and course) • Does the patient have any congenital abnormalities of the hip? (potential risk factor for occurrence) • Concerning the knee joint, does the patient experience locking symptoms? (potential red flag) • Are there any symptoms in other joints? (potential risk factor for occurrence and potential predictor of course) • Is the patient experiencing any sensory and/or motor loss of function? (potential nerve damage as a complication of joint replacement surgery)
Activities
• Does the patient experience limitations when performing the following activities: walking indoors and outdoors, walking up and down stairs, sitting down and getting up, bending, standing (for long periods), sitting (for long periods), getting (un)dressed, washing, lifting, using the toilet, or getting in and out of a car? (potential predictive factors for course) • Does the patient experience any restrictions when cycling, driving a car, or using public transport? • Are there any circumstances or activities that exacerbate or reduce the symptoms? • To what extent is the patient able to bear weight on the hip and/or knee during ADL? • Has the patient suffered any falls in the past year? If so, how often? • To what extent is the patient able to bear weight on the hip and/or knee during the day? (In the case of joint replacement surgery, the patient should be informed that a very active lifestyle could shorten the lifespan of the prosthesis)
Participation
• Does the patient experience challenges when engaging in work (paid or as a volunteer), sport, or other leisure activities? • Does the patient have a job or play a sport that places significant strain on the hip and/or knee? (including heavy lifting, crouching, and kneeling) • Has the patient performed heavy manual labor in the past? (potential risk factor for occurrence) • Does the patient experience problems with social contact due to hip or knee issues?
External factors
Is there a family history of OA? • How do the people surrounding the patient (partner, family, friends, and work colleagues) respond to the symptoms? • Does the patient use modifications, aids, or make provisions when undertaking ADL and household tasks, and during work, sport, or leisure activities? • What is the patient's living situation? Are there stairs at home, and is the patient able to walk up and down stairs? • Have (additional) medical diagnostic tests been conducted? (plain radiographs, blood tests, and collection of joint fluid). If yes, what were the results? • Has the patient undergone any previous therapeutic treatment? If yes, which treatment and what was the result? • Is a medical specialist or another healthcare provider involved? (related to hip and/or knee problems or comorbidities) • Does the patient use medication such as painkillers and/or anti-inflammatories, and what is the effect? • Does the patient use nutritional supplements? If so, what is the effect? • Does the patient use a walking aid (walking stick, Nordic walking sticks, a walker, and walking while holding their bicycle), electric bicycle, or cycle instead of walking? If so, what is the effect? • Does the patient use an aid to perform activities? (standing support, adapted chair, wheeled stool, and knee support) If so, what is the effect?

TABLE 2 (Continued)

- Has the patient suffered any traumatic injury in the past that has resulted in damage to the hip or knee joints? If so, how long did this take place and how did the recovery progress? (potential risk factor for occurrence)
- Has any relevant surgery been performed in the past (e.g., joint replacement surgery or meniscus surgery)? If so, how long did this take place and how did the recovery progress? (potential risk factor for occurrence)

- Personal factors

- Does the patient have any current comorbidity (such as diseases affecting the heart or lungs, diabetes mellitus, visual loss, hearing loss, lower back pain, and/or depression)? If so, have these comorbid conditions affected the patient's ability to function and to tolerate movement/exertion? (In terms of potential predictors for course/measurement, the use of the *Cumulative Illness Rating Scale* is optional to support an estimation of the effect of comorbidity on functioning.)
- Does the patient have a history of any nontraumatic hip or knee conditions (e.g., reactive, crystal, or septic arthritis), resulting in joint damage or faster progression? If so, how long ago did this take place and how did the recovery progress?
- To what extent does the patient rest when experiencing pain? Does the patient lead an active lifestyle?
- Are there any cognitive issues? (e.g., dementia)
- To what extent does the patient consider movement to be harmful?
- To what extent does the patient fear falling or moving?
- Is the patient motivated to start/continue moving?
- What measures has the patient undertaken to ameliorate his/her symptoms (e.g., rest/movement; use of medication, orthoses, and/or walking aids; discussing issues with their employer; and/or obtaining work-related assistance if there are any work-related challenges) and was this helpful?

Abbreviations: ADL, activities of daily living; BMI, body mass index; OA, osteoarthritis.

TABLE 3 Red flags for hip or knee osteoarthritis

- Warm and swollen (red) knee
- Inexplicable severe pain in the hip and/or knee
- Swelling in the groin
- Severe locking of the knee
- Pain (severe) at rest and swelling (with no history of trauma)

In the presence of one or more joint replacement prostheses (postoperative):

- Developing a fever of ≥38.5°C
- If the wound remains very swollen and red
- If the wound presents with excessive exudate or if the wound continues to exude fluid
- Sudden severe pain in the joint containing the prosthesis, with or without a preceding fall or other trauma
- Increased knee pain that has not responded to painkillers
- If the patient is no longer able to stand on the leg, whereas he/she had previously been able to do so
- Developing pain in the calf when dorsiflexing the toes
- Red discoloration and pain development in the lower leg

support this clinical question, the guideline panel first formulated criteria to decide if PT could be started. The guideline panel considered that PT treatment is indicated if a patient (i) has a need for support regarding his/her OA-related hip or knee condition due to limitations in daily activities and/or social participation and/or (ii) is unable to achieve or maintain an adequate level of independent physical functioning without the need for support (Health Council of the Netherlands, 2017; Rausch Osthoff et al., 2018).

The guideline panel concluded that, in specific situations, a physical therapist could consult a physician, for example, if he/she had identified reasons to suspect a diagnosis other than OA, when relevant information on the severity of the condition and/or comorbidity is lacking, when generic or specific red flags were identified, when absolute contraindications for exercise therapy are present, or when there is a justified expectation that PT could worsen the symptoms.

In terms of active PT delivery, four profiles were distinguished. These profiles provide direction in terms of the content and extent of the PT as provided by the physical therapist. No literature was found concerning treatment profiles; therefore, treatment profiles were based on expert opinion within the guideline and review panels. Based on an initial patient assessment, the following four treatment profiles can be considered:

1. A short period of education, advice, and exercise/movement instruction.
2. A short period of guidance and supervision where the patient's needs cannot be addressed through a short period of education, advice, and instruction only.
3. Longer term guidance and supervision, due to the presence of risk factors for delayed recovery (such as comorbidity or poor pain management) that could hinder exercise therapy.
4. Education, preoperative, and/or postoperative exercise therapy before or after OA-related hip or knee joint replacement surgery.

3.2 | Treatment

Clinical questions concerning patient education, exercise therapy, and nonexercise therapeutic interventions were formulated by the *guideline panel*, based on the barrier analysis during the preparation phase. Systematic literature reviews regarding exercise therapy and nonexercise therapeutic interventions were conducted to formulate the recommendations. Additional narrative reviews were conducted to describe the content of exercise therapy and patient education.

3.2.1 | Patient education

Patient education, tailored to individual patient needs, is an essential component of conservative treatment (Fernandes et al., 2013; French et al., 2015). Interpretation of the literature was hampered by the fact

TABLE 4 Relevant points of attention during the physical examination for patients with osteoarthritis of the hip and/or knee

Functional and anatomical characteristics
Inspection
• Where is the pain located? • Do you currently observe mild, moderate, or severe swelling? (knee) • If so, where is the swelling located? Is the swelling diffuse or localized? • Are there any changes in color? (knee) NB: A reddened lower leg observed following joint replacement surgery can be a red flag. • Are there any changes in position compared to the nonaffected side: - of the knee and/or hip joint? - of the pelvis or the spinal column? - of the lower leg compared with the upper leg (e.g., varus/valgus position) and/or the foot? - of the lower/upper leg? • Is there any difference in the circumference of the musculature compared with the other leg, in terms of calf, thigh, and/or buttock musculature? • How is wound healing progressing? (in the case of joint replacement surgery) NB: A wound that remains very swollen and reddened after joint replacement surgery could be a red flag.
Palpation
• Is there any swelling? (knee) • Is there any skin temperature increase at the joint? (knee) • Is there any synovial or osseous thickening (knee) around the joint space? Is palpation painful? (knee) • Is there any pain upon patellofemoral compression? (knee) • Is there any increase in muscle tone of the lumbar extensors, the hip adductors (for hip osteoarthritis), or in the tensor fasciae latae (for knee osteoarthritis)?
Functional examination
• Active range of motion tests, in which the following movements are evaluated: - Knee flexion/extension. - Hip flexion/extension, abduction/adduction, and external/internal rotation. - Ankle/foot dorsiflexion/plantarflexion and pronation/supination of the foot. • Passive examination of the knee and hip with evaluation of the total range of motion, including valgus/varus motion of the knee joint. NB: Caution is advised during passive examinations in the first 2 weeks following knee joint replacement surgery, because of the wound healing process. Following knee joint replacement surgery, if knee mobility and range of motion is <80°–90° during the recovery phase, contact should be made with the treating orthopedic surgeon following the patient consultation. No passive movement examinations should be performed following joint replacement surgery of the hip, due to the risk of dislocation in the first 6 weeks postoperatively. • Passive movement examination of the ankle/foot. • Evaluation of the end sensation and pain provocation of the hip/ankle/foot. • Evaluation of muscle strength/muscle stamina (including the quadriceps femoris and gluteal muscles), stability, muscle length of the affected and nonaffected leg, and proprioception. • Evaluation of balance (both static and dynamic). • Evaluation of aerobic capacity. • Evaluation of the mobility/load-bearing capability of the lumbar spine (mainly in patients with hip osteoarthritis). • Evaluation of joint function of the upper extremities and cervical spine (due to the potential use of walking aids). • The Six Minute Walking test is a supporting function test to estimate physical functioning and to use as a baseline measurement for treatment. • Optional measurement instruments can be used to support the movement examination.
Activities
Inspection
• Evaluation of standing, standing on one leg, walking (up/downstairs), standing up from a seated position/sitting down, and other ADL activities relevant to the patient. To what extent can the hip/knee be used? What is the patient's walking speed? NB: If the patient is in the rehabilitation phase after joint replacement surgery and is no longer able to stand on the leg, whereas he/she had been able to do so beforehand, then this could be a red flag. • Evaluation to determine whether certain movements are being avoided or compensated for with other movements. • Evaluation of balance reactions compared with those of the nonaffected side when standing and walking. • Evaluation of the quality of movement during functional activities, such as sitting down and getting up again, bending, transfers, getting (un)dressed, and walking up/downstairs. • Evaluation of specific activities that are restricted during work, sports, or other leisure activities. • Evaluation of the use of aids. • Evaluation of performing other specific activities where symptoms are reported.

Abbreviation: ADL, activities of daily living.

TABLE 5 The American College of Rheumatology clinical classification criteria for hip and knee osteoarthritis used to support a clinical diagnosis of hip or knee osteoarthritis

Hip	Knee
Hip pain in combination with: - Internal rotation ≤15° - Flexion ≤115° Or Pain in the hip in combination with: - Age > 50 years - ≤60 min of morning stiffness - Pain on internal rotation - Internal rotation ≥15°	Knee pain and at least three of the following: - Age >50 years - >30 min of morning stiffness - Crepitus - Bony tenderness - Bony enlargement - No palpable warmth

that the provision of education and exercise therapy is usually inseparable in practice. The face-to-face provision of education should in all cases be supplemented with written or online information in the form of leaflets, handbooks, websites, or videos of proven quality. Based on international guidelines, the following topics are recommended for discussion with a patient with hip or knee OA: (i) the condition and the possible consequences, (ii) the importance of exercise and a healthy lifestyle, and (iii) treatment options (Fernandes et al., 2013, French et al., 2015). With regard to total hip or knee arthroplasty, patient information and advice should be adapted to the situation of the individual patient but should minimally include the following topics: (i) the surgery, the subsequent rehabilitation period, and the possible use of assistive devices and/or help from others; (ii) the importance of (maintaining) sufficient muscle strength and overall fitness prior to surgery and other factors involved in postoperative recovery; and (iii) the lifestyle restrictions and precautions involved during the first postoperative phase, where indicated by the orthopedic surgeon.

3.2.2 | Exercise therapy

Clinical questions regarding exercise therapy for patients with hip or knee OA were addressed using evidence from high quality systematic reviews (Fransen et al., 2015, 2014). For hip OA, the recommendation was based on a systematic review including 15 RCTs. It was concluded that exercise therapy had a moderate effect on physical functioning (standardized mean difference [SMD], 0.32), with a moderate quality of evidence reported in relation to the immediate post-intervention period (Fransen et al., 2014). For knee OA, the recommendation was based on a systematic review including 52 RCTs. It was concluded that exercise therapy had a moderate effect on

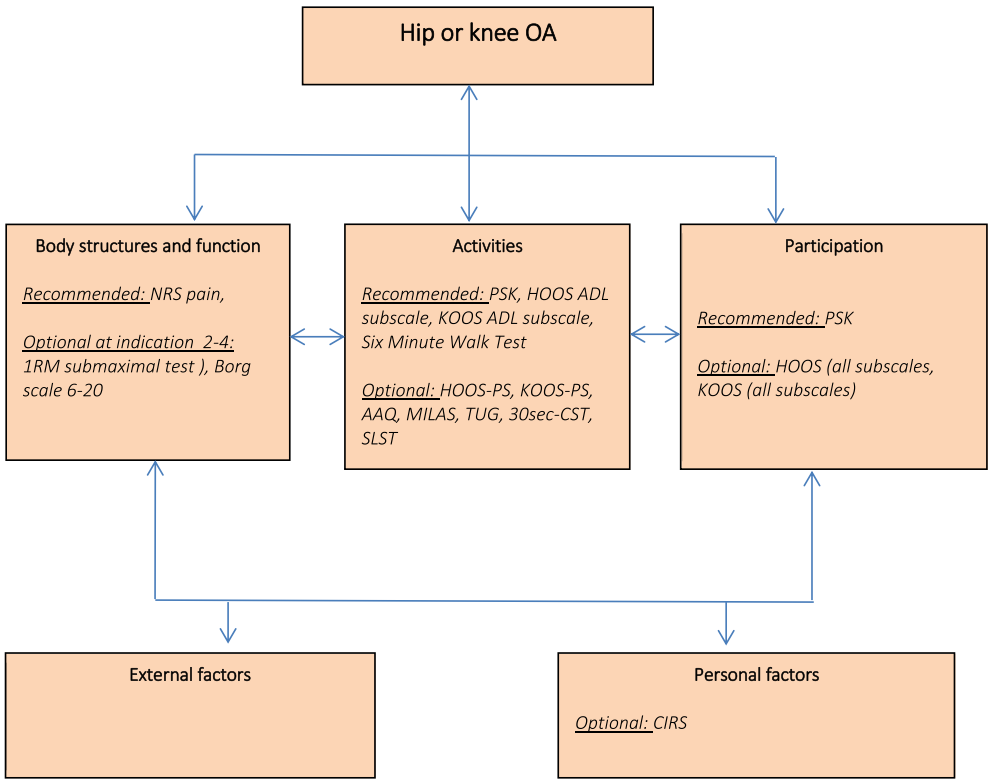

FIGURE 1 Recommended and optional measurement instruments for the treatment of patients with hip or knee osteoarthritis. 30-sec CST, 0-second Chair Stand Test; AAQ, Animated Activity Questionnaire; CIRS, Cumulative Illness Rating Scale; HOOS, Hip disability and Osteoarthritis Outcome Score; HOOS ADL subscale, HOOS subscale function, daily living; HOOS-PS, HOOS Physical function Short form; KOOS , Knee injury and Osteoarthritis Outcome Score; KOOS ADL subscale, KOOS subscale daily living; KOOS-PS, KOOS Physical function Short form; MILAS, Modified IOWA Level of Assistance Score; NRS, Numeric Rating Scale; PSK, Patient Specific Complaints instrument; SLST, Single Leg Stance Test; TUG, Timed Up and Go test

physical functioning (SMD, 0.54), with a moderate quality of evidence reported in relation to only high quality studies (Fransen et al., 2015). The positive effects of exercise therapy were consistent overall, but potentially undesirable effects, such as worsening of symptoms, were infrequently reported and appeared to be rare and not very severe. Therefore, the guideline panel was of the opinion that the positive effects outweighed the undesirable effects. Moreover, the guideline panel considered that most patients would be likely to have a positive attitude toward exercise therapy, given its beneficial effects on symptoms and daily functioning, and that it could be included in their daily routine. A cost-effectiveness analysis showed that exercise therapy performed in the conservative treatment phase resulted in a greater health gain per invested Euro than when exercise therapy was not offered (Cochrane, Davey, & Matthes Edwards, 2005; Hurley et al., 2007; Jessep, Walsh, Ratcliffe, & Hurley, 2009; Richardson et al., 2006; Sevick et al., 2000). For physical therapists, there are minimal costs associated with the provision of exercise therapy, assuming that the required practice area and exercise equipment are already present. Based on the evidence and mentioned considerations, the guideline panel formulated strong recommendations for exercise therapy in all patients with hip or knee OA.

Evidence concerning preoperative exercise therapy showed a moderate effect on physical functioning in patients after total hip replacement (SMD, 0.32) and total knee replacement (SMD, 0.40) (Beaupre, Lier, Davies, & Johnston, 2004; Bitterli, Sieben, Hartmann, & De Bruin, 2011; Calatayud et al., 2017; Ferrara et al., 2008; Lowe, Davies, Sackley, & Barker, 2015; Rooks et al., 2006; Silkman Baker & McKeon, 2012; Villadsen, Overgaard, Holsgaard-Larsen, Christensen, & Roos, 2014; Wallis & Taylor, 2011). For postoperative exercise therapy, evidence showed a moderate effect on physical functioning in patients after total hip replacement (SMD, 0.37) and a small effect after total knee replacement (SMD, 0.18) (Artz et al., 2017, 2015; Barker et al., 2013; Beaupre, Masson, Luckhurst, Arafah, & O'Connor, 2014; Bruun-Olsen, Heiberg, Wahl, & Mengshoel, 2013; French et al., 2015; Hepperger et al., 2017; Jakobsen, Kehlet, Husted, Petersen, & Bandholm, 2014; Liebs et al., 2010; Mitchell et al., 2005; Umpierres et al., 2014). Other considerations concerning exercise therapy in the preoperative and postoperative phase are similar to those of the conservative treatment phase. Based on the evidence and other considerations, the guideline panel formulated conditional recommendations for preoperative and postoperative exercise therapy in patients who undergo hip or knee replacement surgery for OA.

To formulate recommendations concerning the desired content of exercise therapy, exercise programs outlined in the RCTs and in the literature reviews were reviewed, as well as international guidelines and general studies on exercise therapy (American College of Sports Medicine, 2018; Foroughi, Smith, Lange, Singh, & Vanwanseele, 2011; Health Council of the Netherlands, 2017; Jan, Lin, Liau, Lin, & Lin, 2008; Juhl, Christensen, Roos, Zhang, & Lund, 2014; Regnaux et al., 2015; Westby, Marshall, & Jones, 2018), and recommendations using the FITT principles were then formulated (Table 6).

The guideline panel also concluded that joint-specific and general exercises should be combined in a personalized exercise and physical activity plan and be tailored to individual goals, needs, and preferences. The number and frequency of supervised and independently performed home exercises should be determined in consultation with the patient. Given the proven benefits of maintaining the positive effects of treatment, booster sessions planned after the initial treatment are recommended (Pisters et al., 2007).

Another clinical question addressed restrictions for exercise therapy for patients with hip or knee OA and the presence of comorbidity. A systematic review was conducted that aimed to determine the effect of exercise therapy in patients with hip or knee OA and comorbidity. Only one study included a protocol for patients with knee OA and different types of comorbidity (De Rooij et al., 2017). Therefore, for patients with comorbidity, no standardized treatment program is convenient, and exercise therapy should be adjusted accordingly.

The guideline panel addressed a clinical question concerning exercise therapy in patients with hip or knee OA in relation to poor pain management. A systematic review was conducted that aimed to establish the effects of exercise therapy in patients with hip or knee OA and who had poor pain management; however, no studies were identified. Two studies that were initially excluded because they did not specifically select patients with poor pain management did describe an intervention that included pain education and behavioral pain-coping skills (Hunt et al., 2013; Bennel et al., 2016). In these two studies, it was concluded that exercise therapy, according to a time-contingent approach (graded activity) combined with pain education and pain-coping skills training, could be effective. Therefore, the guideline panel recommended exercise therapy for patients with poor pain management.

Additionally, the guideline panel formulated a point of attention regarding the treatment of patients with OA and severe comorbidity or poor pain management, as follows. If a physical therapist's knowledge and skills regarding the management of patients with comorbidity or poor pain management is insufficient, the principle “those incompetent are unauthorized to act” applies, and referral to a competent colleague is required, or the physical therapist should cooperate with that competent colleague.

3.2.3 | Nonexercise therapeutic interventions

Systematic reviews were conducted to address clinical questions regarding the following nonexercise therapeutic interventions: massage therapy, transcutaneous electrical nerve stimulation (TENS) therapy, continuous passive motion (CPM), pulsed electromagnetic field therapy, low-level laser therapy (LLLT), passive mobilization, shockwave therapy, taping, ultrasound, and thermotherapy.

For all of these interventions, the quality of studies and level of evidence was low, with the effects on physical functioning in patients with hip or knee OA seldom reported. Massage therapy (Bervoets, Luijsterburg, Alessie, Buijs, & Verhagen, 2015; Perlman et al., 2012; Perlman, Sabina, Williams, Njike, & Katz, 2006) and TENS therapy (Law, Cheing, & Tsui, 2004; Palmer et al., 2014) should preferably not be offered to patients with hip and knee OA. However, the use of

TABLE 6 FITT factors for exercise therapy in people with hip and/or knee osteoarthritis (summarized)

Frequency
• Aim for the patient to preferably perform exercise therapy daily or at least 2 days a week (for muscle strengthening/functional exercises) or at least 5 days a week for 30 min at a time (for aerobic exercises) (which also complies with the new Movement Guidelines of the Health Council). • Start with one to two times weekly guided exercise therapy, supplemented with independently performed exercises and gradually reduce guidance during the treatment period.
Intensity
• Aim for the following minimum intensity for muscle strength and aerobic training: ◦ Muscle strength training: 60%–80% of 1 repetition maximum (1RM) (Borg score, 14–17) or 50%–60% of 1RM (Borg score, 12–13) for people not accustomed to strength training, with two to four sets of 8–15 repetitions with 30- to 60-s break between sets. ◦ Aerobic training: >60% of maximum heart rate (Borg score, 14–17) or 40%–60% of maximum heart rate (Borg score, 12–13) for people not used to aerobic training. • Ensure a gradual buildup in intensity during the program and follow the training principles.
Type
Offer a combination of: • Muscle strength training: ◦ Select exercises primarily aimed at the large muscle groups around the knee and the hip joints (especially knee extensors, hip abductors, and knee flexors). ◦ Perform these exercises in both legs (for hip or knee osteoarthritis, both for unilateral and bilateral osteoarthritis). ◦ Select functional exercises using the patient's own body weight and exercises using devices. Exercises with a high mechanical knee load (e.g., using a "leg extension device") should preferably be avoided in patients with knee osteoarthritis and after knee joint replacement surgery. • Aerobic training: ◦ Select activities with a relatively low joint load, such as walking, cycling, swimming, rowing, or using a cross-trainer. • Functional training: ◦ Select (parts of) activities that are hindered in the patient's daily life (e.g., walking, climbing stairs, sitting down, and rising from a chair). • Within one treatment session, focus primarily (at least 75% of the treatment time) on one type of training: muscle strength or aerobic training for optimal treatment results. Instruct the patient to independently perform a type of training that is not primarily targeted during the treatment session. • Consider offering specific balance and/or coordination/neuromuscular training in addition to exercise therapy if there are disturbances in balance and/or coordination/neuromuscular control that impede the patient's functioning. • Consider including (active) range of motion or muscle stretching exercises as a supplement to exercise therapy if there are muscle shortening and/or reversible joint mobility limitations that impede the patient's functioning.
Time
• Aim for a treatment period between 8 and 12 weeks, supplemented with one or more follow-up sessions after completion of this treatment period (e.g., 3 and 6 months after the end of the treatment period), to encourage adherence to therapy. • Encourage the patient to continue performing their exercises independently after the treatment period.
General points of attention
• Always offer exercise therapy regardless of patient characteristics such as age, symptom severity, and severity of joint damage. • Always offer exercise therapy in combination with information/advice and a movement plan (including short- and long-term goals for the [continued] execution of movement activities) that has been devised in consultation with the patient. • Always offer exercise therapy in the form of a combination of supervised exercise therapy and independently performed exercises. Determine together with the patient, partly based on the degree of independence/motivation, personal preferences, and practical considerations, the ratio of supervised and independently performed exercise therapy to be undertaken. • Consider using eHealth applications to support the patient in performing (continuing to perform) exercises independently and/or to reduce the level of supervision. • Consider offering group exercise therapy if little individual guidance is required. • Consider offering exercise hydrotherapy in the initial phase of treatment if there are serious pain symptoms during exercise that cannot be resolved in any other way.
Training principles for patients with hip and/or knee osteoarthritis
• Precede any workout with a warm-up session and finish with a cooling-down session. • Determine the starting intensity of strength training and monitor the intensity during treatment using the 1RM submaximal test. • Determine the starting intensity of aerobic training and monitor the intensity during treatment using heart rate and/or the Borg score. • Gradually increase the intensity of training (once a week) to the maximum level possible for the patient. • Reduce the intensity of the next workout if joint pain increases after a workout and persists for >2 h thereafter. • Start with a short period of 10 min (or less if necessary) of aerobic exercise, in patients who are untrained and/or limited due to joint pain and mobility. • Offer alternative exercises using the same muscle groups and energy systems if the exercise leads to an increase in joint pain. • When adjusting training intensity, use variation in sets and repetitions (in strength), intensity, duration of session or exercise, type of exercise, and rest breaks, and determine the adjustment in consultation with the patient.

Abbreviation: 1RM, 1 repetition maximum.

TENS therapy for patients with knee OA can be considered as a short-term intervention to support active exercise therapy if exercise therapy is impeded due to severe pain. CPM (Harvey, Brosseau, & Herbert, 2014; Lenssen et al., 2008; Maniar, Baviskar, Singhi, & Rathi, 2012), pulsed electromagnetic field therapy (Pipitone & Scott, 2001; Thamsborg et al., 2005; Li et al., 2013), LLLT (Alfredo et al., 2012; Huang et al., 2015; Kheshie, Alayat, & Ali, 2014; Tascioglu, Armagan, Tabak, Corapci, & Oner, 2004), passive mobilization (French et al., 2013; Wang et al., 2015), shockwave therapy (Cho, Yang, Yang, & Yang, 2016; Imamura et al., 2017; Zhao et al., 2013), taping (Hinman, Bennell, Crossley, & McConnell, 2003; Kocyiget et al., 2015; Wageck, Nunes, Bohlen, Santos, & De Noronha, 2016), ultrasound (Tascioglu, Kuzgun, Armagan, & Ogutler, 2010; Loyola-Sanchez et al., 2012; Ulus et al., 2012; Zhang et al., 2016), and thermotherapy (evidence absent) should not be offered.

4 | DISCUSSION

An evidence-based practice PT guideline for hip or knee OA was developed according to the AGREE II standard (Brouwers et al., 2010), the G-I-N standards (Qaseem et al., 2012), and the GRADE methodology (Guyatt et al., 2008). This guideline provides the physical therapist with practical information and tools for use in daily clinical practice. The physical therapist is guided through a process of clinical reasoning during the initial assessment, treatment, and evaluation stages, to provide the patient with the most optimal, evidence-based PT treatment available.

To our knowledge, recommendations for physical therapists with regard to initial assessment, treatment, and evaluation have not previously been described in a discipline-specific guideline other than the KNGF guideline (Peter et al., 2011). Recommendations for the general management of hip or knee OA have been made in current international guidelines; however, these recommendations do not comprise specific and concrete information for physical therapists (Hochberg et al., 2012; McAlindon et al., 2012; Fernandes et al., 2013). In view of continuous developments in the field of research and treatment for patients with hip or knee OA, regular updates to evidence-based guidelines are useful to continuously support daily practice in the application of evidence-based treatment.

Strengths related to the methodology of developing this guideline include the involvement of many stakeholders and the formulation of clinical questions derived from focus groups involving physical therapists and patients. Their questions are addressed in the guideline, which will likely facilitate implementation in PT practice. Moreover, along with evidence from the literature, important considerations from clinical practice and the opinions of experts and patients were taken into account when formulating the recommendations using Evidence-to-Decision forms (Bijlsma, Berenbaum, & Lafeber, 2011; Doherty, Hunter, Bijlsma, Arden, & Dalbeth, 2016). Finally, a field test was conducted among physical therapists from November 2017 to December 2017 to evaluate the applicability of the guideline, which contributes to guideline uptake in daily clinical practice.

One limitation regarding the methodology used in developing this guideline was that, concerning PT interventions, the literature search was limited to systematic reviews and RCTs. When these were unavailable, we undertook a narrative review involving textbooks, key articles, and current guidelines, as suggested by the panel experts. A more extensive literature search might have provided more information and evidence concerning initial assessment and evaluation of treatment. Another limitation was that we chose physical functioning, pain, and quality of life as the main outcome measures for the systematic literature reviews. However, in line with the ICF additional outcome measures covering other domains, such as participation in work or sports, these could also have been evaluated and considered.

In this CPG, recommendations on preoperative and postoperative PT have been added, which is a change from the 2010 CPG. This addition is relevant, given the increasing number of joint replacement surgeries and early discharge from hospital using fast track strategies. The recommended preoperative and postoperative interventions are in general similar to those described by Westby, Brittain, and Backman (2014), although they are described in less detail in the current guideline. Although the current guideline's focus is broader than preoperative and postoperative PT alone as described in the Canadian guideline, the difference between the guidelines can be explained through variations in the method of guideline development, with expert opinion playing a larger role in the Canadian guideline than in the present guideline.

A number of knowledge gaps remain concerning physical therapeutic treatment for hip or knee OA. Although the required frequency, intensity, type, and duration of exercises have been more clearly defined than in previous versions of the guideline, questions remain concerning the optimal composition, dosage, and mode of delivery. Literature concerning the mode of delivery, on which our recommendations were based, was relatively dated, with few studies using alternatives to face-to-face contact such as telephone guidance or eHealth. Another question remains as to how treatment should best be tailored to an individual patient. Moreover, there is considerably less evidence concerning exercise therapy with regard to hip OA compared with knee OA. Therefore, further studies are necessary concerning exercise therapy for hip OA and to determine whether the treatment of hip and knee OA requires different approaches.

Given scientific developments, maintaining an up-to-date guideline is important. Therefore, the author group will evaluate all recommendations annually and consider revisions, as required. The CPG was developed in a modular manner; therefore, revisions can be conducted efficiently in the future through updating a single clinical question.

Finally, implementation of the guideline in daily practice is important, and presentations and an E-learning module have been developed for this purpose. Information with regard to the guideline has been published on the KNGF website and in journals for professionals and patients.

Based on the guideline recommendations, quality indicators are currently being developed that can be used as a tool to evaluate and improve the quality of physical therapeutic care for patients with hip or knee OA.

In conclusion, an up-to-date evidence-based PT guideline for the management of patients with hip or knee OA has been developed. To improve the quality of care for these patients, adequate dissemination, implementation, and timely updates are needed.

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CONFLICT OF INTEREST

The authors declare that there is no conflict of interest regarding the publication of this article or the development of the CPG.

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APPENDIX A

TABLE A1 Stakeholders and their representing organizations

Stakeholders	Representing organization
Physical therapists	Royal Dutch Society for Physical Therapy (KNGF)
Exercise therapists	Association of Exercise Therapists Cesar and Mensendieck (VvOCM)
Patients	Dutch Arthritis Society (ReumaNederland), Arthritis Care Netherlands (RZN), Polyarthritis Companions (P-AL)
General practitioners	Dutch College of General Practitioners (NHG)
Orthopedic surgeons	Dutch Orthopaedic Association (NOV)
Rheumatologists	Dutch Society for Rheumatology (NVR)
Elderly care physicians and social geriatricians	Dutch Association of Elderly Care Physicians and Social Geriatricians (Verenso)
Clinical geriatricians	Dutch Society for Clinical Geriatric Medicine (NVKG)
Rehabilitation physicians	Dutch Society of Rehabilitation Physicians (VRA)
Nurses	Dutch Nurses' Association (V&VN)
Dieticians	Dutch Society of Dieticians
Podiatrists	Dutch Society of Podiatrists
Health insurers	Health Insurers Netherlands (ZN)
Government	National Healthcare Institute

APPENDIX B

TABLE B1 Clinical questions constituting the basis for a physical therapy guideline for patients with hip or knee osteoarthritis

Assessment
How is hip and knee osteoarthritis diagnosed by a physical therapist?
Which domains of the International Classification of Functioning Disability and Health (ICF) should be assessed during the diagnostic process?
Which measurement instruments are recommended during the diagnostic phase and for the evaluation of patients with osteoarthritis of the hip or knee?
What are the indications for physical therapy/exercise therapy in people with osteoarthritis of the hip and/or knee?
Treatment
What type of education and advice is recommended for patients with osteoarthritis of the hip or knee?
What type of education and advice is recommended at the time of total hip or knee arthroplasty?
Is exercise therapy recommended for people with hip or knee osteoarthritis?
Is exercise therapy recommended prior to total hip or knee arthroplasty?
Is exercise therapy recommended after total hip or knee arthroplasty?
Which exercise therapy is recommended in terms of frequency, intensity, type, and time duration for the treatment of patients with osteoarthritis of the hip or knee?
What modifications to exercise therapy are recommended for patients with hip or knee osteoarthritis if they also have one or more comorbidities affecting their physical functioning?
What modifications to exercise therapy are recommended for patients with hip or knee osteoarthritis if a patient is unable to cope with osteoarthritis-related pain?
Are nonexercise therapeutic interventions recommended for patients with osteoarthritis of the hip or knee?

APPENDIX C

TABLE C1 Search string exercise therapy

Search date	December 19, 2016
Consulted databases	PubMed, EMBASE, Web of Science, Cochrane Library, CENTRAL, EmCare, CINAHL.
General search terms[a]	(("hip osteoarthritis"[tw] OR "knee osteoarthritis"[tw] OR "Osteoarthritis, Knee" [MeSH] OR "Osteoarthritis, Hip"[mesh] OR (("Osteoarthritis"[Mesh] OR "osteoarthritis"[tw] OR osteoarthrit*[tw] OR "osteoarthrosis"[tw] OR osteoarthro* [tw] OR "degenerative arthritis"[tw] OR degenerative arthriti*[tw] OR "osteoarthrosis deformans"[tw]) AND ("Knee"[Mesh] OR "knee"[tw] OR "knees"[tw] OR "Knee Joint"[Mesh] OR "Hip"[Mesh] OR "hip"[tw] OR "hips"[tw] OR "Hip Joint"[Mesh] OR "menisci"[tw] OR "meniscus"[tw] OR menisc*[tw] OR "coxa"[tw] OR "coxas"[tw] OR "patellofemoral"[tw] OR "Patella"[Mesh] OR patella*[tw])) OR coxarthro*[tw] OR gonarthro*[tw]) AND (exercis*[tw] OR "stretching"[tw] OR "Exercise Therapy"[Mesh] OR "exercise therapy"[tw] OR exercise therap*[tw] OR "Continuous Passive Motion Therapy"[tw] OR "Continuous Passive Movement"[tw] OR "CPM Therapy"[tw] OR "Muscle Stretching Exercises"[tw] OR "Muscle Stretching Exercise"[tw] OR "Static Stretching"[tw] OR "Passive Stretching"[tw] OR "Static-Passive Stretching"[tw] OR "Static Passive Stretching"[tw] OR "Isometric Stretching"[tw] OR "Active Stretching" [tw] OR "Static-Active Stretching"[tw] OR "Static Active Stretching"[tw] OR "Ballistic Stretching"[tw] OR "Dynamic Stretching"[tw] OR "PNF Stretching"[tw] OR "Plyometric Exercise"[tw] OR "Plyometric Exercises"[tw] OR Plyometric Drill*[tw] OR "Plyometric Drills"[tw] OR "Plyometric Training"[tw] OR "Plyometric Trainings"[tw] OR "Stretch- Shortening Exercise"[tw] OR "Stretch Shortening Exercise"[tw] OR "Stretch- Shortening Exercises"[tw] OR "Stretch-Shortening"[tw] OR "Stretch Shortening"[tw] OR "Stretch-Shortening Drills"[tw] OR "Stretch-Shortening Cycle Exercise"[tw] OR "Stretch Shortening Cycle Exercise"[tw] OR "Stretch-Shortening Cycle Exercises"[tw] OR "Resistance Training"[tw] OR "Strength Training"[tw] OR "Weight-Lifting"[tw] OR "Weight Lifting"[tw] OR "Weight-Bearing"[tw] OR "Weight Bearing"[tw] OR "Exercise"[Mesh] OR "Exercise"[tw] OR "Exercises"[tw] OR "Physical Exercise"[tw] OR "Physical Exercises"[tw] OR "Isometric Exercises"[tw] OR "Isometric Exercise"[tw] OR "Aerobic Exercises"[tw] OR "Aerobic Exercise"[tw] OR "Circuit-Based Exercise"[tw] OR "Cool-Down Exercise"[tw] OR "Cool-Down Exercises"[tw] OR "Physical Conditioning" [tw] OR "Running"[tw] OR "Jogging"[tw] OR "Swimming"[tw] OR "Walking"[tw] OR "Warm-Up Exercise"[tw] OR "Warm-Up Exercises"[tw] OR "Physical Exertion"[Mesh] OR "Physical Exertion"[tw] OR "Physical Effort"[tw] OR "Physical Efforts"[tw] OR "Physical Fitness"[Mesh] OR "Physical Fitness"[tw] OR "Physical Endurance"[mesh] OR "Physical Endurance"[tw] OR "Anaerobic Threshold"[tw] OR "Exercise Tolerance" [tw] OR "Exercise Movement Techniques"[Mesh] OR "Exercise Movement"[tw] OR "Bicycling"[tw] OR "Walking"[tw] OR "Motor Activity"[Mesh] OR "Physical Activity" [tw] OR exertion*[tw] OR run*[tw] OR jog*[tw] OR treadmill*[tw] OR swim*[tw] OR bicycl*[tw] OR cycle*[tw] OR cycling[tw] OR walk*[tw] OR row[tw] OR rows[tw] OR rowing[tw] OR muscle strength*[tw]) NOT ("Animals"[mesh] NOT "Humans"[mesh]))

[a]For reasons of efficiency, the searches for hip and knee were conducted simultaneously and then completed separately.

TABLE C2 Selection criteria of systematic review to exercise therapy in conservative phase

Type of study	RCT's
Type of patient	Adults with a clinical diagnosis of hip or knee osteoarthritis[a]
Type of intervention	Any form of exercise therapy (irrespective of frequency, intensity, type, duration, and form)
Types of comparisons	No exercise therapy
Types of outcomes	Pain, physical functioning and quality of life (patient-reported outcomes).

[a]For reasons of efficiency, the searches for hip and knee were launched simultaneously and completed separately.
Abbreviation: RCT, randomized controlled trial.

TABLE C3 Selection criteria of systematic review to exercise therapy in preoperative phase

Type of study	RCT's
Type of patient	Adults with a clinical diagnosis of osteoarthritis who are eligible for joint replacement surgery of the hip or knee[a]
Type of intervention	Any form of preoperative exercise therapy (irrespective of frequency, intensity, type, duration, and form)
Types of comparisons	No exercise therapy
Types of outcomes	Physical functioning (patient-reported outcomes)

[a]For reasons of efficiency, the searches for hip and knee were launched simultaneously and completed separately.
Abbreviation: RCT, randomized controlled trial.

TABLE C4 Selection criteria of systematic review to exercise therapy in postoperative phase

Type of study	RCT's
Type of patient	Adults with a clinical diagnosis of osteoarthritis who are undergoing joint replacement surgery for hip or knee osteoarthritis[a]
Type of intervention	Any form of postoperative exercise therapy (irrespective of frequency, intensity, type, duration, and form)
Types of comparisons	No exercise therapy
Types of outcomes	Physical functioning (patient-reported outcomes)

[a]For reasons of efficiency, the searches for hip and knee were launched simultaneously and completed separately.
Abbreviation: RCT, randomized controlled trial.

TABLE C5 Selection criteria of systematic review to exercise therapy in patients with comorbidity

Type of study	SR and RCT
Type of patient	Adults with a clinical diagnosis of osteoarthritis of the hip or knee and comorbidity[a]
Type of intervention	Any form of exercise therapy (irrespective of frequency, intensity, type, duration, and form)
Types of comparisons	No exercise therapy
Types of outcomes	Physical functioning (patient-reported outcomes)

[a]For reasons of efficiency, the searches for hip and knee were launched simultaneously and completed separately.
Abbreviations: RCT, randomized controlled trial; SR, systematic review.

TABLE C6 Selection criteria of systematic review to exercise therapy in patients with inadequate pain coping

Type of study	SR and RCT
Type of patient	Adults with a clinical diagnosis of osteoarthritis of the hip or knee and inadequate pain coping[a]
Type of intervention	Any form of exercise therapy (irrespective of frequency, intensity, type, duration, and form) that specifically takes inadequate pain coping into consideration
Types of comparisons	No exercise therapy
Types of outcomes	Physical functioning (patient-reported outcomes)

[a]For reasons of efficiency, the searches for hip and knee were launched simultaneously and completed separately.
Abbreviations: RCT, randomized controlled trial; SR, systematic review.

TABLE C7 Search string nonexercise therapy

Search date	August 14, 2017
Consulted databases	PubMed, EMBASE, Web of Science, Cochrane Library, CENTRAL, EmCare, CINAHL.
General search terms[a]	((“hip osteoarthritis”[tw] OR “knee osteoarthritis”[tw] OR “Osteoarthritis, Knee”[MeSH] OR “Osteoarthritis, Hip”[mesh] OR (“Osteoarthritis”[Mesh] OR “osteoarthritis”[tw] OR osteoarthrit*[tw] OR “osteoarthrosis”[tw] OR osteoarthro*[tw] OR “degenerative arthritis”[tw] OR degenerative arthriti*[tw] OR “osteoarthrosis deformans”[tw]) AND (“Knee”[Mesh] OR “knee”[tw] OR “knees”[tw] OR “Knee Joint”[Mesh] OR “Hip”[Mesh] OR “hip”[tw] OR “hips”[tw] OR “Hip Joint”[Mesh] OR “menisci”[tw] OR “meniscus”[tw] OR menisc*[tw] OR “coxa”[tw] OR “coxas”[tw] OR “patellofemoral”[tw] OR “Patella”[Mesh] OR patella*[tw])) OR coxarthro*[tw] OR gonarthro*[tw]) AND (“Motion Therapy, Continuous Passive”[Mesh] OR “Continuous Passive Motion Therapy”[tw] OR “Continuous Passive Movement”[tw] OR “CPM Therapy”[tw] OR “Passive Stretching”[tw] OR “PNF Stretching”[tw] OR “musculoskeletal manipulations”[Mesh] OR “musculoskeletal manipulations”[tw] OR “Applied Kinesiology”[tw] OR “Chiropractic Manipulation”[tw] OR “Osteopathic Manipulation”[tw] OR “Soft Tissue Therapy”[tw] OR “Acupressure”[tw] OR “Massage” [Mesh] OR “massage”[tw] OR massag*[tw] OR “Zone Therapy”[tw] OR “Reflexology” [tw] OR “Rolfing”[tw] OR “Bodywork”[tw] OR Bodywork*[tw] OR “Electric stimulation therapy”[Mesh:NoExp] OR “electric stimulation therapy”[tw] OR “electrical stimulation therapy”[tw] OR “therapeutic electric stimulation”[tw] OR “therapeutic electrical stimulation”[tw] OR “electrotherapy”[tw] OR electrotherap*[tw] OR “interferential current electrotherapy”[tw] OR “electrical stimulation”[tw] OR “electrical nerve stimulation”[tw] OR “transcutaneous electric nerve stimulation” [Mesh:NoExp] OR “TENS”[tw] OR “transcutaneous electric nerve stimulation”[tw] OR “Ultrasonic Therapy”[Mesh] OR “therapeutic ultrasound”[tw] OR ultrasound therap*[tw] OR “ultrasonic therapy”[tw] OR “electromagnetic therapy”[tw] OR “Electromagnetic Radiation/therapeutic use”[Mesh] OR “Electromagnetic Phenomena/therapeutic use”[Mesh] OR “thermotherapy”[tw] OR “hot pack”[tw] OR “hot packs”[tw] OR hot pack*[tw] OR

(Continues)

TABLE C7 (Continued)

Search date	August 14, 2017
	hotpack*[tw] OR "cold pack"[tw] OR "cold packs"[tw] OR cold pack*[tw] OR coldpack*[tw] OR "cold treatment"[tw] OR "heat treatment"[tw] OR "Hyperthermia, Induced"[Mesh] OR fever therap*[tw] OR heat therap*[tw] OR "Induced Hyperthermia"[tw] OR Thermotherap*[tw] OR "Therapeutic Hyperthermia"[tw] OR "Local Hyperthermia"[tw] OR "Hot Temperature"[mesh] OR "Cold Temperature"[mesh] OR "Cryotherapy"[mesh] OR "Hypothermia, induced" [mesh] OR cold temperature*[tw] OR Cryotherap*[tw] OR "Induced Hypothermia"[tw] OR therapeutic hypotherm*[tw] OR "low level laser therapy"[tw] OR "low level laser treatment"[tw] OR "low intensity laser"[tw] OR "soft-laser therapy"[tw] OR "low energy laser therapy"[tw] OR "low-power laser therapy"[tw] OR "low level laser"[tw] OR "low level lasers"[tw] OR "low intensity lasers"[tw] OR "low energy laser"[tw] OR "low energy lasers"[tw] OR "low-power laser"[tw] OR "low- power lasers"[tw] OR "lllt"[tw] OR "Low-Level Light Therapy"[Mesh] OR "medical taping"[tw] OR "taping"[tw] OR "tape"[tw] OR "tapes"[tw] OR "taped"[tw] OR "kinesiotaping"[tw] OR "kinesio taping"[tw] OR kinesiotap*[tw] OR kinesio tap* [tw] OR "Bandages"[mesh] OR "Athletic Tape"[mesh] OR "Bandages"[tw] OR "Bandage"[tw] OR "Athletic Tape"[tw] OR "Athletic Tapes"[tw] OR "Hydrocolloid Bandages"[tw] OR "Biological Dressings"[tw] OR "Compression Bandages"[tw] OR "Compression Stockings"[tw] OR "Occlusive Dressings"[tw] OR "Hydrocolloid Bandage"[tw] OR "Biological Dressing"[tw] OR "Compression Bandage"[tw] OR "Compression Stocking"[tw] OR "Occlusive Dressing"[tw] OR "Dry needling"[tw] OR dry needl*[tw] OR "Acupuncture Therapy"[mesh] OR Acupunctur*[tw] OR Electroacupunctur*[tw] OR "Meridians"[tw] OR "Moxibustion"[tw] OR "Trigger Points"[tw] OR "Trigger Point"[tw] OR "Shockwave therapy"[tw] OR "Shock wave therapy"[tw] OR shockwav*[tw] OR shock wav*[tw] OR "High-Energy Shock Waves"[mesh] OR "HESW"[tw] OR "High Energy Shock Waves"[tw] OR "High-Energy Shock Wave"[tw] OR "Ultrasonic Shock Wave"[tw] OR "Ultrasonic Shock Waves"[tw] OR "Ultrasonic Shockwave"[tw] OR "Ultrasonic Shockwaves"[tw] OR "Ultrasonic Waves"[mesh] OR "Lithotripsy"[mesh] OR "Lithotripsy"[tw])) NOT ("Animals"[mesh] NOT "Humans"[mesh]))

[a]For reasons of efficiency, the searches for hip and knee were launched simultaneously and then completed separately.

TABLE C8 Selection criteria of systematic review to electromagnetic field, low level laser therapy, massage, passive mobilization, shockwave, taping, TENS, thermotherapy, and ultrasound

Type of study	SR and RCT
Type of patient	Adults with a clinical diagnosis of osteoarthritis of the hip or knee[a]
Type of intervention	Any form of treatment with an electromagnetic field
	Any form of treatment with low level laser therapy
	Any form of massage therapy
	Any form of treatment with passive mobilizations
	Any form of treatment with shockwave
	Any form of treatment with taping
	Any form of treatment with TENS
	Any form of thermotherapy
	Any form of treatment with ultrasound
Types of comparisons	No nonexercise therapeutic intervention
Types of outcomes	Physical functioning (patient-reported outcomes)

[a]For reasons of efficiency, the searches for hip and knee were launched simultaneously and completed separately.
Abbreviations: RCT, randomized controlled trial; SR, systematic review; TENS. transcutaneous electrical nerve stimulation.

TABLE C9 Selection criteria of systematic review to continuous passive motion therapy

Type of study	SR and RCT
Type of patient	Adults after or with an indication for a joint replacing prosthesis for osteoarthritis of the hip or knee[a]
Type of intervention	Any form of continuous passive motion therapy
Types of comparisons	No continuous passive motion therapy
Types of outcomes	Physical functioning (patient-reported outcomes)

[a]For reasons of efficiency, the searches for hip and knee were launched simultaneously and completed separately.
Abbreviations: RCT, randomized controlled trial; SR, systematic review.

APPENDIX D

TABLE D1 Evidence-to-Decision form

	Therapeutic intervention							
Desired effects	Very small	Small	Moderate	Large		Varies	No idea	Not measured
Undesirable effects	Large	Moderate	Small	Very small		Varies	No idea	Not measured
Quality of desired effects	Very low	Low	Reasonable	High		Varies	No idea	Not measured
Balance between desired and undesirable effects	The unfavorable effects definitely outweigh the favorable effects	The unfavorable effects probably outweigh the favorable effects	The favorable and unfavorable effects are equal	The favorable effects probably outweigh the unfavorable effects	The favorable effects definitely outweigh the unfavorable effects	Varies	No idea	No undesirable effects measured
Value of desired effects	Very low	Low	Reasonable	Large		No idea		
Variation in value of desired effects	Large variation	Moderate variation	Low variation	No variation		No idea		
Required resources (costs)	High costs	Moderate costs	Virtually no costs or savings	Moderate savings	High savings	Varies	No idea	
Variation in required resources (costs)	High	Moderate	Low	Very low		No idea		
Cost- effectiveness	Not cost-effective	Probably not cost- effective	Intervention and standard care are equal	Probably cost-effective	Cost- effective	Varies	No studies available	
Type of recommendation	Strong recommendation against intervention	Conditional recommendation against intervention	Conditional recommendation, neither in favor nor against the intervention	Conditional recommendation for intervention	Strong recommendation for intervention	Expert opinion		

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REVIEW

Hip Osteoarthritis: Etiopathogenesis and Implications for Management

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ABSTRACT

Highly prevalent among the elderly, hip osteoarthritis (OA) carries a heavy burden of disease. Guidelines for the management of hip OA are often extrapolated from knee OA research, despite clear differences in the etiopathogenesis and response to treatments of OA at these sites. We propose that hip OA requires specific attention separate from other OA phenotypes. Our understanding of the etiopathogenesis of hip OA has seen significant advance over the last 15 years, since Ganz and colleagues proposed femoroacetabular impingement (FAI) as an important etiological factor. This narrative review summarizes the current understanding of the etiopathogenesis of hip OA and identifies areas requiring further research. Therapeutic approaches for hip OA are considered in light of the condition's etiopathogenesis. The evidence for currently adopted management strategies is considered, especially those approaches that may have disease-modifying potential. We propose that shifting the focus of hip OA research and public health intervention to primary prevention and early detection may greatly improve the current management paradigm.

Keywords: Etiology; FAI; Femoroacetabular impingement; Hip; Management; Osteoarthritis; Risk factors; Rheumatology; Therapy

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INTRODUCTION

Hip osteoarthritis (OA) is among the most prevalent and disabling conditions affecting the elderly. There is an estimated 25% lifetime risk of symptomatic hip OA in people who live to age 85 [1], and almost 10% lifetime risk of undergoing a total hip replacement for end-stage OA [2]. However research on hip OA has generally languished behind knee OA-specific research, possibly owing to the even higher prevalence of

knee OA [3] and the greater ease with which the knee joint can be imaged [4] and accessed for clinical interventions. Clinical guidelines often combine hip and knee OA [5–7], at times extrapolating from knee OA research to make recommendations for the management of hip OA. This is despite the growing consensus that OA is not a single disease affecting the joints, but rather a number of distinct conditions, each with unique etiological factors and possible treatments, which share a common final pathway [8–10]. This review will focus on the joint-specific etiopathogenesis of hip OA and its implications for future management approaches. Perhaps the greatest potential for improved management lies in shifting the management paradigm from palliation of end-stage disease, to instead focus on the earliest stages of the condition's pathogenesis.

METHODS

For this narrative review, Medline was searched using various combinations of terms pertinent to the topic, including "hip osteoarthritis", "etiology", "femoroacetabular impingement", "pathogenesis", "risk factors", "epidemiology", and "management". Key articles of importance were selected through this process as well as from the authors' prior knowledge of the literature; the reference lists of these key articles were also used to select additional references of relevance for our review. This article is based on previously conducted studies and does not involve any new studies of human or animal subjects performed by any of the authors.

DIAGNOSIS OF HIP OA

The American College of Rheumatology have established criteria that are commonly used for the diagnosis of hip OA in clinical practice (Table 1) [11]. It is often possible to diagnose hip OA on the basis of clinical presentation alone, although radiographic investigation can be useful to confirm the diagnosis and to monitor disease progression.

The most common system for measuring radiographic OA severity is the Kellgren and Lawrence (K&L) grade, which uses a five-point scale between 0 and 4, with grades of 2 and higher indicating radiographic OA [12]. Higher K&L grades demonstrate increased joint space narrowing, increased osteophyte involvement, and subchondral sclerosis. Symptomatic disease progression can also be monitored with patient-reported outcomes such as the Oxford Hip Score. There is substantial discord between symptoms and radiographic findings; a high proportion of those with radiographic features of hip OA are asymptomatic, and a similarly high proportion of those with symptoms suggestive of hip OA lack radiographic evidence [13]. Consideration of both clinical and radiographic severity is relevant to direct clinical management.

PREVALENCE OF HIP OA

The age-standardized prevalence of symptomatic radiographic hip OA has varied from 1% to 10% in large population-based prevalence surveys [14–18]. These marked differences in prevalence can be attributed to differences in risk factor profiles between the populations sampled. The two largest USA-based prevalence surveys, the Johnston County Osteoarthritis Project [18] and Framingham Osteoarthritis Study [16], found prevalence rates of 10% and 4.2%, respectively. The higher prevalence in the Johnston County Project is likely due to this rural population

Table 1 American College of Rheumatology criteria for the diagnosis of hip osteoarthritis [11]

Clinical criteria A	Clinical criteria B	Clinical plus radiographic criteria
Hip pain; AND	Hip pain; AND	Hip pain; AND any 2 of the following:
Hip internal rotation <15°; AND	Pain with internal hip rotation; AND	ESR <20 mm/h
ESR ≤45 mm/h or hip flexion ≤115° if ESR unavailable	Morning stiffness of hip ≤60 min; AND	Radiographic femoral and/or acetabular osteophytes
	Over 50 years of age	Radiographic joint space narrowing

ESR erythrocyte sedimentation rate

containing a much higher proportion of farmers and African Americans, both of which are independent risk factors for hip OA [18]. In contrast, the Framingham Osteoarthritis Study included an urban, mostly Caucasian population. The prevalence of hip OA was 1% in the Beijing Osteoarthritis Study, reflecting greatly reduced risk of hip OA in Asian ethnicities [14]. It is worth noting that the prevalence of hip OA in each of these studies is much higher when hip OA is defined using either radiographic or symptomatic criteria in isolation [14–18].

PATHOGENESIS OF EARLY OA

Although this review is written on the premise that hip OA has a unique etiology and epidemiology requiring specific attention, it is instructive to consider the elements common to the pathogenesis of all OA-affected joints. Physiological biomechanical loading has long been recognized as necessary for joint tissue homeostasis [19, 20]. However in joints undergoing osteoarthritic change, pathological biomechanical stress disrupts the homeostatic equilibrium between joint tissue synthesis and degradation, eventually resulting in end-stage OA [21]. Pathological biomechanical stress is caused by the presence of risk factors both at the joint and person levels, and plays a central role in initiating and driving the pathogenesis of OA [22–24]. Particular biomechanical patterns have been implicated in this process. Repetitive shear stress at the articular surface has been associated with cellular and molecular changes involved in the pathogenesis of OA, including decreased expression of type II collagen and proteoglycans in articular cartilage, increased release of pro-inflammatory mediators, and increased apoptotic cellular changes [22].

The cellular and molecular changes that accompany altered biomechanical loading in the pathogenesis of early OA are the subject of a large body of research. The osteochondral junction, a region encompassing the subchondral bone and articular cartilage, has been heavily implicated. The subchondral bone and articular cartilage act as a single functional unit, responding in a coordinated fashion to altered biomechanical loading [25–27]. In response to altered joint biomechanics, subchondral bone remodelling with accelerated levels of subchondral bone turnover occurs. This manifests as increased porosity and thinning of the subchondral bone plate and trabecular bone. Simultaneously, cartilage microdamage occurs in the form of microcracks, which span the thickness of the non-calcified, tidemark and calcified cartilage regions and subchondral bone. These microcracks facilitate increased vascularization

and the bidirectional passage of important cytokines and growth factors throughout the osteochondral junction, thus connecting the cartilage and subchondral bone biochemically as well as mechanically [25–27]. The precise signalling molecules involved in the biochemical cross talk between articular cartilage and subchondral bone have not yet been fully elucidated. It is hypothesized that stressed articular cartilage releases pro-inflammatory cytokines and osteoclast-stimulating molecules that reach the subchondral bone to affect subchondral bone remodelling [25, 28]. Likewise, pro-inflammatory signalling molecules released by osteoblasts in subchondral bone are thought to reach articular cartilage where they promote cartilage breakdown [25, 29]. Synovitis with lymphocytic infiltration has also been identified in early-stage OA [30], underlining the whole-joint nature of the disease's pathogenesis even in its earliest stages. Increased understanding of the pathogenesis of early OA is important, as the potential for arresting disease course before extensive joint damage has occurred is likely greater at this stage.

ETIOLOGY AND RISK FACTORS FOR HIP OA

Risk factors for hip OA can be split into those at the joint level and those at the whole person level, with the caveat that these two categories of risk factors do not exist independently of one another. Rather, joint level risk factors may be considered the etiological basis for the development of hip OA, whereas whole person level risk factors contribute to the development of hip OA indirectly, by increasing susceptibility to joint level risk factors (Fig. 1).

Joint Level Risk Factors

Joint Morphology

In hip OA, the most significant factor that has emerged as responsible for the onset of the cascade described above is the presence of abnormal hip joint morphology, be it subtle or obvious, which is believed to lead to pathological loading patterns that produce shear stresses on the hip joint over time [31]. Although obvious hip joint deformity such as in severe developmental dysplasia of the hip (DDH) has long been recognized as a cause of early-onset secondary hip OA [32–34], it was originally thought that the majority of hip OA was idiopathic [35]. Some decades ago it was first proposed that almost all hip OA is secondary to subtle forms of joint deformity [36]; however, it is only in the last 15 years that this idea has gained traction [37, 38]. It has been proposed that joint morphology abnormalities exist on a continuous spectrum, with worse abnormalities such as in severe femoroacetabular impingement (FAI) or DDH associated with high risk of early OA onset, and more subtle morphological abnormalities associated with late-onset, so-called primary OA [31].

Developmental Dysplasia of the Hip

A shallow and oftentimes maloriented acetabulum causes decreased femoroacetabular contact surface area in DDH. This results in the distribution of shear forces anterosuperiorly in the hip joint onto the acetabular rim (Fig. 2) [39]. Over time these forces cause degeneration of the acetabular labrum anterosuperiorly and degeneration of the articular cartilage via its response to shear stress described earlier. Eventually whole joint failure occurs with the onset of hip OA [40]; in severe dysplasia this

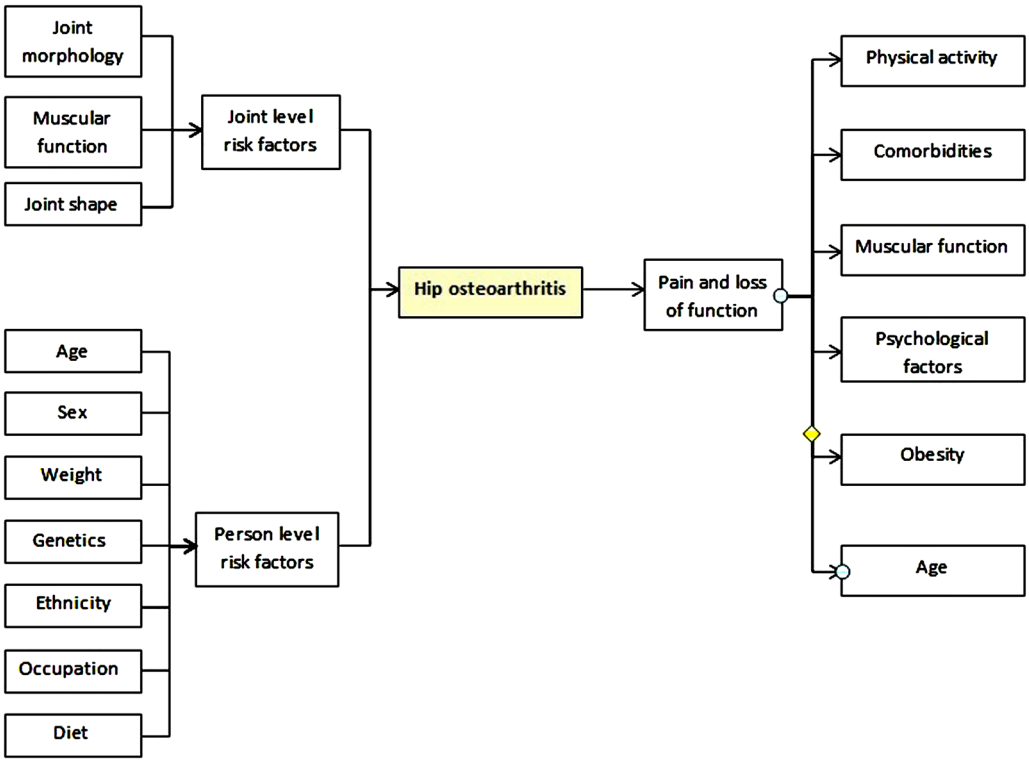

Fig. 1 Risk factors for hip osteoarthritis

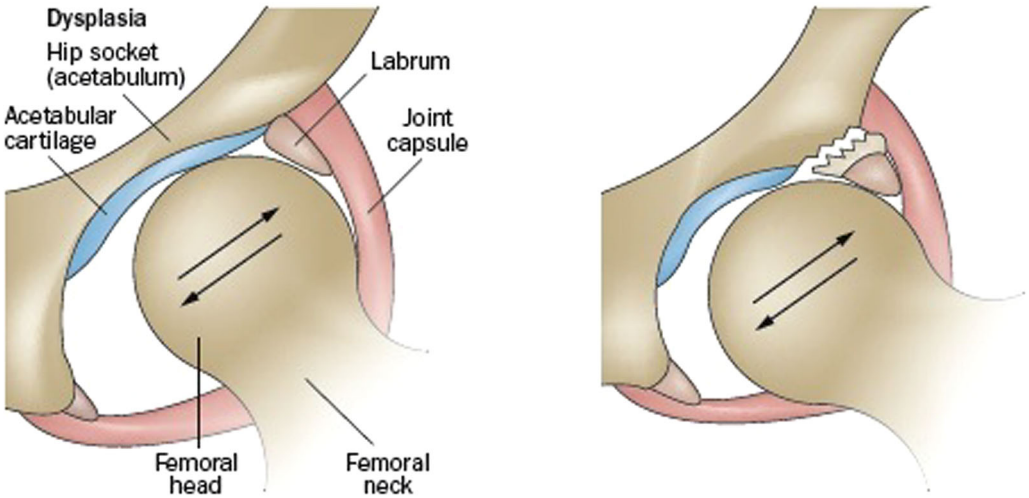

Fig. 2 Developmental dysplasia of the hip (DDH). The femoral head is less stable within the shallow acetabulum (image on *left*), causing the distribution of shear forces that damage the articular cartilage and predispose to labral tears (image on *right*) [31] (reprinted by permission from Macmillan Publishers Ltd)

tends to occur earlier in life [33], but in milder dysplasia can occur much later [41]. Surgical strategies to restore normal joint loading patterns have been developed, involving pelvic osteotomy to reorient the acetabulum to reduce pathological force distribution patterns, thus

preventing or at least substantially delaying the onset of hip OA [42].

Femoroacetabular Impingement (FAI)

FAI is likely a more prevalent underlying cause for the development of hip OA. Ganz and colleagues described two different morphological patterns of FAI: cam and pincer FAI [38]. In cam FAI, the predominant morphological abnormality is a thickened, aspherical femoral head–neck junction (Fig. 3). When the hip joint is flexed, the cam lesion on the proximal femur abuts against the anterosuperior labrum of the hip, compressing it and pushing it outwards. Meanwhile the acetabular cartilage is compressed and pushed inwards by the shearing force exerted by the cam lesion. The overall effect is separation of the acetabular cartilage from the labrum and delamination of acetabular cartilage from the subchondral bone [43]. In pincer FAI, there is a deepened acetabulum, with acetabular over coverage of the femoral head. As a result the femoral neck abuts against the acetabular labrum, exerting compressive forces that result first in damage of the labrum and eventually the underlying cartilage (Fig. 4) in a thin circumferential band around the acetabular rim [38, 43, 44]. Because the most common movement of the hip joint is flexion, a preponderance of the labral lesions are still found anterosuperiorly with pincer FAI, as with cam FAI. However with pincer FAI, lesions are also commonly found posteroinferiorly on the acetabular rim [43]. These lesions are believed to occur as a result of continued flexion of the hip joint after the femoral neck is already abutting against the anterosuperior acetabular rim, causing the femoral head to sublux posteriorly, thus producing a so-called contre-coup lesion in the femoral head and posteriorinferior acetabulum [37, 43]. Although two distinct pathomechanisms for FAI exist, the reality is that in most cases a combination of both types of impingement are present [45].

Estimates for the prevalence of FAI morphology in the general population have varied wildly owing to significant heterogeneity in the definition of FAI morphology used and in the populations sampled [47, 48]. The estimated prevalence of cam morphology has varied between 10% and 25% of the population [49, 50]. A systematic review found that radiographic evidence of pincer-type morphology is present in almost two–thirds of the population [48], although this figure is likely inflated because of the poor reliability and specificity of many of the radiographic signs considered suggestive of pincer morphology [51]. Other disorders arising as

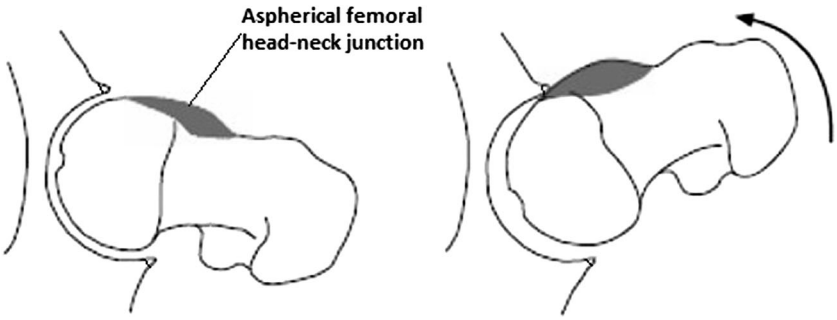

Fig. 3 Cam impingement. The cam lesion abuts against the labrum, pushing it outwards and compressing the acetabular cartilage inwards. The labrum separates from the cartilage and the acetabular cartilage delaminates from the bone [46] (reproduced with permission from Springer)

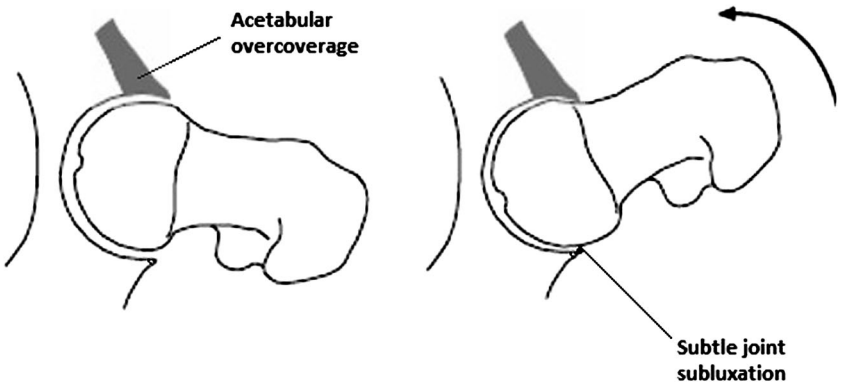

Fig. 4 Pincer impingement. Owing to acetabular over-coverage, the femoral neck abuts against the hip labrum, damaging the labrum and eventually the underlying cartilage. A contre-coup lesion can also occur, where continued flexion of the hip, after the femoral neck is already abutting against the acetabular rim, causes subtle joint subluxation and damage to the acetabular cartilage. The labrum separates from the cartilage and the acetabular cartilage delaminates from the bone [46] (reproduced with permission from Springer)

developmental abnormalities of the hip, including slipped capital femoral epiphysis and Legg–Calvé–Perthes disease are also associated with FAI morphology, although these make up only a small minority of hips with FAI [52]. The proportion of the population with symptomatic FAI is only a fraction of those with FAI morphology, and an important but not yet well-understood area of research lies in determining the cause of onset of symptoms in some with FAI morphology but not others. It is widely recognized that symptomatic FAI occurs most commonly in young, active people, with particularly increased prevalence rates in athletes [53]. Symptoms most commonly include insidious onset of groin or buttock pain exacerbated by physical activity, oftentimes combined with loss of terminal hip range of motion [54]. Although osseous abnormalities underlie FAI morphology, symptomatic FAI is postulated to arise as a result of labral and/or chondral injury occurring secondarily to bony impingement [53].

The poor predictive value of FAI morphology for symptomatic disease [55, 56] is likely in part related to the inadequacy of the imaging parameters used to diagnose FAI morphology. Each FAI parameter is measured on a two-dimensional planar image, and is usually considered in isolation from other FAI-relevant parameters, an approach that fails to accurately reflect the dynamic interaction between the proximal femur and acetabulum. For instance, a femoral head classified as having cam morphology on account of an alpha angle greater than 55° (Fig. 5a) in reality may not suffer any functional impingement due to the relatively shallow acetabulum with which it is interacting [57]. Likewise, an acetabulum considered to exhibit pincer morphology on account of an increased lateral center edge angle (Fig. 5b) may not experience true impingement if it occurs in conjunction with a spherical femoral head and a suitably anteverted acetabulum. True FAI is a dynamic, three-dimensional condition affected by the complex relationship between various anatomical parameters. Anatomical parameters implicated in FAI morphology have included the alpha and lateral center edge angles [58], the extent of acetabular retroversion [59] and femoral anteversion [60], and the femoral neck

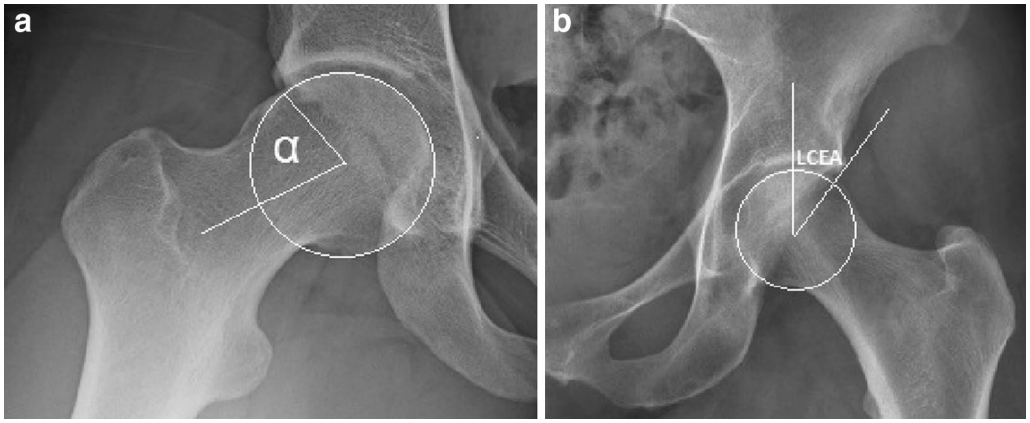

Fig. 5 Diagnosis of FAI morphology. The **a** alpha angle and **b** lateral center edge angle are two of the imaging parameters commonly used to classify FAI morphology. The alpha angle (**a**), shown here on a modified Dunn X-ray view, is the angle formed by the femoral neck axis and a line connecting the center of the femoral head to the point at which the head–neck contour becomes aspherical. Greater than 50° or 55° is often considered suggestive of cam morphology. The lateral center edge angle (**b**), measured on an AP pelvic X-ray, is the angle formed by a vertical line connecting the center of the femoral head with the lateral edge of the acetabulum. Greater than 40° is often considered suggestive of pincer morphology

shaft angle [61]. Bouma and colleagues have attempted to develop a model that uses CT and motion simulation software to integrate these parameters, with the aim of producing a single, comprehensive measure of FAI morphology [62]. This approach is still in its infancy and requires further study to refine developed models and establish their clinical relevance. However the notion of a more comprehensive and functionally accurate measure of FAI morphology holds promise for improving the accuracy of FAI diagnosis and prediction of hip OA risk for screening purposes.

There is growing evidence that FAI is an important cause of hip OA. Numerous studies have demonstrated an association between the presence of FAI morphology and cartilage damage [38, 43, 44, 63, 64, 65, 66, 67, 68]. For example, a study in which 244 asymptomatic young males underwent MRI found that the 67 participants with cam lesions had increased occurrence of labral lesions, impingement pits, and labral deformities [64]. Zeng and colleagues investigated the association between hip morphology and hip OA by comparing the 3D CT reconstruction of 186 normal hips to those of 132 hips with mild–moderate hip OA. Participants with OA demonstrated more features consistent with impingement morphology: less spherical femoral heads, less concavity of the femoral head–neck junction, less acetabular and femoral neck anteversion, and greater acetabular coverage [68]. Studies using delayed gadolinium-enhanced MRI of cartilage (dGEMRIC), a technique used to quantify the glycosaminoglycan (GAG) content of cartilage and thus detect GAG loss that is associated with the early onset of OA [69, 70], have demonstrated that people with FAI are more likely to have damaged cartilage suggestive of early OA [44, 71], and the extent of this damage correlates with severity of cam deformity [72]. In recent years active shape modelling of hips has been shown to predict future risk of hip OA, with various FAI-type morphologies being shown to correlate with increased hip OA incidence [73, 74]. However the fact that severe morphological

abnormalities do not always bring about hip OA [33, 75, 76] suggests that there are more variables at play in the etiology of hip OA than joint morphology alone.

Periarticular Musculature of the Hip Joint

The importance of the periarticular musculature for shock absorption has been recognized as a characteristic common to many joints [9]. The deep stabilizing muscles of the hip likely play a role in absorbing shock and protecting the joint from aberrant movement patterns, although there is a paucity of research in this area. Physiotherapy-led rehabilitation for FAI has the strengthening and conditioning of the periarticular hip musculature as its cornerstone. Specifically, it aims to improve control of the femoral head by strengthening the deep stabilizing hip muscles, particularly the deep hip abductors and external rotators, so as to reduce impingement that occurs when the hip moves into the commonly exacerbating position of combined flexion, internal rotation, and adduction [77–79]. A recent review on the limited body of research on physiotherapy-led management of FAI suggested that it confers symptomatic benefit, although further study is needed comparing its efficacy to other treatment modalities such as hip arthroscopy [80]. It seems highly plausible that muscular dysfunction of the deep hip stabilizers plays a role in pathological hip joint biomechanics. In knee OA, an analogous relationship with quadriceps strength is well recognized [81–83].

The possible role of muscular dysfunction in biomechanical insult at the hip joint is yet to be rigorously studied. Three studies examining hip muscle weakness in symptomatic FAI found hip abductor weakness [84–86]; two also reported hip flexion weakness [84, 86], and weakness in other directions of movement was identified in isolated studies. Biomechanical gait analysis found abnormally high levels of muscular co-contraction in FAI-affected hips compared to matched controls [87]. A systematic review of muscle weakness in hip OA [88] found eight cross-sectional studies examining muscle strength, all of which reported an association of hip and lower limb weakness with hip OA. Weakness was commonly found in hip and knee flexion and extension, as well as in hip abduction and adduction. Muscle weakness associated with FAI and hip OA could be due to a variety of different factors, including pain inhibition, muscle disuse atrophy, or aberrant joint mechanics. The role of the deep hip stabilizers in aberrant joint mechanics, possibly leading to the onset of FAI and subsequent hip OA, warrants further study. Moreover, targeted research into the specific muscular changes associated with successful physiotherapy treatment for FAI is required to better understand the role the periarticular muscles play in the etiology of hip OA.

Joint Injury and Labral Tears

A well-established risk factor for OA is joint injury, the archetypal example being anterior cruciate ligament rupture of the knee, which substantially increases risk of knee osteoarthritis in the years following injury [89]. In the hip, a common form of joint injury is an acetabular labral tear, which warrants further study as a possible contributing factor to the development of hip OA. Acetabular labral tears are very common, estimated to be present in 66% of people with mechanical hip pain [90] and roughly 39% of the asymptomatic population [91], with increasing age an important risk factor. The etiology of such tears can be an acute traumatic event, degenerative change of insidious onset such as is often caused by chronic impingement, idiopathic or occasionally congenital [92]. There is a strong

association between abnormal osseous morphology and the presence of symptomatic labral tears [38, 43, 44]. However case series have found that 13% to 30% of patients undergoing surgery for repair of symptomatic labral tears had no sign of abnormal osseous morphology [93, 94], suggesting that FAI and dysplasia are not the only cause of symptomatic acetabular labral tears. Acute traumatic events have been identified as the cause of symptomatic labral tears in approximately 20% of cases [92–94], oftentimes accompanying sudden twisting motions [95]; however, it is likely that occult traumatic events lead to more cases. The acetabular labrum has important and under-recognized anatomical functions in the hip [96]. Cadaveric studies have found that the labrum increases the articular surface area of the acetabulum by 22% and contributes up to 33% of the hip joint's volume [97, 98]. An intact labrum is believed to provide a suction seal that contributes to the stability of the hip joint, as well as distributing pressure more evenly between the femur and acetabulum, while maintaining synovial fluid important for lubrication within the joint space [99, 100]. Conversely, tears are believed to reduce the capacity of the labrum to perform these important functions, resulting in reduced hip joint stability and suboptimal femoroacetabular pressure distribution [100].

The extent of labral damage has been shown intraoperatively and on magnetic resonance arthrography (MRA) to correlate both with the amount of chondral damage and the extent of bone marrow lesions in people with symptomatic labral tears [90, 101, 102]. Since chondral damage and bone marrow lesions are two characteristic features of hip OA, it may be inferred that labral tears are intimately related to the OA process in the hip. It is likely that labral and chondral damage often occur simultaneously as a result of the same traumatic event or because of exposure to the same bony impingement pattern over time. There is also the possibility that in some cases the occurrence of a labral tear itself, for instance via trauma to the hip joint, could be the initial event that alters the biomechanical environment of the joint and contributes to the onset of joint damage that leads to hip OA [90, 101]. Isolated labral tears are much more prevalent in younger people, while labral tears accompanying chondral damage tend to occur later in life, lending support to the notion that labral tears may precede chondral damage in many cases, possibility contributing to its onset [102]. In many cases both of these scenarios may even occur, with bony impingement causing labral damage; the labral damage itself subsequently worsens the hip's biomechanical function, with a positive feedback cycle thus being created that leads to accelerated development of hip OA. The pathophysiology of labral tears and their relationship with hip OA is incompletely understood and warrants further study.

Whole Person Level Risk Factors

Whole person level risk factors can be understood as influencing risk of hip OA development through the effect they exert on joint level risk factors.

Age

The very strong relationship between OA and age is well-recognized in all joints [103], including the hip. In the Johnston County Project only 5.9% of people in the 45–54 age group suffered from symptomatic hip OA;

however, in people over 75 this figure increased to 17% [18]. Age-related biological changes such as cellular senescence have been observed in articular cartilage, with chondrocytes undergoing changes such as telomere shortening [104]. Declining chondrocyte density has also been demonstrated [105], resulting in decreased extracellular matrix synthesis and production of smaller, more irregular proteoglycans [106]. Similar change occurs in other joint tissues such as bone and ligaments as part of the ageing process. The gradual onset of sarcopenia and frailty with ageing have a complex flow on effects that can place biomechanical stress on the hip joint and may predispose to joint damage [107]. In the context of a joint under mild biomechanical stress due to subtle morphological abnormalities or poor periarticular muscular support, these age-related changes are more likely to disrupt the equilibrium between joint tissue synthesis and degradation.

Sex

Overall the relationship between sex and hip OA is unclear; if a relationship does exist it seems it is weaker at the hip compared to other joints, where female sex is often considered a risk factor. A large meta-analysis considering more than 14,000 people suggested there was no difference in hip OA prevalence or severity between men and women [108]. Counter-intuitively, the same meta-analysis found an increased incidence of hip OA in females, although there were only two such studies used for pooling in this meta-analysis because studies looking at OA incidence are less common. The Framingham Osteoarthritis Study found a higher prevalence of radiographic hip OA in men compared to women, but no significant difference in symptomatic hip OA risk [16].

Weight

The best available evidence suggests that increased BMI is associated with increased risk of hip OA, although this relationship is less marked than the strong correlation between BMI and knee OA [109, 110]. A large meta-analysis [109] found that a dose–response relationship exists between BMI and risk of hip OA, with each five-unit increase in BMI associated with an 11% increased risk of hip OA. The association was consistent across both sexes, cohort and cross-sectional studies, and across all definitions of OA used. In previous studies, the evidence found linking hip OA and weight has been inconsistent [111], possibly because of population differences combined with the relative weakness of the effect of obesity on hip OA risk compared to knee OA.

Two mechanisms are proposed to link hip OA and increased BMI. Firstly, increased body weight increases biomechanical loading at the hip joint and thus leads to larger joint stresses, particularly in the presence of any joint level risk factors [109, 112]. Secondly, a metabolic theory has been proposed, whereby systemic pro-inflammatory factors associated with obesity act on joints to increase risk of OA [113]. This is supported by the association between obesity and hand OA [114], despite the hand not being a weight-bearing joint.

Genetics

Genetic factors are very important in hip OA; twin studies have suggested that genetic factors contribute approximately 60% of hip OA risk [115]. Familial clustering of hip OA has been observed, with increased relative risk of total hip arthroplasty (THA) demonstrated for first-, second-, and third-degree relatives of people who had undergone THA [116]. Genome-wide association studies have identified several candidate genes for hip OA, although many of

these have not been found to be reproducible across studies [117]. Tellingly, the majority of genes identified as most likely to increase risk of hip OA thus far are genes associated with synovial joint development, which supports the notion of congenital/developmental hip joint deformity being paramount in hip OA development [31]. Sandell proposed a model (Fig. 6) that ties the continuous spectrum of morphological abnormalities in the hip joint to genes implicated in the development of hip OA [31]. In future studies further elucidation of the exact genes and mutations involved in hip OA is necessary to enable the possibility of screening and calculation of hip OA risk prior to disease onset.

Ethnicity

Great variation in the prevalence of hip OA has been noted between races. Most notably, the Beijing Osteoarthritis Study found hip OA to be 80% to 90% less prevalent in the Chinese population compared to Caucasian populations in the USA [14], a finding replicated in other studies [118, 119]. This may be explained by differences in hip morphology between the two races, with substantially higher rates of femoral head asphericity and pincer impingement morphometry having been found in white women compared to Chinese women [120]. Another likely contributing factor is genetic differences between the races, many of which are probably expressed in hip morphology.

Occupation

It has been suggested that increased levels of high-impact physical activity, via occupational exposure or long-term participation in high-impact sports, may predispose to the development of hip OA. The underlying mechanism may be similar to that of obesity, with high-impact joint loading causing biomechanical stress to the joint, especially in a hip that is already predisposed via morphological abnormality or suboptimal periarticular muscular support. Epidemiological evidence has suggested that occupations involving heavy manual work have increased risk of developing hip OA [121, 122]. In particular, farmers are at increased risk, with those who have farmed for more than 10 years at more than three times relative risk compared to the general population [121]. The exact patterns of movement or activities responsible for the increased risk are unknown, although heavy lifting may play a significant role.

It has been proposed that athletes participating in high-impact sports are

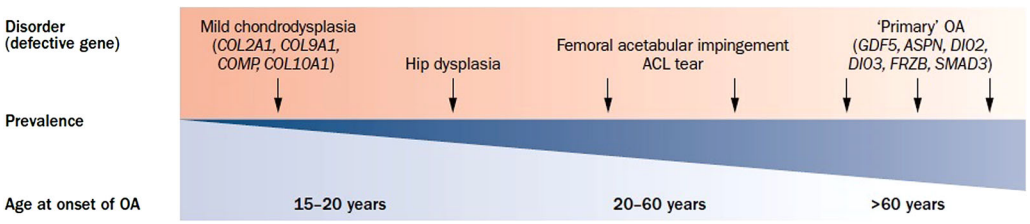

Fig. 6 The genes responsible for the development of OA have been proposed to exist on a continuum related to joint morphology. Some defective genes are expressed in markedly abnormal joint morphology, such as in some chondrodysplasias, causing early-onset OA. Other more common genetic defects are expressed in subtle morphological aberrations that cause late-onset OA, previously considered primary OA [31] (reprinted with permission from Macmillan Publishers Ltd)

predisposed to developing hip OA. This is difficult to assess because of the confounding factor of higher rates of traumatic joint injury in athletes owing to their sports participation, as well as great heterogeneity between studies related to this topic [123, 124]. Two mechanisms may predispose athletes to increased risk: firstly, increased high-impact joint loading as described for heavy manual workers; secondly, increased prevalence of cam morphology which may be caused by high levels of physical activity during a critical period during adolescence while osseous development is still occurring [125]. Several studies have found increased prevalence of FAI morphology amongst professional athletes in high-impact sports such as basketball, ice hockey, and football [126–128], as well as increased prevalence of symptomatic FAI [54]. Although long-term participation in high-impact sport or heavy-duty manual labor may predispose to hip OA, it is important to note that there is no solid epidemiological evidence to support the misperception that exercise or physical activity has a deleterious effect on risk of hip OA in the general population.

Diet

It has been suggested that dietary factors may be important in affecting OA risk [129], although strong evidence to support this is lacking. Several vitamins and minerals have been suggested as potentially important, some of the most commonly implicated being vitamins D, K, and C. Vitamin D was thought to be relevant to OA risk on account of its role in bone mineralization. A recent meta-analysis found no association between serum vitamin D levels and prevalence or incidence of hip, knee, or hand OA [130], despite early studies on vitamin D and OA suggesting a possible relationship [131, 132]. Low vitamin K has been associated with knee and hand OA in a small number of studies [133–135]; however, supplementation with vitamin K has not demonstrated any effect on disease progression [136]. Vitamin C and various other antioxidants have also been investigated for a possible association with OA but results have been inconclusive [137–139]. At present there is a lack of high-quality evidence relating hip OA to dietary factors.

MANAGEMENT

Unfortunately the management of hip OA remains reactionary and palliative. Management begins after the onset of symptoms, by which point the disease is usually well established and significant joint damage has already been incurred. The focus is on symptom management, which is usually only moderately effective. Disease-modifying interventions, although the subject of a great deal of research, have thus far remained elusive in hip OA. Eventually joint amputation occurs in the form of a total hip replacement (THR), which although highly effective in relieving symptoms, occurs at substantial cost and with risk of morbidity. A shift to focus the efforts of research and public health intervention on primary prevention may hold the key to enhancing the current model for the management of hip OA.

Primary Prevention

Modifiable risk factors represent the lowest hanging fruit in terms of OA prevention. A problem with hip OA is that of the known risk factors, few are easily modifiable. Body weight is modifiable, and hence weight loss in overweight or obese patients should be

actively pursued to reduce the risk of disease development and possibly delay disease progression [5–7]. Patient education around this issue is vital in the primary healthcare setting. The role that periarticular muscular factors play in the etiopathogenesis of hip OA requires investigation. If well-designed studies determine that the periarticular musculature plays a sufficiently important role in hip joint biomechanics to influence hip OA risk, this may become a fertile field for physiotherapy-led primary preventative measures.

In the last 15 years it has emerged that possibly the most important risk factor for hip OA development is abnormal hip joint morphology, particularly in the form of FAI. There is a large body of research activity being conducted to identify the environmental exposure/s that may trigger the development of this shape abnormality. If this is found it may enable restriction of this environmental exposure through public health interventions. Until the day when genetic editing is available and the genes involved in hip OA are fully understood, the only mechanism available for alteration of joint morphology is surgical intervention. Hip arthroscopy to alter joint shape is an increasingly utilized procedure in the treatment of symptomatic FAI [140]; however, clinical trials are still needed that compare outcomes between hip arthroscopy and conservative management to establish the procedure's efficacy [141]. In particular, longitudinal clinical trials are needed to determine the efficacy of surgical and physiotherapy-based interventions for modification of future hip OA risk. It is important to note that joint-preserving surgery should be pursued before the onset of hip OA or early in the disease course, as emerging evidence suggests these patients obtain much greater benefit from the procedure than those with advanced hip OA, for which THA is more appropriate [142, 143]. The question of whether asymptomatic FAI of sufficient morphological severity warrants surgical intervention to reduce future hip OA risk also requires investigation.

Current Management Approaches

Conservative Non-Pharmacological Management

Rehabilitation for hip OA encompasses several different aspects, including patient education, weight management, land- and water-based exercise, and strength training [144]. While consistent evidence supports the efficacy of these strategies in the management of knee OA [145], the evidence in hip OA is far more variable [144]. Weight loss is recommended for people with hip OA who are overweight/obese; however unlike knee OA, there is a paucity of clinical trial evidence for weight loss in hip OA [146]. A cohort study reported that a combined dietary and exercise weight loss program improved functional symptoms and reduced pain [147]; however, much further study is needed to establish the efficacy of weight loss in hip OA conclusively.

Exercise therapy is widely recommended in clinical guidelines for hip OA management [5–7]. Overall there is evidence that exercise offers small to moderate benefit in reducing pain and improving function in hip OA [146, 148, 149], although the strength of this evidence is less than for knee OA [150]. Small clinical trials have recently suggested exercise therapy may postpone the need for THA [151] and may reduce medical expenditure for people with hip OA [152]. There are various activities included under the banner of exercise therapy, including strengthening, aerobic, and flexibility activities, many of which can be carried out on land or in the water. No particular activity type

has been shown to produce superior results, and thus it is recommended that exercise programs be personalized to reflect the unique needs of each patient [153].

Physiotherapy for hip OA usually includes physiotherapist-led exercise therapies in conjunction with manual therapy. The value of physiotherapy in the management of hip OA is a hotly contested issue, with recent evidence suggesting it offers little benefit beyond what could be expected from a self-guided exercise program [149]. Systematic reviews on the topic have reported no benefit from the use of manual therapy in treating hip OA, nor any additional benefit when manual therapy is combined with an exercise program than is obtained from exercise alone [154, 155]. A recent clinical trial comparing physiotherapy-led management to sham therapy found no benefit of physiotherapy on pain or function [156]. More high-quality research is needed in this area, but the limited evidence currently available does not establish physiotherapy as effective in treating hip OA. A novel strategy being investigated for a potential role in modifying biomechanics to treat hip OA is bracing, although this research is still very much in its infancy [157–160].

Pharmacological Management

A myriad of different pharmacological compounds have been produced with the aim of treating OA, although few trials have focused on hip OA specifically. Pharmacological treatments include those administered topically, orally, and by intra-articular injection. Some treatments aim to relieve symptoms alone, whereas others, disease-modifying osteoarthritis drugs (DMOADs), attempt to alter the course of disease. DMOADs generally have shown promise in preclinical trials but results have proved disappointing in later phase trials, with disease-modifying efficacy of any agent yet to be convincingly established [161–163]. Historically DMOADs have aimed to inhibit steps in the pathway of cartilage degradation or stimulate steps in cartilage synthesis [164]. However as the understanding of the pathogenesis of OA has progressed to become less cartilage-centric, DMOADs targeting other joint tissues such as synovium and bone have been developed [162]. DMOADs have included, among others, glucosamine sulfate, chondroitin sulfate, doxycycline, bisphosphonates, diacerein, matrix metalloprotease inhibitors (MMPs), avocado soy bean unsaponifiables, platelet-rich plasma (PRP) injections, strontium ranelate, and sprifermin [163, 164].

Until recently, clinical guidelines have recommended that symptom management in OA begin with paracetamol [5, 7]. However current large-scale meta-analyses have found strong evidence that paracetamol confers a clinically unimportant reduction in short-term pain for hip and knee OA [165, 166]. In the near future clinical guidelines will likely be adapted to reflect the lack of efficacy of paracetamol for hip and knee OA. NSAIDs have a well-recognized role in the symptomatic relief of OA and can be administered topically or orally. A recent meta-analysis reported strong evidence that diclofenac and etoricoxib are the most efficacious NSAIDs for pain relief in hip and knee OA, producing a moderate to large effect size [166]. However because of the risk of gastrointestinal and cardiovascular adverse events associated with their use, clinical guidelines recommend the use of NSAIDs for hip OA be restricted to the lowest possible doses and duration [5, 7]. Topical NSAIDs provide local pain relief in hand and knee OA; however, the depth of the hip joint renders it an inappropriate target for topical NSAIDs [167]

and hence there are no recommendations for their use in hip OA [5, 7].

Duloxetine is a selective serotonin and norepinephrine reuptake inhibitor (SNRI) posited to inhibit pain via mechanisms acting on the central nervous system. Although untested in hip OA, phase III clinical trials have reported reduced pain and improved function associated with duloxetine use in knee OA [168, 169]. Further study of the efficacy of duloxetine for symptomatic management of hip OA is warranted, especially given its favorable safety profile [170]. Where other management strategies are unable to relieve symptoms sufficiently, tramadol, a weak non-narcotic opioid, may be considered for pain relief, although a drawback is its side-effect profile [171]. Non-tramadol opioids are not routinely recommended in hip OA, as in most cases the burden of side effects and possible adverse events outweighs reductions in pain [172].

Intra-articular injection therapies for hip OA are an area of increasing interest. The available evidence suggests that intra-articular corticosteroid injections (IASI) offer symptomatic relief in hip OA. A recent meta-analysis identified five clinical trials, each with fewer than 100 participants, examining the efficacy of IASI specifically in hip OA [173]. With regards to pain reduction, it reported a large effect size 1 week post-injection and a moderate effect size after 8 weeks, although treatment effect declined thereafter. Guidelines currently recommend the use of IASI as an adjunct to other treatments for pain relief in hip OA [5, 7].

Hyaluronic acid (HA), a glycosaminoglycan normally constituent in synovial fluid but present in decreased concentrations in OA, is a compound used in clinical practice for its possible anti-inflammatory and analgesic properties. The evidence for the efficacy of HA is conflicting [174–177]. A challenge in interpreting findings is the great heterogeneity between studies with regard to the amount and type of HA injected, the number of doses given, and the length of follow-up [178]. Clinical guidelines do not currently recommend HA injections for hip or knee OA [5, 7].

There have been relatively few studies investigating the use of platelet-rich plasma (PRP) as an intra-articular injection therapy in hip OA [179], and hence it is too early to comment on its efficacy [180]. Two small clinical trials have investigated PRP injections for hip OA, in both cases comparing to HA; one reported no difference between the two treatments [181], while the other found PRP to be more efficacious at 2- and 6-month follow-up [182]. For each of these injection therapies there is a great need for more high-quality clinical trials to inform clinical practice.

Surgical Management

More than 1 million people worldwide undergo THA annually, over 90% of these because of end-stage hip OA [183]. Although THA occurs at substantial expense to individuals and the healthcare economy, several cost–benefit analyses have demonstrated that THA is a highly cost-effective procedure for people with hip OA not responding to conservative management approaches [184]. At 10 years post-THA more than 95% of implanted hips are still functioning, and this figure remains above 80% after 25 years [183, 185]. Following a course of failed conservative therapy, research suggests that patient outcomes are enhanced when THA is undergone quickly rather than waiting until the condition deteriorates further, since poor function preoperatively is correlated with worse postoperative function [183, 186].

Although THA is an effective management approach for patients with hip OA who have exhausted other options, the need for this operation in the future will hopefully be reduced by an early intervention, disease-modifying approach to hip OA management.

Hip resurfacing was developed as an alternative to THA for younger, more active patients in the interests of bone preservation to enable easier revision surgery and reduce the chance of dislocation. A systematic review identified substantially higher rates of revision and reoperation for hip resurfacing compared to THA [187]. Current evidence suggests hip resurfacing is a suitable option only for carefully selected patients; usually young, active male patients with primary OA and a sufficiently large femoral head size [188, 189].

Implications for Future Management

The symptomatic management of hip OA remains an important area of research to enhance quality of life for those suffering from the disease. However disease-modifying treatment represents the holy grail of OA research. Although treatment modalities such as DMOADs aim at disease modification, a problem with their approach is that they are not based on the condition's joint-specific etiopathogenesis. We know that OA is not a single disease affecting several joints in the body, but rather is a distinct condition at each joint, with unique etiological factors and responses to treatments. With this in mind, it seems improbable that a single pharmacological compound acting on all joints will be a curative solution. In hip OA it is becoming increasingly evident that biomechanical factors are the primary driver of the condition's etiopathogenesis, and thus treatments addressing these factors may offer better chances of effecting a cure [9].

Of the currently employed treatment strategies, physiotherapy seems the modality most congruous with the goal of joint-specific, biomechanically oriented management, yet paradoxically it has not proven to be among the more efficacious treatments. However physiotherapy, and indeed any treatment aiming at disease modification, faces an uphill battle in treating already well-established hip OA. By the time treatment is begun, substantial joint injury has already been incurred, likely worsening the maladaptive biomechanical environment that led to the development of OA in the first place. Expecting any treatment modality to overcome an already substantially damaged joint is probably unrealistic.

CONCLUSION

Our hypothesis is that true inroads in reducing the burden of hip OA are most likely to be seen with an increased focus on risk factor modification prior to or in the early stages of the condition's pathogenesis. It is important that the risk factors identified in this review are considered during the development of new therapeutic approaches and public health interventions for hip OA. Risk calculators such as those that currently exist for heart disease could be developed, incorporating imaging and even genetic biomarkers to enable stratification of people into varying risk levels for appropriate monitoring and management. With improved understanding of the etiopathogenesis of hip OA, intervention prior to or early in the disease course in a

disease-modifying manner is likely to become feasible in the future. The management of hip OA has the potential to be an area of medicine undergoing substantial advancement in the decades to come.

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