Aspects of improving and maintaining physical activity in patients with hip or knee osteoarthritis

REGINA BENDRIK
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Abstract


Aim: This thesis aims to enhance knowledge of how people with osteoarthritis should be managed and supported in order to increase and maintain physical activity in the long-term.

Method: Study I and study II was based on a randomised controlled study (RCT) including 141 osteoarthritis patients. The short and long-term effect of an individualised physical activity on prescription intervention compared with individualised advice about physical activity were evaluated. The primary outcome was physical activity and secondary outcomes were fitness/performance, pain and quality of life, evaluated at 6, 12 and 24 months. In Study III, 7-day diaries were evaluated regarding which forms of physical activity i.e. walking, swimming, cycling, gardening etc. the patients chose themselves and maintained after one and two years. In addition were evaluated, which category these activities belonged to: aerobic, muscle strength, mind-body or everyday activity, and whether there were differences in characteristic of the patients in the different forms. In study IV responsiveness of function, how well instruments captured an improvement, one year after a physical activity intervention was measured. Two unilateral performance-based tests were compared with a bilateral performance-based test and with questionnaires about function.

Results: The RCT provided no evidence that individualised physical activity on prescription differ from individualised advice on physical activity in improving short and long-term physical activity, function, pain and quality of life (Study I and II). Walking was the form of physical activity performed most frequently and best maintained after 12 and 24 months. Walking were preferred by women, older individuals and individuals with weak legs while men also preferred everyday activity and cycling. Few patients preferred strength training (Study III). The maximal step-up test (one-leg testing) was more responsive to change in physical function (SMD effect size 0.57) compare to the bilateral 30-second chair-stand test (0.48) (Study IV).

Conclusion: There is still absence of evidence for any particular physical activity intervention to effectively increase physical activity in the long-term in osteoarthritis patients. Individual counselling with support to choose preferred physical activities that are easy to perform in daily life may be a beneficial approach for long-term maintenance.

Keywords: osteoarthritis, hip, knee, physical activity, walking, physical function


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Do the best you can until you know better. 
Then when you know better, do better. 
Maya Angelou
List of papers

This thesis is based on the following papers, which are referred to in the text by their Roman numerals.


II. Bendrik, R., Kallings, LV., Bröms, K., Emtner, M. Follow-up of individualised physical activity on prescription and individualised advice in patients with hip or knee osteoarthritis: A randomised controlled trial. *Clinical Rehabilitation* 2024; accepted February 7, 2024.

III. Bendrik, R., Peterson, M., Hed Ekman, A., Emtner, M., Bröms, K., Kallings, LV., Sundström, B. Walking is the preferred form of physical activity in people with osteoarthritis in the hip or knee (*manuscript*).

Svensk sammanfattning

Patienter med artros i höft eller knä får sin diagnos sent i sjukdomsprocessen, kommer igång med träning sent och har svårt att bibehålla en fysisk aktiv livsstil över tid. Detta trots att fysisk aktivitet förbättrar smärta, funktion och livskvalitet samt minskar risken för följsjukdomar.

Denna avhandling består av fyra studier, alla med deltagare från primärvård som sökt vård på grund av smärta och besvär från höft eller knä. De som inkluderades var 40-74 år, hade artros enligt klinisk bedömning och var otillräckligt fysiskt aktiva (subjektiva riktlinjer mindre än 150 minuter fysiskt aktiva per vecka). Det övergripande syftet med avhandlingen var att undersöka faktorer av betydelse för att personer med artros i höft eller knä ska öka och bibehålla fysisk aktivitet över tid.

Studie I var en randomiserad kontrollerad studie som inkluderade 141 patienter och utvärderade fysisk aktivitetsnivå efter 6 månader både objektivt med accelerometer och självrapporterat med frågeformulär. Sekundära utgångspunkter var att fungera objektivt med funktionella tester och självrapporterat i frågeformulär samt smärta och livskvalitet mätt med skattningsformulär. Ena gruppen fick individuellt anpassad fysisk aktivitet på recept (FaR) med fyra uppföljningar under sex månader. Den andra gruppen fick ett besök med individuellt råd att utföra valfri aktivitet 30 minuter 3 gånger i veckan och att tränas muskelstyrkande aktivitet i vardagen.

Studie II inkluderade en uppföljning efter 12 och 24 månader av samma grupp patienter och utvärderingsinstrument.

Studie III inkluderade 94 patienter och utvärderade vad patienterna själva väljer för fysisk aktivitet, t.ex. promenad, simning, dans, tai chi, gymtränning, trägdårsarbete etc. och vilken kategori den fysiska aktiviteten de väljer då tillhör (aerob aktivitet, styrketränande aktivitet, mind-body eller aktivitet i det dagliga livet). Vi utvärderade även vilken fysisk aktivitet och vilken kategori av fysisk aktivitet de fortsatte att utföra efter 12 och 24 månader. Analyserna baseras på dagböcker där patienterna själva registrerat vilka aktiviteter de utfört under 7 dagar vid baslinjen och vid 12 och 24 månader.

Studie IV inkluderade 111 patienter och jämförde funktionella tester och dess känslighet att mäta en förändring i funktion mätt ett år efter fysisk aktivitetsintervention. Test som mäter ett ben för sig jämfördes med både test som mäter båda benen samtidigt och med frågeformulär som mäter funktion.
Även de olika instrumentens samstämmighet och eventuella golv eller takefekter analyserades.


Om vården ska stötta personer med artros att öka och bibehålla fysisk aktivitet över tid kan en fördelaktig strategi vara att ge individuellt stöd att personen ska fortsätta med aktiviteter som den redan gör och trivs med samt själv tror kommer att fungera över tid. Eftersom få personer i vår studie utförde styrketränande aktivitet är en slutsats att vården tillsammans med patienten behöver utforska och hitta aktiviteter där muskelstärkande aktiviteter ingår. Uppföljningar där individuellt rådgivning om fysisk aktivitet sker över tid och där patienten får feedback från funktionella tester kan vara ett sätt att främja långsiktig fysisk aktivitet hos artrospatienten.
## Contents

Introduction ................................................................................................... 13

Background ................................................................................................... 14
  Osteoarthritis ............................................................................................ 14
  Treatment of osteoarthritis ....................................................................... 15
  Physical activity recommendations .......................................................... 15
  Assessing physical activity ....................................................................... 16
  Assessing physical function ..................................................................... 17
  Minimal clinically important difference ................................................... 17
  Theory and behaviour change .................................................................. 18
  Physical activity on prescription .............................................................. 18
  Osteoarthritis, exercise and physical activity ........................................... 19
  Rationale .................................................................................................. 21

Aims .............................................................................................................. 23
  Specific aims ............................................................................................ 23

Methods ........................................................................................................ 24
  Ethical approval ........................................................................................ 24
  Design ...................................................................................................... 24
  Participants Study I and II ........................................................................ 24
  Participants Study III ................................................................................ 25
  Participants Study IV ............................................................................... 25
  Data collection Study I and II ................................................................... 27
  Data collection Study III .......................................................................... 28
  Data collection Study IV .......................................................................... 28
  Randomisation and intervention ............................................................... 29
  Statistics ................................................................................................... 30

Results ........................................................................................................... 33
  Main findings Study I ............................................................................... 33
  Main findings Study II ............................................................................. 36
  Main findings Study III ............................................................................ 39
  Main findings Study IV ............................................................................ 41

Discussion ..................................................................................................... 43
  Main findings of this thesis ...................................................................... 43
## Abbreviations

<table>
<thead>
<tr>
<th>Abbreviation</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>ADL</td>
<td>Activity of daily living</td>
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<tr>
<td>BCT</td>
<td>Behaviour change technique</td>
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<td>BMI</td>
<td>Body mass index</td>
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<td>EQ-5D</td>
<td>EuroQoL-5 Dimension Questionnaire</td>
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<td>HOOS</td>
<td>Hip Disability and Osteoarthritis Outcome Score</td>
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<td>KOOS</td>
<td>Knee Injury and Osteoarthritis Outcome Score</td>
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<td>MET</td>
<td>Metabolic equivalent of task</td>
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<tr>
<td>QoL</td>
<td>Quality of life</td>
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<tr>
<td>SD</td>
<td>Standard deviation</td>
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<td>WHO</td>
<td>World Health Organization</td>
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<td>VAS</td>
<td>Visual Analog Scale</td>
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## Definitions

<table>
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<th>Term</th>
<th>Definition</th>
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<tr>
<td><strong>Exercise</strong></td>
<td>Subcategory of physical activity that is planned, structured, repetitive, and have the purpose to improve or maintain one or more dimensions of health related fitness [1].</td>
</tr>
<tr>
<td><strong>Health related fitness</strong></td>
<td>Includes cardiorespiratory endurance, muscular strength, muscular endurance, body composition and flexibility [1].</td>
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<tr>
<td><strong>Metabolic equivalent of task</strong></td>
<td>One MET correspond to the resting energy expenditure during quiet sitting for a standard 70 kg person, approximately 3.5 ml O2/kg/min (or 1 kcal/kg/h) [2].</td>
</tr>
<tr>
<td><strong>Performance-based test of function</strong></td>
<td>Assess different constructs of function as walking speed, stairclimbing ability, standing from sitting, balance and strength [3].</td>
</tr>
<tr>
<td><strong>Physical activity</strong></td>
<td>Any bodily movement produced by skeletal muscles that require energy expenditure [1].</td>
</tr>
<tr>
<td><strong>Sedentary behaviour</strong></td>
<td>A very low energy expenditure, such as sitting or lying down, defined as energy expenditure at the level of 1.0-1.5 metabolic equivalent units [4].</td>
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Introduction

It is well known that physical activity benefits individuals with osteoarthritis of the hips and knees. Increased physical activity improves osteoarthritis symptoms and general health [5-7]. However, there is no well-documented evidence for which method of delivery is superior in improving long-term physical activity [8-12]. This thesis focuses on individuals with osteoarthritis of the hips and knees, in relation to physical activity. Patients from primary care who had a clinical diagnosis of osteoarthritis were included and evaluated.
Background

Osteoarthritis

The complex pathogenesis of osteoarthritis involves mechanical, inflammatory and metabolic factors. An imbalance between the destruction and repair of joint tissue leads to structural changes of the joint. Osteoarthritis affects the entire joint and involves hyaline articular cartilage, subchondral bone, ligaments, capsule, synovium and muscles. There is currently no cure for osteoarthritis [13]. Pain is the predominant symptom and usually the reason for seeking treatment from the health service. Other symptoms are e.g. stiffness in the joints after sitting or lying down, joints that emit a noise, low muscle strength in the legs and impaired function such as difficulty climbing stairs or putting on socks [14, 15].

The prevalence of osteoarthritis varies depending on which definition is used and which population is evaluated [16]. Radiographic osteoarthritis is more common than clinically assessed osteoarthritis, and the prevalence is higher in patients seeking care compared to population-based cohorts, and higher in older ages compared to younger ones [16]. There is a discrepancy between radiographic osteoarthritis and clinically assessed osteoarthritis. Almost half of patients with radiographic assessed osteoarthritis have no symptoms, and almost half of patients with osteoarthritis symptoms do not have radiographic assessed osteoarthritis [17]. Osteoarthritis is the most common joint disease worldwide [18]. A Swedish cohort study reported that approximately 25% of the population aged 45 or older had doctor-diagnosed osteoarthritis in at least one joint. The most common locations were knee (13.8%), hip (5.8%) and hand (3.1%) [19]. The incidence worldwide is increasing due to an aging population, increasing obesity, joint injuries and sedentary lifestyles [13, 20]. The number of people with prevalent osteoarthritis in the Nordic countries had increased by 43% from 1990 to 2015 [20].

Risk factors for developing osteoarthritis of the hip or knee are older age, female gender, previous joint injury, heredity, low physical activity level and low muscle strength [14, 15]. Specific risk factors for developing osteoarthritis of the hip are deformities in the joint due to cam and dysplasia [21]. Obesity is a more prominent risk factor for developing osteoarthritis of the knee compared to the hip [22].
Comorbidity is common in individuals with osteoarthritis. A systematic review found that 67% of individuals with osteoarthritis had comorbidity with at least one other chronic condition, which is 20% higher than for those without osteoarthritis [23]. The key comorbidity was stroke, and other common diagnoses were metabolic syndrome, diabetes type 2, depression and Alzheimer’s disease [23]. The low level of physical activity in this population contributes to the increased risk of comorbidity [24, 25]. With a large population cohort, it was found that hip/knee osteoarthritis and self-reported difficulty walking was associated with a 30% increased hazard for cardiovascular events [26].

Treatment of osteoarthritis

As there is no cure for osteoarthritis, suggested treatments focus on reducing symptoms and slowing down functional decline [27]. Exercise therapy has at least the same pain-relieving effect as NSAID, and a 2-3 times greater effect than paracetamol in patients with knee osteoarthritis [28, 29]. The core treatment in hip and knee osteoarthritis is exercise/physical activity, patient education and weight reduction if necessary [29-32]. The treatment effect seems to be effective regardless of baseline pain intensity and radiographic severity of the osteoarthritis [33, 34]. This treatment is cost-effective for managing hip and knee osteoarthritis [35]. Patient education alone may have only a small effect on pain and function [29], but patient education combined with exercise interventions is more effective [36]. Weight-loss, even modest weight loss of 5% appears to have a significant impact on osteoarthritis symptoms if the individual is obese [37]. Combined diet and exercise produce greater weight loss than diet or exercise alone [38]. Surgery with joint arthroplasty is usually necessary if treatment with physical activity/exercise, information, weight-reduction and pain-relief drugs has been applied for 3-6 months with no effect on the osteoarthritis symptoms and if the patients have severe pain at night and during activity, impaired physical function and reduced quality of life [39].

Physical activity recommendations

Guidelines for physical activity to promote health and prevent disease in adults (aged 18-64) presented in 2010 by the World Health Organization (WHO), determined a minimum of 150 minutes per week of aerobic activity of moderate intensity or 75 minutes of vigorous intensity, or a combination of both [40]. The minimum length of sequences of moderate or vigorous physical
activity should be at least 10 minutes. In addition, muscle strengthening activities should be performed involving major muscle groups on two or more days a week. Older adults (aged 65 and above) should follow the recommendations for adults and add balance-enhancing exercise on three or more days a week to prevent falls [40]. The updated 2020 WHO guidelines for physical activity in adults have added that up to 300 minutes per week of aerobic activity of moderate intensity or 150 minutes of vigorous intensity is desirable. Moreover the minimum duration of at least 10 minutes has been removed and a recommendation to limit the amount of time spent in a sedentary position has been added [41].

Assessing physical activity

The level of physical activity can be assessed subjectively or objectively. Historically physical activity was assessed subjectively with self-reported methods such as questionnaires and diaries [42]. Today, a range of different monitors such as pedometers and accelerometers are common methods for objectively assessing physical activity [42]. Self-reported instruments are assumed to capture perceived physical activity, whereas accelerometers aim to capture the continued acceleration of the body above a certain threshold [43]. Questionnaires are easy to use in research and clinical practice but have some limitations. For example, it is well known that individuals can find it difficult to recall precisely what physical activity has been performed and at what intensity, and therefore over- or underestimate it [44].

Accelerometers are small devices that frequently assess physical activity on at least three axes. Each accelerometer model has its own algorithm to convert accelerometer counts into kilocalories (kcals) or the metabolic equivalent of tasks (METs) [44]. Assessing physical activity objectively using an accelerometer makes it possible to estimate the absolute intensity of the work by using the metabolic equivalent method (MET) [2]. Physical activity can thus be classified as: sedentary <1.5 METs; light intensity 1.5-2.99 METs; moderate-intensity 3-5.99 METs; and vigorous-intensity >6 METs [2]. A limitation of accelerometers is the difficulty of collecting information from strength training, swimming and cycling [44]. Questionnaires and accelerometers assess different aspects of physical activity. Questionnaires assess the relative intensity and accelerometers assess absolute intensity of physical activity. The results from questionnaires and accelerometers often differ [44].
Assessing physical function

Physical performance of function can be assessed both objectively by means of performance-based tests and self-reported by means of questionnaires. Both methods are recommended as they assess various aspects of function [45, 46]. Performance-based tests assess various aspects of function such as walking speed, stairclimbing ability, standing up from sitting, balance and strength. Performance-based tests assess what the individual can do and self-reported questionnaires assess what the individuals perceive they can do [46, 47]. Previous research has shown that performance-based tests are more sensitive to recognising decline in function compared to questionnaires concerning osteoarthritis [48, 49]. There is no gold standard single performance-based test for hip or knee osteoarthritis, but the Osteoarthritis Research Society International (OARSI) has recommended a core set of three tests to evaluate function. The recommend tests are: 30-second chair-stand test, 40-m walk test, and a climb test. These recommended tests are all easy to use without specialist equipment and they have displayed a high level of measurement properties [46, 50]. However, one limitation is that it is possible to compensate with the other leg if one leg has impaired function.

Patient-reported measures of function assess the same domains as performance-based tests. These questionnaires are useful from various perspectives. They capture the individual’s opinion and can be used in large populations over time, for example in patient registers [51]. Questionnaires such as the Hip Disability and Osteoarthritis Outcome Score (HOOS) [52] and the Knee Injury and Osteoarthritis Score (KOOS) [53] can assess function by means of self-reporting. Both HOOS and KOOS have five subscales: pain; other symptoms; function ADL; function sport/recreation; and quality of life. HOOS and KOOS can be used in both younger and older people with osteoarthritis, as well as before and after arthroplasty surgery, if surgery is needed. HOOS and KOOS have displayed a high level of measurement properties [52, 53].

Minimal clinically important difference

A minimal clinically important difference is defined as the smallest change in a treatment outcome that a patient would identify as important [54]. There are various methods to calculate this effect, but there is no consensus [55]. Some studies calculate a new minimal clinically important difference independently, but most studies use previous values as a measure with which to compare their results [56]. Previous studies present the minimal clinically important difference in improvement in osteoarthritis performance-based tests of function [57, 58], pain [59] and a questionnaire on osteoarthritis symptoms [53].
Theory and behaviour change

Theory explains how phenomena relate to each other, and what can be explained under unknown conditions [60]. A health behaviour theory describes principles for modification of behaviour and strategies for maintaining healthy behaviour. Physical activity is an example of a health behaviour. Commonly used theories involved in physical activity interventions are social cognitive theory [61] and the trans-theoretical constructs of Stages and Process of Change [62]. An important element in the social cognitive theory is self-efficacy. A person’s self-efficacy can be described as the person’s self-confidence in the ability to perform a certain behaviour under certain circumstances, e.g. physical activity. The degree of self-efficacy the person has in relation to physical activity in a specific situation can be decisive for whether the individual takes the initiative for an action, the level of effort, and the extent to which the individual is able to continue with the action if he/she encounters resistance [61]. The model transtheoretical constructs of Stages and Process of Change model describes how a person moves through different stages of change in their effort to change a behaviour, such as physical activity. The stages are: pre-contemplation; contemplation; action; maintenance [62].

Behaviour change technique (BCT) is the definition of the smallest active component of an intervention designed to change a behaviour [63]. Each technique can occur in more than one health behaviour theory. Michie et al. have identified and described 93 different BCTs and grouped them into 16 hierarchies [63]. The BCTs that contribute to increasing the long-term level of physical activity have been evaluated [64, 65]. In a meta-regression analysis in healthy eating and physical activity, they found that interventions with the BCTs of goal-setting, self-monitoring, feedback and review of behavioural goals were effective in the long-term [64]. A meta-analysis evaluating the long-term effect of physical activity interventions in adults with risk factors found that the BCT feedback was the most effective [65]. A review of osteoarthritis with no meta-analysis recommended goalsetting together with behavioural contracts, self-monitoring of behaviour, social support and non-specific rewards to be effective in promoting physical activity in the long-term [66].

Physical activity on prescription

The Swedish “physical activity on prescription” method is patient-centred, individualised counselling in relation to physical activity [67, 68] based on social cognitive theory [61], and the trans-theoretical model [62], and is influenced by motivational interviewing technique [69]. The mandatory active behaviour change techniques in the Swedish physical activity on prescription
method relate to goals, planning and natural consequences, i.e., goal setting, action planning, review of behaviour goals, behavioural contract and information about health consequences. Physical activity on prescription can also include optional BCTs, depending on the patient’s individual needs, as well as the prerequisites and competence of the prescriber. These might for example, be BCTs such as self-monitoring of behaviour, social support and graded tasks.

Osteoarthritis, exercise and physical activity

Low levels of physical activity are common in individuals with osteoarthritis in comparison with the general population [24, 25]. In a cohort with both hip and knee osteoarthritis patients, only 61% self-reported physical activity at the level recommended by the WHO of 150 minutes per week [40, 70]. In a meta-analysis when an accelerometer was used, only 41% of patients with knee osteoarthritis and 58% of patients with hip osteoarthritis reached 150 minutes per week [24]. Patients that reached ≥7000 steps per day, which has been suggested to correspond to 150 minutes per week [71], was for knee osteoarthritis 48% and for hip osteoarthritis 60% [24]. The level of physical activity is typically lower in people with osteoarthritis and they are more likely to have more chronic condition (i.e. comorbidities) [25], and physical activity decreases over time in older age groups [72].

The benefits of reduced osteoarthritis symptoms after exercise interventions are significant in people with hip or knee osteoarthritis. Meta-analyses have shown that the effects lasts for 2-6 months [5-7]. In people with osteoarthritis of the hip, a Cochrane Review showed clear evidence of reduced pain and improved function from exercise [6]. In people with knee osteoarthritis, a similar Cochrane Review showed evidence of reduced pain, improved function and improved quality of life from exercise [5]. A meta-analysis from 2019 including 77 trials on individuals with hip or knee osteoarthritis confirmed significant benefits of exercise on pain, function, performance and quality of life, peaking around two months after baseline, and thereafter declining to similar effects as seen in usual care at 9-18 months [7]. Studies with younger participants, those that had knee osteoarthritis, and were not awaiting joint replacement reported better effect on pain and function [7]. Thus, the long-term effects of exercise and other physical activity interventions on pain, function and quality of life are low in patients with hip or knee osteoarthritis [5-7], particular in older people [7].

In a systematic review by Juhl et al, different exercise interventions were divided into three subgroups in people with knee osteoarthritis: aerobic, resistance and performance exercise [28]. The effects on pain and general illness were similar between the different types of exercise [28]. When evaluating
pain, the standard mean difference (SMD) for aerobics was 0.67, resistance 0.62, and performance exercise 0.48 [28]. In another review by Gohl et al, exercise interventions for people with hip or knee osteoarthritis were divided into the following subgroups: aerobic, mind-body, strengthening, flexibility/skill and mixed. Aerobic exercise and mind-body exercise (Tai Chi or yoga) showed the greatest effect for improvements in pain and function [73]. Both reviews concluded that for best results, the interventions should focus on one type of exercise at a time and not mix different types [28, 73]. Juhl et al argued that the poor effect of mixed types of exercise may be explained by different molecular responses, which diminish the overall effect when several types of exercise are performed during the same session. Resistance training increases the myofibrillar protein response and aerobic exercise increases the content of mitochondria in the muscle [28]. Gohl et al argued that there is no satisfactory biological explanation for the poor efficacy of mixed exercise. It may be more difficult for patients to adhere to mixed exercise that contains several components than exercise that focuses on one type of exercise [73]. However, in the recently updated European League Against Rheumatism (EULAR) recommendations for non-pharmacological core management of hip and knee osteoarthritis, the expert panel states that mixed exercise programs should be recommended although the evidence is conflicting [74].

There are few studies that have evaluated which form of physical activity (e.g. walking, cycling, and strength training) the patients prefer when they select the activities themselves, and which activities they maintain in the long-term. However, specific exercise and physical activity interventions have been compared with respect to effect on pain and function. For example, comparisons have been made on the effect of: land-based compared to water-based [75]; high-dose versus low-dose physical activity [76, 77]; Nordic walking compared to strength training [78]; and swimming compared to cycling [79]. The results showed that land-based was better than water-based but water-based is better for some people with a lot of pain [75]; no evidence for that high-dose is better compared to low-dose [76, 77]; Nordic walking was better than strength training [78]; and swimming was similar to cycling [79]. In conclusion, no form of activity is clearly better than any other activity in improving function and reducing pain [75-77, 79]. Guidelines for individuals with osteoarthritis of the hip or knee therefore recommend individualised physical activity. The individualised counselling should focus on the patients’ needs and preferences when discussing forms and dosage of physical activity [29-32].

Physical activity can be delivered as: supervised or unsupervised; individual or group; face-to-face or online; home training or at a training facility; with booster strategies or as mixed models. Juhl et al found that, in the short-term, a supervised exercise programme performed three times a week for at least 12
sessions was more effective in reducing pain compared to fewer than 12 sessions and fewer than three times per week in people with knee osteoarthritis [28]. A systematic review by Nicolson et al found that booster sessions with a physiotherapist may improve the adherence to prescribed exercise, and that graded exercise may be beneficial [80]. Despite guidelines, it is still unclear how to best deliver exercise and physical activity interventions in detail [29-31].

However recently, general recommendations have been presented by an expert panel from 43 countries [32]. The recommendations were spread across the following 11 domains [32].

1. use an evidence-based approach
2. consider exercise in the context of living with OA and pain
3. undertake a comprehensive baseline assessment with follow-up
4. set goals
5. consider the type of exercise
6. consider the dose of exercise
7. modify and progress exercise
8. individualise exercise
9. optimise the delivery of exercise
10. focus on exercise adherence
11. provide education about OA and the role of exercise

These specific recommendations have not yet been evaluated in trials, and in the long-term there is no well-proven delivery method to increase the level of physical activity in people with hip or knee osteoarthritis [8-12].

Rationale

Exercise and physical activity are the most important modifiable factors to reduce symptoms of osteoarthritis, improve general health [5-7], and prevent comorbidity [40, 41]. It is well established that in combination with education and if necessary, weight control, exercise and physical activity is the first line treatment in patients with hip or knee osteoarthritis. However, there is no well-documented evidence for which delivery methods that improve long-term exercise and physical activity [8-12]. A need exists therefore to evaluate which interventions increase physical activity in the long-term.

Our hypothesis in Study I and II was that patients with hip or knee osteoarthritis who received physical activity as a prescription intervention would increase their physical activity to a greater extent and maintain it on a long-
term basis (up to 2 years) compared to those who received advice about physical activity. Our hypothesis in Study IV was that performance-based tests that evaluate each leg separately are more responsive to evaluate functional changes after a physical activity intervention compared to a two-leg oriented test. Study III is an exploratory descriptive study [81] that evaluates which forms of physical activity patients with hip or knee osteoarthritis prefer and maintain when they decide for themselves.
Aims

The overall aim of this thesis was to enhance knowledge of how people with osteoarthritis should be managed and supported in order to increase and maintain physical activity in the long-term.

Specific aims

1. To evaluate the *short-term effect* after six months of an individualised, patient-centered physical activity on prescription intervention compared with individualised advice, on physical activity and on the secondary outcomes of fitness/performance, pain and quality of life.

2. To evaluate the *long-term effect* after one and two years of an individualised, patient-centered physical activity on prescription intervention compared with individualised advice, on physical activity and on the secondary outcomes of fitness/performance, pain and quality of life.

3. To evaluate what *forms* (i.e. walking, swimming) of physical activity people with hip or knee osteoarthritis prefer when they select the activities themselves and which forms they maintain one and two years after an individualised intervention. Another aim was to evaluate what *type* (i.e. aerobic, muscle strength) the patients select themselves and whether there are differences in gender and the characteristics of patients in different forms of activities.

4. To compare the responsiveness of two performance-based tests that evaluate each leg separately in hip or knee osteoarthritis, i.e. the one-leg rise test and the maximal step-up test, with the bilateral 30-second chair-stand test and a self-reported questionnaire on physical function (HOOS/KOOS). Other aims were to evaluate floor/ceiling effect and association between the instruments.
Methods

Ethical approval
The Regional Ethical Review Board Uppsala (number 2010-001 and 2022-06838-02) has ethically approved this clinical trial. Written informed consent was obtained from all patients before participation in the study.

Design
Study I and II were based on 141 patients with osteoarthritis of the hip or knee. The design was a parallel randomised experimental group design. Study I was a short-term follow-up study six months after baseline. Study II was a long-term follow-up study, 12 and 24 months after baseline.

Studies III and IV are both longitudinal follow-up studies in which the two study arms from the RCT were combined to a single group. In Study III, 94 patients were followed-up 12 and 24 months after baseline and in Study IV, 111 patients were followed-up 12 months after baseline.

Participants Study I and II
Patients were recruited from seven different primary care health centres in a medium sized town in the central Sweden. The healthcare professionals informed patients about the study if the patient sought care for pain in hip or knee. If they were willing to participate in the study, a physiotherapist at the health care centre assessed the inclusion and exclusion criteria [82].

Patients were included with a verified clinical diagnosis of osteoarthritis in hip [83] or knee [84], insufficient level of physical activity [40] and aged 40 to 74. A clinical diagnosis requires at least 1 of the risk factors, 3 symptoms, and 1-3 clinical findings [83, 84]. An overview of the clinical diagnosis is shown in Table I.
Table I. Clinically verified diagnosis

<table>
<thead>
<tr>
<th>Risk factors (1)</th>
<th>Hip</th>
<th>Knee</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age &gt;40 years, female gender, obesity, overload during work or leisure time, heredity, previous joint damage</td>
<td>Age &gt;40 years, female gender, obesity, overload during work or leisure time, heredity, previous joint damage</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Symptoms (3)</th>
<th>Hip</th>
<th>Knee</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pain in the hip, stiffness after inactivity, decreased function</td>
<td>Pain in the knee, stiffness after inactivity, decreased function</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Clinical findings (1-3)</th>
<th>Hip</th>
<th>Knee</th>
</tr>
</thead>
<tbody>
<tr>
<td>Reduced flexion, reduced internal rotation, pain in internal rotation</td>
<td>Crepitus, restricted movement, bone enlargement</td>
<td></td>
</tr>
</tbody>
</table>

Insufficient level of physical activity was defined as not fulfilling the WHO recommendation on physical activity, i.e. self-reported physical activity ≤150 minutes at moderate intensity or ≤75 minutes at vigorous intensity per week, or a combination of the two, in the previous month [40]. The level of physical activity was assessed by a validated questionnaire called “Activity Minutes” [85, 86].

Patients were excluded if they reported being diagnosed with hip fracture, hip or knee replacement, severe meniscal injury with locking, severe cruciate ligament injury with instability, back injury with pain in the leg, rheumatoid arthritis, severe cancer, severe cardiovascular disease, inability to perform physical activity or if they did not understand Swedish. The characteristics of the final participating population is described in Table II.

Participants Study III

Eligible for the study were patients included in Study I and II and who had completed the diary with form of physical activity at baseline, and at 12 and 24 months. Forty-eight participants were included from the part of the study that received advice and 46 participants from the part of the study that received physical activity on prescription. A total of 94 patients were included in this study and they were managed as a single study group (Table II).

Participants Study IV

Eligible for the study were patients included in Study I and II and who had complete data at baseline and at 12 months from the HOOS [52] and KOOS [53] questionnaires and the three performance-based tests: maximal step-up test [87], one-leg rise tests [88], and 30-second chair-stand test [46]. Fifty-
eight participants were included from the part of the study that received advice and 53 participants from the part of the study that received physical activity on prescription. A total of 111 patients were included in this study and they were managed as a single study group (Table II).

**Table II.** Background characteristics of participants Study I, II, III, and IV.

<table>
<thead>
<tr>
<th>Variables</th>
<th>Study I, II n=141</th>
<th>Study IV n=111</th>
<th>Study III n=94</th>
</tr>
</thead>
<tbody>
<tr>
<td>Women, n (%)</td>
<td>102 (72)</td>
<td>81 (73)</td>
<td>68 (72)</td>
</tr>
<tr>
<td>Age (years), mean (SD)</td>
<td>60.3 (8.3)</td>
<td>61.3 (8.3)</td>
<td>62.0 (8.2)</td>
</tr>
<tr>
<td>BMI (kg/m²), mean (SD)</td>
<td>30.8 (4.8)</td>
<td>30.2 (4.2)</td>
<td>30.2 (4.4)</td>
</tr>
<tr>
<td>Location osteoarthritis</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Hip, n (%)</td>
<td>37 (26)</td>
<td>31 (28)</td>
<td>26 (28)</td>
</tr>
<tr>
<td>Knee, n (%)</td>
<td>104 (74)</td>
<td>80 (72)</td>
<td>68 (72)</td>
</tr>
<tr>
<td>Radiographic OA severity a, n (%)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Score 0-2</td>
<td>113 (82)</td>
<td>99 (90)</td>
<td>83 (89)</td>
</tr>
<tr>
<td>Score 3-4</td>
<td>24 (18)</td>
<td>11 (10)</td>
<td>10 (11)</td>
</tr>
<tr>
<td>Comorbidity</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Depression, n (%)</td>
<td>11 (8)</td>
<td>9 (8)</td>
<td>6 (6)</td>
</tr>
<tr>
<td>Heart disease b, n (%)</td>
<td>23 (16)</td>
<td>20 (18)</td>
<td>19 (20)</td>
</tr>
<tr>
<td>Asthma/COOPD, n (%)</td>
<td>12 (9)</td>
<td>10 (9)</td>
<td>10 (11)</td>
</tr>
<tr>
<td>Severe obesity, BMI&gt;35, n (%)</td>
<td>22 (16)</td>
<td>13 (12)</td>
<td>12 (13)</td>
</tr>
<tr>
<td>Severe pain c, n (%)</td>
<td>7 (5)</td>
<td>5 (4)</td>
<td>5 (5)</td>
</tr>
<tr>
<td>Diabetes mellitus, n (%)</td>
<td>7 (5)</td>
<td>5 (4)</td>
<td>5 (5)</td>
</tr>
<tr>
<td>Life style self-reported</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Current smoker, n (%)</td>
<td>13 (9)</td>
<td>10 (9)</td>
<td>7 (7)</td>
</tr>
<tr>
<td>Physical activity &lt;150 minutes/week d, n (%)</td>
<td>107 (76)</td>
<td>85 (77)</td>
<td>69 (73)</td>
</tr>
<tr>
<td>Education</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Elementary school, n (%)</td>
<td>45 (32)</td>
<td>35 (32)</td>
<td>30 (32)</td>
</tr>
<tr>
<td>High school, n (%)</td>
<td>67 (47)</td>
<td>52 (47)</td>
<td>44 (47)</td>
</tr>
<tr>
<td>College/University, n (%)</td>
<td>29 (21)</td>
<td>24 (21)</td>
<td>20 (21)</td>
</tr>
</tbody>
</table>

a Scores on the Kellgren-Lawrence scale range from 1-4, higher scores indicate more severe diseases. bHeart disease: myocardial infarction, angina pectoris or heart failure. cSevere pain not due to knee/hip. dPhysical activity selfreported, <150 minutes/week of moderate or <75 minutes/week of vigorous physical activity.
Data collection Study I and II

Baseline characteristic
An X-ray examination was performed on the affected joint at baseline and after two years. The aim was to ensure the diagnosis of osteoarthritis i.e. to exclude other diagnoses and grade osteoarthritis [89]. Height was measured with a stadiometer. Weight was measured without shoes and with indoor clothing (Tanita model BC-420 MA). A weight of 0.5 kilograms was subtracted for the weight of the clothes.

Physical activity
Objective physical activity was measured with an accelerometer (Sense Wear Armband Mini MF-SW, Pittsburgh, USA) [90] (Figure 1), using SenseWear Armband software 9.0 for the analyses. Data collected from the accelerometer were considered valid and were included in the analyses if the wear time was at least 90 percent over a period of four or more days. For time in sedentary, all minutes were added together from which a total sleep time of 450 minutes (7.5 hours) was subtracted. Self-reported physical activity was assessed by means of three questionnaires. The questionnaires were: Activity Minutes, which evaluate physical activity in an ordinary week by asking about time spent in exercising and time spent in physical activity in daily life [85]; Leisure time physical activity in the past year [91]; and sitting-time, which evaluated time in sitting with a single question from the IPAQ instrument [92].

Osteoarthritis symptoms
Osteoarthritis symptoms were self-reported by the Hip Disability and Osteoarthritis Outcome Score (HOOS) [52] and by the Knee Injury and Osteoarthritis Outcome Score (KOOS) [53]. HOOS/KOOS has five subscales: 1.pain 2.other symptoms 3.activity of daily living (ADL) 4.activity in sport and recreation and 5.quality of life. Each subscale ranges from 100 (best) to 0 (worst).

Quality of life and pain
General health related quality of life was assessed using EuroQol-5D (EQ-5D) and EuroQol-VAS rating scale (EQ-VAS) [93]. Pain after walking for 6 minutes was assessed with a Visual Analogue Scale (VAS), 0-100 mm [94].

Performance-based tests
Cardiorespiratory capacity was measured with a 6-minute walk test [95]. Lower-limb physical function was measured by means of three different tests: 30-s chair-stand test [96] (Figure 2), maximal step-up test [87] (Figure 3), and one-leg rise test [88] (Figure 4).
Data collection Study III

**Participant characteristic**
Age, gender, length, weight, BMI, affected joint and grade of osteoarthritis measured with x-ray were assessed at baseline. Six-minute walk test [95], 30-second chair-stand test [96] and maximal step-up test [87] were measured at 24 months.

**Physical activity**
The patients themselves registered which activities they had undertaken every day in a 7-day physical activity diary. They recorded the form of activity, cycling and skiing for example, as well as perceived exertion. A valid session was defined as a session lasting at least 10 minutes at an exertion of at least 11 (light exertion) on the Borg scale (0-20) [97].

Data collection Study IV

**Physical function measured with questionnaire**
Physical function was self-reported in the Hip Disability and Osteoarthritis Outcome Score (HOOS) [52] and the Knee Injury and Osteoarthritis Outcome Score (KOOS) [53]. We used the “activity of daily living” (ADL) subgroup for evaluation and comparison. The other subgroups being pain, other symptoms, sport/recreation and quality of life.

**Physical function measured with performance-based tests**
Lower limb physical function was measured by means of three different tests: maximal step-up test [87] (Figure 2), 30-s chair-stand test [96] (Figure 3), and one-leg-rise test [88] (Figure 4).
Randomisation and intervention

Block randomisation was used. Sealed and opaque envelopes in groups of 10, five each for prescription and advice groups were prepared by the assessor who was not involved in the intervention, and distributed to each primary health care centre. The physiotherapist at the health care centre opened the envelope before the intervention was to be performed.

The prescription group received information about osteoarthritis and the importance of physical activity and weight control, (the same information as the advice group, described below). The information was both oral and in a brochure [98]. The BCT identified was information about health consequences [63]. Patients in the prescription group met the physiotherapist face to face for a 1-hour session and received counselling about physical activity, which resulted in a plan for specific modes of physical activity and an individualised written prescription [99, 100]. After a discussion with the physiotherapist, each patient set an individual goal that he/she felt was possible to achieve (goal-setting, behavioural). It was consequently not a goal to reach 150 minutes per week of physical activity, but rather a goal in relation to the patient’s behaviour. For example, “being able to play with my grandchildren” or “being able to walk up the stairs”. The written prescription summarised the goal (goal-setting, behaviour) and the determined activities (action-planning). The planned type, dose, frequency and intensity were written on the prescription. The patients in the prescription group recorded activities performed on
the back of the prescription (self-monitoring). Follow-ups were included at three weeks and three months either by telephone or face to face with the physiotherapist (15-60 minutes), depending on each patient’s needs. A mandatory return visit was held after six months (60 minutes). The patient and physiotherapist together evaluated the physical activity the patient had or had not performed. Sometimes a new goal and new activities were planned (review of behaviour goals, graded tasks). Participants were also offered a booster session, in groups of 5-8 subjects on physical activity, weight control and osteoarthritis (information about health consequences). This was a 60-minute session and took place approximately 12 weeks after the first intervention. The time spent face to face and in the group session with a physiotherapist was 150 to 300 minutes. In summary, based on the International Consensus for the Reporting of Behaviour Change Interventions [63], the techniques for behavior change identified in the prescription group were: information about health consequences, goal-setting behavioural, self-monitoring, review of behaviour goals, graded tasks.

The advice-group received information about osteoarthritis and the importance of physical activity and weight control (same as the prescription group). The information was both oral and in a brochure [98]. The BCT identified was information about health consequences [63]. The patients only met the physiotherapist face to face for a 1-hour session, and received oral advice on how to perform cardiorespiratory physical activities three times per week for at least 30 minutes. They would were allowed to undertake an activity they preferred. They were also advised to add muscle-strengthening activities to their everyday life (for example, climbing stairs and focusing on the legs when rising from a chair). Based on the International Consensus for the Reporting of Behaviour Change Interventions [63], the behaviour change techniques identified in the advice group were goal setting (outcome) and information about health consequences [63].

Statistics

The level of significance was set to p <0.05 in all four studies. SPSS, version Statistic 22 (SPSS Inc., Chicago, IL, USA) was used in study I, and Jamovi version 1.6 15.0 (IBM, New York, USA, https://www.jamovi.org) was used for analyses in Studies II, III, and IV.

Power calculation

A power calculation was based on a similar previous study that used accelerometry to measure steps per day [101]. The purpose was to ensure sufficient statistical power for the analysis of the effects of physical activity measured as steps per day with an accelerometer. We assumed a mean difference
of 800 steps between the physical activity of the prescription group and the advice group in treatment effect, a standard deviation within group of 1700 steps, and a correlation of 0.75 between assessments of the same person before and after the interventions. A two-tailed t-test on the difference in effect between the two groups had the aim of achieving a target power of 80 percent (p=0.05) with a sample size of approximately 70 patients per group.

**Descriptive data**

Descriptive statistics were used to present group characteristics. Data were presented for normally distributed numerical data as mean and standard deviation or 95 percent confidence intervals (95% CI); skew distributed data were presented as median and interquartile ranges or 95% CI; categorical data were presented as counts and percentages (Study I, II, III, IV).

**Intention to treat**

Analyses followed the intention-to-treat principle and included all participants who were randomised, and analysed all data according to the group to which they were originally assigned [102] (Study I and II).

**Missing data**

If data were missing at the 6-month assessments, the patient’s own value from baseline was imputed. We used the last case carried forward method [102]. If data were missing at baseline, the patient’s own value from the six-month follow-up was imputed (Study I). In Study II, when using the linear mixed modelling we did not imputed missing data as the participants appeared to be either missing completely at random or missing at random [103]. In addition in Study II, when evaluating the moderate/vigorous physical activity assessed by accelerometer we used the last case carried forward method [102].

**Comparison between groups**

The change between groups was analysed using the Welch t-test in normally distributed data and in the event of skewed outcomes, with the Mann-Whitney U-test in all analyses in Study I. In study II we used a linear mixed modelling to account for repeated measures in the outcomes; activity minutes per week, steps per day, six-minute walk distance, repetitions in the 30-second chair-stand test, maximal step-up height, pain and quality of life [103]. The model included time (baseline, 6, 12 and 24 months) and group (physical activity on prescription or advice) as categorical fixed factors, interactions between time and group, random intercepts, and an unstructured covariance matrix. Marginal means were computed based on the estimated coefficients in the linear mixed models and presented with 95 percent confidence intervals (Study II). In Study II we also analysed change between groups in accelerometer assessed
moderate and vigorous physical activity using the Welch t-test in normally distributed data and the Mann-Whitney U-test in skewed outcomes. In Study III, data was summarised, organised, and described in relation to the form and type of physical activity chosen by the patients. The differences in characteristics between groups were assessed with chi-square or Fischer’s test in categorical variables, and with independent two-tailed test or Mann Whitney U test in numerical data (Study III).

**Comparison within groups**

The change from baseline to follow-up within group was tested using the paired t-test in normally distributed numerical data and using Wilcoxon’s signed-rank test in skewed data, as well as by means of linear mixed model (Study I and II). The effect size was calculated in Study IV, when the effects from baseline to follow-up were evaluated in various functional measurements.

**Effect size**

Cohen’s $d$, known as standardised mean difference (SMD), was used in study IV to measure effect size and subsequently compare the responsiveness of change between instruments. Cohen's $d$ is defined as the difference between two means divided by a standard deviation for the data. The difference used was the paired mean values from baseline and 12 months follow-up and the paired standard deviation. The statistical difference between effect sizes in the tests were evaluated using a bootstrap method comparing the respective standardised effect sizes in 10,000 bootstrap samples. Effect size was considered as small ($d=0.20-0.49$), medium ($d=0.50-0.79$) or large ($d=\geq0.8$) [104, 105] (Study IV).

**Correlation**

Correlation between performance-based tests and HOOS/KOOS questionnaire was analysed at baseline and at 12 months using Pearson’s correlation coefficient. Definition of the correlations were; negligible 0.00-0.09, small 0.10-0.29, moderate 0.30-0.49 and strong $>0.5$ [106] (Study IV).

**Minimal clinically important difference**

A minimal clinically important difference in change was evaluated [54], and set to a change of $\geq 14.0$ m in the six-minute walk test [57], a decrease of $\geq 19$ mm in the Visual Analogue Scale [59], a change of $\geq 2.0$ repetitions in the 30-second chair-stand test [58], a change of $\geq 10$ points in the HOOS/KOS [53] and a change of $\geq 0.08$ in the EQ-5D [107] (Study I and II).
Results

Main findings Study I

A total of 141 patients underwent randomisation, 72 to the prescription group and 69 to the advice group. There were no between-group differences in background characteristics. Sixty-one and 59 patients, respectively, were followed up at six months (Figure 5). Of these patients, all had valid data in the questionnaires and in the fitness tests and valid accelerometer-assessed data was available for 58 and 55 patients, respectively [82] (Figure 5).

In the primary outcome, physical activity, we found no differences in change between groups from baseline to six months, neither in self-reported nor accelerometer assessed physical activity (Table III). The physical activity level assessed with an accelerometer (minutes in moderate/vigorous physical activity and steps/day) did not increase after the intervention, although patients in both groups assessed themselves as more physically active in the questionnaires. There were no differences between groups in self-reported sitting time or in accelerometer’s estimated time in sedentary at six months (Table III).

Regarding pain after walking, there was a difference in favor of the prescription group after the six-minute walk test (p=0.016 between groups). The prescription group decreased from VAS 31 (95% CI 26-36) at baseline to VAS 18 (95% CI 13-23) at six months and the advice group decreased from VAS 26 (95% CI 21-31) to VAS 23 (95% CI 18-28). There were no significant differences between the groups in any of the other secondary outcomes (six-minute walk test, 30-second chair-stand test, maximal step-up test, one-leg rise test, HOOS/KOOS questionnaires or the EQ-5D questionnaire) [82].
Figure 5. Enrollment, randomization, drop-out and follow-up at 6, 12 and 24 months.

a One person who dropped out after 6 months, due to cancer in the family, returned to the study.

b One person who dropped out after six months due to work in another city, returned to the study.
Table III. Physical activity and sedentary time, self-reported and accelerometer assessed, at baseline and at 6 months, between group comparisons from baseline to 6 months.

<table>
<thead>
<tr>
<th></th>
<th>Prescription group (n=72)</th>
<th>Advice-group (n=69)</th>
<th>p-value between-groups</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Self-reported physical activity,</strong>&lt;br&gt;<strong>median (95% CI) in activity minutes, mean (95% CI) in sitting time</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Activity minutes/week</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>baseline</td>
<td>105 (75-120)</td>
<td>75 (75-105)</td>
<td></td>
</tr>
<tr>
<td>6 months</td>
<td>165 (135-218)</td>
<td>150 (120-225)</td>
<td>0.264</td>
</tr>
<tr>
<td><strong>Sitting time, h/day</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>baseline</td>
<td>7.8 (7.1-8.5)</td>
<td>7.2 (6.6-7.9)</td>
<td></td>
</tr>
<tr>
<td>6 months</td>
<td>6.5 (5.9-7.1)</td>
<td>6.1 (5.4-6.8)</td>
<td>0.709</td>
</tr>
<tr>
<td><strong>Accelerometer assessed physical activity, median (95% CI)</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>MVPA$^a$, ≥10 min bouts, min/day</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>baseline</td>
<td>31 (22-43)</td>
<td>31 (26-37)</td>
<td></td>
</tr>
<tr>
<td>6 months</td>
<td>35 (27-36)</td>
<td>30 (30-40)</td>
<td>0.253</td>
</tr>
<tr>
<td>MVPA, total min/day</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>baseline</td>
<td>70 (29-77)</td>
<td>62 (32-70)</td>
<td></td>
</tr>
<tr>
<td>6 months</td>
<td>69 (29-78)</td>
<td>60 (31-71)</td>
<td>0.821</td>
</tr>
<tr>
<td>LIPA$^b$, min/day</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>baseline</td>
<td>225 (203-252)</td>
<td>220 (190-232)</td>
<td></td>
</tr>
<tr>
<td>6 months</td>
<td>218 (195-247)</td>
<td>215 (205-221)</td>
<td>0.692</td>
</tr>
<tr>
<td>Sedentary$^c$, h:min/day</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>baseline</td>
<td>10:52 (10:22-11:30)</td>
<td>11:20 (10:49-11:34)</td>
<td></td>
</tr>
<tr>
<td>6 months</td>
<td>10:40 (10:15-11:37)</td>
<td>11:20 (10:56-11:34)</td>
<td>0.704</td>
</tr>
<tr>
<td>Steps/ day</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>baseline</td>
<td>7531 (6358-8589)</td>
<td>7161 (6940-7947)</td>
<td></td>
</tr>
<tr>
<td>6 months</td>
<td>7715 (6263-8477)</td>
<td>6972 (6267-7722)</td>
<td>0.505</td>
</tr>
</tbody>
</table>

$^a$MVPA= Moderate and vigorous physical activity, ≥3 METs  
$^b$LIPA= light intensity physical activity, 1.5-2.99 METs  
$^c$Sedentary <1.5 METS
Main findings Study II

Out of 141 patients originally included, 111 patients (79%) were followed up at 12 months and 107 patients (76%) at 24 months. Valid data on physical activity measured by accelerometer were available for 74% of the participants at 12 months and for 70% at 24 months. There were no between-group differences in background characteristics. There were only minor differences in change between the two groups in primary and secondary outcomes at 12 and 24 months (Table IV).

In self-reported physical activity, there was no difference in change between groups at 12 months, but at 24 months the advice group had increased their physical activity with 66 minutes more (95% CI 65-67) per week than the prescription group (p=0.01 between groups; Table IV, Figure 6). Objectively assessed physical activity measured as steps per day was about 7500 steps per day at baseline in both groups and stayed stable from baseline to 12 months, subsequently decreasing to about 6800 steps per day. From baseline to 24 months both groups decreased significantly, the prescription group by -852 (95% CI -804 - -900) steps per day and the advice group by -514 (95% CI -462 - -567) steps per day (p=0.415 between groups) (Table IV).

Pain HOOS/KOOS was reduced from baseline to 12 months in both groups (p<0.05), however, from baseline to 24 months the prescription group decreased significantly more than the advice group (p=0.024 between groups). In the other secondary outcomes i.e. for functional tests and quality of life, there was no difference between groups (Table IV).

At 24 months, approximately 40% of patients in both groups showed a clinically meaningful improvement in physical function measured as six-minute walk test (≥ 14m improvement) [57], and 30-second chair-stand test (≥ 2 numbers improvements) [58]. About 30% in both groups showed clinically meaningful improvements in pain and quality of life (≥ 10 points improvement in HOOS/KOOS) [53].
Table IV

Effects of prescription and advice interventions at baseline, 6, 12 and 24 months, and differences in change from baseline to 24 months, in physical activity (activity minutes per week and steps per day), physical performance (six-minute walk test, 30-s chair stand test and maximal step-up test), pain and quality of life. Estimated marginal means and 95% CI from a linear mixed model.

<table>
<thead>
<tr>
<th></th>
<th>Prescription group</th>
<th>Advice group</th>
<th>Mean difference</th>
<th>p-value*</th>
<th>0-24 months a</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Baseline</td>
<td>6 months</td>
<td>12 months</td>
<td>24 months</td>
<td>Baseline</td>
</tr>
<tr>
<td>Activity minutes per week</td>
<td>130 (103-157)</td>
<td>185 (155-214)*</td>
<td>176 (145-207)*</td>
<td>176 (145-207)*</td>
<td>102 (74-130)</td>
</tr>
<tr>
<td>Steps per day</td>
<td>7636 (6895-8377)</td>
<td>7813 (7038-8589)</td>
<td>7543 (6755-8332)</td>
<td>6784 (5995-7573)*</td>
<td>7361 (6601-8121)</td>
</tr>
<tr>
<td>Six-minute walk test (m)</td>
<td>501 (482-521)</td>
<td>526 (506-547)*</td>
<td>526 (505-547)*</td>
<td>523 (502-544)*</td>
<td>510 (490-530)</td>
</tr>
<tr>
<td>30-s chair-stand test (n)</td>
<td>11.3 (10.6-12.2)</td>
<td>12.4 (11.6-13.3)*</td>
<td>12.6 (11.8-13.5)*</td>
<td>13.3 (12.4-14.1)*</td>
<td>11.4 (10.6-12.2)</td>
</tr>
<tr>
<td>Maximal step-up test (cm)</td>
<td>22.1 (20.6-25.3)</td>
<td>25.1 (23.5-26.7)*</td>
<td>26.1 (24.5-27.8)*</td>
<td>26.6 (25.0-28.2)*</td>
<td>23.7 (22.2-25.3)</td>
</tr>
<tr>
<td>HOOS/KOOS pain (points)</td>
<td>53.0 (48.5-57.5)</td>
<td>66.0 (61.3-70.7)*</td>
<td>66.2 (61.3-71.1)*</td>
<td>67.7 (62.8-72.6)*</td>
<td>53.7 (49.2-58.3)</td>
</tr>
<tr>
<td>HOOS/KOOS quality of life (points)</td>
<td>40.0 (35.4-44.6)</td>
<td>52.5 (47.6-57.3)*</td>
<td>53.9 (48.8-58.9)*</td>
<td>54.9 (49.9-60.0)*</td>
<td>37.7 (33.0-42.4)</td>
</tr>
</tbody>
</table>

*24-months follow-up compared to baseline between group difference [linear mixed-model]. *=p<0.05 in group from baseline

Table IV was first shown in Clinical Rehabilitation 2024: doi.org/10.1016/j.joca.2024.03.111
Figure 6. Estimated marginal means from a linear mixed effects model in patients with hip or knee osteoarthritis at baseline, 6, 12 and 24 months (n=141 at baseline, n=120 at six months, n=111 at 12 months, n=107 at 24 months). *p<0.05 between groups from baseline).
Main findings Study III

Of the 94 patients, walking was the most frequent form of physical activity that osteoarthritis patients self-selected and maintained after one and two years. Women walked >4 times/week and men 3-4 times/week. Everyday activity and cycling were performed 2-3 times/week (Table V). Walking was the form of physical activity most frequently maintained by the same patient at all three time points (50%) (Table V). Of the 47 patients who reported walking at all three time points, 12 of them also reported that another physical activity was performed concurrently at all three time points (everyday activity (5), cycling (4), strength training (2) and other activity/boule (1).

Table V. Forms of physical activity grouped together, and number of patients with hip or knee osteoarthritis at baseline and at 1 and 2 years.

<table>
<thead>
<tr>
<th></th>
<th>Baseline sessions</th>
<th>1 year sessions</th>
<th>2 year sessions</th>
<th>Same activity all three times n=94</th>
</tr>
</thead>
<tbody>
<tr>
<td>Walking a</td>
<td>250 (60)</td>
<td>286 (63)</td>
<td>254 (62)</td>
<td>47 (50%)</td>
</tr>
<tr>
<td>Everyday activities b</td>
<td>37 (21)</td>
<td>54 (25)</td>
<td>58 (31)</td>
<td>12 (13%)</td>
</tr>
<tr>
<td>Cycling c</td>
<td>34 (13)</td>
<td>56 (22)</td>
<td>81 (26)</td>
<td>5 (5%)</td>
</tr>
<tr>
<td>Strength training d</td>
<td>26 (14)</td>
<td>28 (16)</td>
<td>40 (18)</td>
<td>2 (2%)</td>
</tr>
<tr>
<td>Water-activities e</td>
<td>1 (1)</td>
<td>7 (4)</td>
<td>5 (4)</td>
<td>0</td>
</tr>
<tr>
<td>Mind-body f</td>
<td>1 (1)</td>
<td>4 (3)</td>
<td>5 (4)</td>
<td>0</td>
</tr>
<tr>
<td>Other activities g</td>
<td>10 (9)</td>
<td>12 (8)</td>
<td>9 (7)</td>
<td>1 (1%)</td>
</tr>
<tr>
<td>No activity</td>
<td>0 (23)</td>
<td>0 (14)</td>
<td>0 (10)</td>
<td>4 (4%)</td>
</tr>
<tr>
<td>Total number of sessions</td>
<td>359</td>
<td>447</td>
<td>452</td>
<td></td>
</tr>
</tbody>
</table>

aWalking= walking, Nordic-walking, treadmill walking. bEveryday activities= gardening, shovelling snow, cleaning the house, painting the house, washing the car, carpentry, chopping firewood, shopping. cCycling= outdoor and indoor cycling. dStrength training= gym-training, strength training, exercise programme. eWater activities= swimming, water training. fMind-body= yoga, Qigong. gOther activities= jogging, skiing, skating, dance, Zumba, riding, boule, bowling, curling.

For women, 73.5% undertook walking at baseline and 73.5% at two years. For men, 38.5% preferred walking at baseline and 46.2% at two years. Men also preferred everyday activity and cycling, with 50.0% and 42.3% respectively at two years (Table VI).
Table VI. Number of sessions and number of women and men with hip or knee osteoarthritis in the most common forms of physical activity, in patients participating in an individualised physical activity intervention, reported at baseline and after one and two years.

<table>
<thead>
<tr>
<th>Form of activity</th>
<th>Overall n=94</th>
<th>Women n=68</th>
<th>Men n=26</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>sessions</td>
<td>n (%)</td>
<td>sessions</td>
</tr>
<tr>
<td>Walkin</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Baseline</td>
<td>250</td>
<td>60 (63.8)</td>
<td>217</td>
</tr>
<tr>
<td>1 year</td>
<td>286</td>
<td>63 (67.0)</td>
<td>238</td>
</tr>
<tr>
<td>2 year</td>
<td>254</td>
<td>62 (66.0)</td>
<td>217</td>
</tr>
<tr>
<td>Everyday activity</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Baseline</td>
<td>37</td>
<td>21 (22.3)</td>
<td>17</td>
</tr>
<tr>
<td>1 year</td>
<td>54</td>
<td>25 (26.6)</td>
<td>33</td>
</tr>
<tr>
<td>2 year</td>
<td>68</td>
<td>31 (33.0)</td>
<td>37</td>
</tr>
<tr>
<td>Cycling</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Baseline</td>
<td>34</td>
<td>13 (13.8)</td>
<td>28</td>
</tr>
<tr>
<td>1 year</td>
<td>56</td>
<td>22 (23.4)</td>
<td>43</td>
</tr>
<tr>
<td>2 year</td>
<td>81</td>
<td>26 (27.7)</td>
<td>47</td>
</tr>
<tr>
<td>Strength training</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Baseline</td>
<td>26</td>
<td>14 (14.9)</td>
<td>22</td>
</tr>
<tr>
<td>1 year</td>
<td>28</td>
<td>16 (17.0)</td>
<td>26</td>
</tr>
<tr>
<td>2 year</td>
<td>40</td>
<td>18 (19.1)</td>
<td>28</td>
</tr>
</tbody>
</table>

aWalking= walking, Nordic-walking, treadmill walking. bEveryday activities= gardening, shoveling snow, cleaning the house, painting the house, washing the car, carpentry, chopping firewood, going shopping. cCycling= outdoor and indoor cycling. dStrength training= gym-training, strength training, exercise programme. e p-value= between groups, compares the number of women and men at 2 years in the different forms of activity.

The most frequent type of physical activity was aerobic training/activity. At two years 349 sessions of aerobic physical activity were recorded in a week by the 94 patients included, compared to 58 sessions of everyday activity, 40 sessions of strength training and 5 sessions of body-mind activity.

We found differences in characteristics between patients that preferred walking compared to patients that did not walk. Walkers comprised significantly more women, they were older and also weaker in the affected leg when measured with the maximal-step-up test. There were no differences between walkers and non-walkers in BMI, location of the affected joint (hip or knee), grade of osteoarthritis, reported pain, walking distance completed in the six-minute walk test and performance in the 30-second chair-stand test (Table VII).
### Table VII. Characteristics of walkers and non-walkers of 94 patients with hip or knee osteoarthritis participating in an individualised physical activity intervention, compared at baseline (age, gender, body mass index, affected joint, radiographic severity) and after 2 years (function, pain).

<table>
<thead>
<tr>
<th>Characteristics</th>
<th>Overall (n=94)</th>
<th>Walkers (n=62)</th>
<th>Non-walkers (n=32)</th>
<th>Between-group P-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age, mean (SD)</td>
<td>62.0 (8.2)</td>
<td>64.1 (7.6)</td>
<td>57.9 (7.7)</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>Women, n (%)</td>
<td>68 (72.3)</td>
<td>50 (73.5)</td>
<td>18 (26.5)</td>
<td>0.012</td>
</tr>
<tr>
<td>BMI, mean (SD)</td>
<td>30.2 (4.4)</td>
<td>30.2 (4.4)</td>
<td>30.3 (4.5)</td>
<td>0.891</td>
</tr>
<tr>
<td>Affected joint/ knee OA, n (%)</td>
<td>68 (72.3)</td>
<td>43 (69.4)</td>
<td>25 (78.1)</td>
<td>0.468</td>
</tr>
<tr>
<td>Radiographic OA severity*, grade 3-4, n (%)</td>
<td>10 (10.6)</td>
<td>8 (12.9)</td>
<td>2 (6.3)</td>
<td>0.519</td>
</tr>
<tr>
<td>30-s chair-stand test, n, mean (SD)</td>
<td>13.5 (3.7)</td>
<td>13.0 (3.5)</td>
<td>14.4 (3.9)</td>
<td>0.095</td>
</tr>
<tr>
<td>Maximal step-up height, cm, mean (SD)</td>
<td>26.9 (6.7)</td>
<td>25.6 (6.2)</td>
<td>29.5 (6.8)</td>
<td>0.010</td>
</tr>
<tr>
<td>Six-minute walk distance, meter, mean (SD)</td>
<td>531 (96)</td>
<td>520 (94)</td>
<td>555 (98)</td>
<td>0.113</td>
</tr>
<tr>
<td>Pain (VAS) after walking six-minute, (IQR)</td>
<td>5.0 (25.0)</td>
<td>5.5 (30.3)</td>
<td>3.5 (24.0)</td>
<td>0.529</td>
</tr>
<tr>
<td>Pain (HOOS/KOOS), 0-100, median (IQR)</td>
<td>63.9 (36.1)</td>
<td>68.7 (35.0)</td>
<td>63.0 (36.9)</td>
<td>0.389</td>
</tr>
</tbody>
</table>

*Scores on the Kellgren-Lawrence scale range from 0-4, higher scores indicate more severe disease. Abbreviations: SD= standard deviation. OA= osteoarthritis. BMI= body mass index. VAS= visual analogue scale, ranges from zero (best) to 100 (worst). HOOS= Hip disability and Osteoarthritis Outcome Score. KOOS=Knee injury and Osteoarthritis Outcome Score, ranges from 100 (best) to zero (worst).

### Main findings Study IV

The most responsive performance-based test to measure an improvement from baseline to one year in individuals with osteoarthritis in hip or knee was the maximal step-up test. The effect sizes were for the HOOS/KOOS questionnaire 0.65 (0.95% CI 0.44, 0.85) which was considered as a medium effect; maximal step-up test 0.57 (95% CI 0.37, 0.77) also a medium effect size; for the 30-second chair-stand test 0.48 (0.95% CI 0.29, 0.68) which was a small effect size; and for the one-leg rise test 0.12 (0.95% CI -0.06, 0.31) which was considered a negligible effect size. However, it was no statistically difference between the maximal step-up test and the 30-s chair-stand test even if they...
were placed in different effect groups, \( p = 0.501 \). The one-leg rise test had a floor effect, as 72\% of the patients were not able to rise at all from the chair on one leg at baseline and 63\% at 12 months. The correlation between performance-based tests of function and the questionnaires was considered to be minor, \((r=0.188 \text{ to } 0.226) \ (p=0.018 \text{ to } 0.048)\).
Discussion

Main findings of this thesis

Walking was the most common form of physical activity that patients with hip or knee osteoarthritis chose themselves, and the form of activity patients most often maintained after 12 and 24 months. Walking suits many patients with osteoarthritis, even those who are elderly and with weak legs, while few patients in our study chose strength training (Study III). The RCT provides no evidence that individualised physical activity on prescription differ from individualised advice on physical activity in increasing long-term physical activity, function, pain and quality of life. (Study I and II). When comparing the performance-based tests, the maximal step-up test (one-leg testing) was the most responsive to change in performance (Study IV).

Methodological considerations

The similarities between the two interventions in Study I and study II may have contributed to the lack of differences in results between the two intervention groups. It would have been desirable to also have a control group without physical intervention, however, we decided it was unethical to have a control group with no physical treatment for 24 months, as the evidence for exercise in osteoarthritis is strong [108]. The design of the study still provided basis for comparing the effect of different means of delivery methods. An alternative explanation for the fact that there were only minor differences in results between the two groups could be that the dropouts resulted in a type-2 error. The dropout rate in questionnaires and fitness tests at 6, 12 and 24 months were, 15%, 21% and 24% respectively. Thus, we may have lost the power in the following analyses and should have included more participants from start.

The fact that we did not have a true control group means that there are methodological limitations to interpreting the results. It is impossible to determine whether the improved self-reported physical activity is due to the specific efficacy of the treatments. Our results indicate that the patients have increased their physical activity, but there are several other possible explanations besides the treatment effect. Natural history of the disease, regression to
the mean, and type-1 error must all be considered. Another influence on the results could be a recall bias amongst the patients when answering the questionnaires on physical activity [44]. In addition, the advice group that met with the physiotherapist for just one session might have conducted their own searches for information and support in media or online. Among the strengths of the thesis work are the conduct of a randomized controlled trial where the patients were followed over a long period with both objective and subjective measures and with several follow-ups from baseline to 24 months. In summary the results collected by different means of questionnaires on physical activity, pain, function and quality of life; diaries about physical activity; and objective measurements with performance-based tests of function, indicated the same result, i.e. that patients in both groups improved. The results of these studies cannot confirm that the interventions with individualised physical activity on prescription, based on BCTs are more effective than simple advice on physical activity. However, there may be aspects of conducting a long-term study that demand more future research to further clarify the effects of structured advice according to BCTs. It is difficult to conduct studies that have a placebo control group with participants who are blinded to the intervention when evaluating physical activity interventions, and the regression to the mean effect must be considered when interpreting the results in studies of osteoarthritis [109].

The results of this thesis in comparison with other long-term studies

The overall results of this thesis are generally in line with previous reviews and meta-analyses, i.e. there is still lack of evidence for any effective physical activity intervention to increase physical activity in the long-term in patients with osteoarthritis [8-12]. We were not able to show that one of the interventions was better than another in improving long-term physical activity.

The fact that both our groups improved in self-reported physical activity from baseline to follow-ups at 12-24 months with no significant difference between groups (Study II) is consistent with what has been reported in other studies [110, 111]. Similar to our study, their interventions might also have been too similar to each other, to expect a difference in outcome. Brosseau et al. compared a supervised walking programme (3 times/week for 12 months) with a self-directed walking programme [110]. Bennel et al. compared an individualised physical activity intervention of five sessions with a group that in addition received 6-12 telephone sessions [111].

Other studies have also evaluated individualised interventions and their effect on long-term physical activity, but contrary to ours, some studies found that the intervention had a larger effect compared to a control group [112,
The explanation might be that their interventions included behavior-oriented graded activity and several booster sessions. The interventions were fairly comprehensive, with 15-25 contacts between a physiotherapist and the patient over 12-15 months [112, 113]. In another study, the Fit & Strong study, the treatment group, consisting of patients with hip or knee osteoarthritis with a mean age of 73 years, increased in physical activity at 12 months [114] and at 18 months compared to a control group [115]. The intervention combined flexibility, aerobic walking and resistance training with education. The participants received 24 contacts including 36 hours of treatment and all participants developed individualised plans for long-term maintenance [116]. Nevertheless, despite this ambitious intervention in the Fit & Strong study, it seems difficult to evaluate the effect of physical activity in the long-term to a proper control group, as at 12 months only 32% of the control group completed the study (and 50% of the treatment group) [114]. The attrition might have influenced the results. Worth noting is that when participants in the Fit & Strong study were evaluated at 18 months, those in the group that also received 18 phone calls for support between months 3 and 18, increased in physical activity [115].

A first line intervention has been implemented in Sweden, Denmark and Norway, that includes education, physical activity interventions and, if necessary, weight loss. The patients are offered individualised exercise interventions or supervised exercise of 10-12 sessions over 5-6 weeks [70, 117, 118]. It is proposed that these treatments (called “Osteoarthritis school/basic treatment” in Swedish) are introduced to patients with hip or knee osteoarthritis at an early stage of the disease. The results are documented in a patient register, often from baseline to 3 and 12 months respectively. Similar to our findings, the patients in the first line intervention in Sweden, Denmark and Norway showed an increase in self-reported physical activity when measured at 3-6 months compared to baseline [70, 117, 118]. In Sweden and Denmark, the patients then decreased in physical activity to the same level as at baseline when assessed at 12 months [70, 117], while both our groups and a subgroup of the Norwegian patients increased significantly from baseline to 12 months [118]. There may be various reasons for these different results. In the Swedish cohort, data were analysed from the registry-based study in which 55% of individuals dropped out at 12 months, and it is not known whether those who dropped out were physically active or not [117]. Furthermore, cohort studies, that evaluate patients before and after an intervention, is not an appropriate design for evaluating the effectiveness of an intervention. It has been shown that the regression to the mean is at least 10 %, which will affect the results [109].

Regarding which forms of physical activity people with osteoarthritis choose themselves and maintain in the long-term, there are (to our knowledge)
no such previous evaluation as the one performed in Study III. The findings are summarized and discussed below.

Considerations of the results

Osteoarthritis patients choose walking
We found that both female and male patients prefer walking when they choose activities themselves. Women walked on average 4.3 times/week both at baseline and after two years, and men walked on average 3.3 times/week at baseline and 3.1 times/week after two years. Walking seems to be the form of activity that was most easily maintained over time, as 47 of the 60 patients (78%) that walked at baseline also walked at 12 and 24 months. Our finding that walking is a popular form of physical activity is in accordance with other studies evaluating people with osteoarthritis [119, 120]. Interestingly, we found that the walkers were older, more often women and weaker in the osteoarthritis leg than non-walkers. This indicates that walking seems to be a form of physical activity that suits older patients with osteoarthritis and is an easy way of maintaining physical activity in the long-term.

Men and women mostly choose walking, but men also choose everyday activities and cycling
Overall, the men undertook walking sessions most frequently per week, followed by everyday activities and cycling in third place. There is a difference between women and men in terms of the proportion of people that choose walking (p=0.012) and those that choose everyday activities (p=0.020). The general conclusion of our study was that women mostly choose walking and men choose different activities in addition to walking. This deviates slightly to a previous study that found no difference between men and women in terms of walking [119]. A general conclusion is that if the physical activity interventions are individualised according to each person’s needs and preferences, it becomes more likely that the individual will maintain this activity in the long-term.

Few patients choose strength training
Strength training is recommended as an important activity to maintain for all adults [41]. It is also recommended in osteoarthritis guidelines [29-32]. Our finding that few patients maintained strength training in the long-term may explain previous results in Cochrane reviews that showed improvements in function up to six months after interventions and then a declined to baseline [5, 6]. It is important that counselling on physical activity takes into account the fact that few osteoarthritis patients choose strength training themselves.
and that few maintain strength training in the long-term. Our results suggest that caregivers should support the activities that patients prefer themselves for best long-term effects, i.e. if patients prefer walking, caregivers should support walking. Strength training can be discussed and added later if and when patients attend follow-up. One possible strategy may be to help the patient use the “habit stacking” method, a method for “how to build new habits by taking advantage of old ones” [121]. If patients are used to walking (or performing some other activity) regularly, it may be a successful strategy to add muscle strengthening activities immediately after this activity.

**Individual counselling on physical activity may improve the self-reported level of physical activity in the short and long-term**

As people with osteoarthritis need to continue performing physical activity and/or exercise for the rest of their life, it is important to find physical activities that work in the long-term. Previous research has shown that the motivation to initiate a behaviour change differs from the motivation to maintain a new behaviour in the long-term [60]. For example, a person might instigate a behaviour change, such as taking up physical activity and quitting smoking, if the doctor says this is needed due to health issues. After a while, this person will need a fresh motivation to maintain the (new) habit. A person is more likely to maintain new activities if he or she enjoys these new activities, if the activity fits with their values or if the person is satisfied with the effect and outcome of the new behaviour [60]. Furthermore, few trials have evaluated patients preferences for OA treatment, and a previous narrative review highlighted a gap in preferences concerning types of therapeutic exercise and mode of delivery that are most acceptable to patients [122]. It is therefore important to take into account the individual’s own perception of which activity will work in the long-term and support this activity. Patients in both groups of our study discussed with the physiotherapist who supported them to the physical activity they preferred and that they could undertake these activities on their own. They were also able to start the activities immediately and did not have to wait for a supervised group to start, as no supervised group was offered (Study I and II). I believe that supporting the patients to choose activities themselves, empowers the patient and improves their confidence. If the patient tells the healthcare professional that they like to walk and then get confirmation that walking is an excellent physical activity for the osteoarthritic joint and health, this may improve the patient’s self-efficacy for physical activity [123]. If counselling is individualised in relation to the patient and comprises a process with follow-ups, the patient can change activities or add other activities as they go along if so desired. In our study we were not able to confirm whether this approach with individualised interventions and follow-ups is beneficial for increasing and maintaining physical activity. However, this is now
part of the recently specified recommendations of an expert panel from 43 counties [32].

**Behaviour change techniques (BCTs) might possibly improve physical activity in osteoarthritis patients**

The BCTs that were similar in both our interventions were *information about health consequences; goalsetting; and feedback*. We were not able to confirm that the behavioural change techniques improved long-term physical activity. Although the results do not indicate superiority of any of the two interventions over the other, and although we have to interpret the results with caution, these results provide important clinical thoughts on how to mediate physical activity. Future research should evaluate whether individualised intervention about physical activity might be beneficial if specific or multiple behaviour change techniques are included. *Information about health consequences* is an important BCT included in guidelines for first-line treatment of patients with hip or knee osteoarthritis [29, 31, 32]. However, it appears that information alone has no effect on increased physical activity in the long-term [124], but a combination of education and physical activity is better [124]. *Goalsetting* has shown to be effective in increasing long-term physical activity (≥12 months) [66, 125]. O’Brien et al. showed that the *feedback* was the most effective BCT in increasing physical activity in the long-term [65]. *Feedback*, defined as providing people with data about their own recorded behaviour [63], was given to patients in our study several times as part of the study. They were assessed at baseline and at 6, 12 and 24 months using performance-based tests (Study I and II). I believe that the information from the performance-based tests motivated the patients to continue with physical activity. If both the tests and the interventions are close to what the patient actually performs in daily life, this can work synergistically together in motivating the patient to maintain physical activity.

**One-leg testing and responsiveness to change**

We found that the maximal step-up test, which is a test evaluating one leg at a time, was more responsive to improvements after an intervention with physical activity than the two-leg oriented 30-second chair-stand test (Study IV). Performance-based tests, such as the two-leg oriented tests recommended by OARSI are well proven, have displayed good measurement properties, and are easy to use [46]. However, in clinical practice it might be beneficial to add a test evaluating one leg at a time, as these tests provide more information. Assessing the patients regularly by performance-based tests may motivate the patient to maintain physical activity and strength training as feedback is an important behavioural change technique [65].
Pain, function and quality of life

As for the secondary outcomes, we could see in both groups of Study I and II, that pain decreased and function and quality of life improved in both short and long-term. There were no significant differences between the groups in change in any outcomes at 6, 12 and 24 months, except for pain. We found that pain after walking (VAS) differed between groups at six months (Study I), and that pain measured by the HOOS/KOOS differed at 24 months (Study II), on both occasions in favor of the prescription group. Pain is experienced in the brain and is affected by many factors, but we can only speculate about this difference in perceived pain between the groups.

Minimal clinically important difference

At 24 months, approximately 40% of patients in both groups showed a clinically meaningful improvement in physical function (six-minute walk test and 30-second chair-stand test), and about 30% in both groups showed meaningful improvement in pain and quality of life. The results indicate that even minor interventions (1 to 5 sessions), of individualised physical activity may be effective for about one third of osteoarthritis patients. Thus, with proper individualisation for the patients, some of them will only need a minor intervention, while others will need a more comprehensive approach, with information, supervised physical activity sessions, and booster sessions [112, 114, 115].

Clinical implications

There is still absence of evidence for any particular physical activity intervention to effectively increase physical activity in the long-term in osteoarthritis patients. Individual counselling with support to choose preferred physical activities that are easy to perform in daily life may be a beneficial and cost-effective approach for long-term maintenance. Caregivers should support the individual patient to maintain preferred and self-selected activities such as walking, but also help the patient find long-term strategies that include muscle strengthening activities.
Conclusions

- Individualised physical activity on prescription has similar effects as individualised advice on physical activity in the long-term
- Walking is the preferred form of physical activity by osteoarthritis patients when they decide the physical activity themselves
- Walking is the form of physical activity performed most frequently and best maintained in the long-term
- Walking is preferred by women, older individuals, and individuals with weak legs
- Men prefer a mix of activities such as walking, everyday activities and cycling
- A minority of individuals with osteoarthritis choose strength training when they decide the physical activity themselves
- One leg testing, using the maximal step-up test, can be used to obtain information from each leg separately in individuals with osteoarthritis
Acknowledgments

Att skriva en avhandling är en lång och spännande resa och ni är många som har bidragit på olika sätt så att detta blev möjligt! Några vill jag tacka särskilt!

Alla patienter, som under två års tid kom för att testas och svara på frågor.

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58


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