Faculteit Geneeskunde en Levenswetenschappen

master in de revalidatiewetenschappen en de kinesitherapie

Masterthesis

Effects of Exercise Therapy after Total Hip Arthroplasty: A Systematic Review

Vienna Mertens
Lotte Vormeuilen
Eerste deel van het scriptie ingediend tot het behalen van de graad van master in de revalidatiewetenschappen en de kinesitherapie

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Research questions

Which active rehabilitation content including M. Gluteus Medius exercises was offered to persons after total hip arthroplasty?

What were the effects of different active exercise therapy modalities after total hip arthroplasty according to the ICF-model?

Highlights

Following active rehabilitation contents including M. Gluteus Medius exercises are provided to patients after total hip arthroplasty: standard, inpatient, outpatient and home-based rehabilitation.

Improvements on body function and structures level are best obtained by using supervision and/or progression.

For activity level home-based exercises appear to be equally effective to other interventions.

More studies are needed about this topic. Future research should include a detailed description of rehabilitation content, more specifically of exercise volume.

Students

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Promoters and co-promoters

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OUTLINE

This systematic review is situated on the research domain of musculoskeletal rehabilitation. Total hip arthroplasty is performed when severe hip osteoarthritis or traumatic events are present. Weakness of the hip muscles, more specifically the hip abductors, is a common complaint after this surgical procedure. The effects of a weakened M. Gluteus Medius are destabilisation of the pelvis in the frontal plane (e.g. during gait), limping and strength reduction and/or pain when performing hip abduction.

To date the role of M. Gluteus Medius exercises is acknowledged in total hip arthroplasty rehabilitation. However, the effectiveness of different forms of active physical therapy after total hip arthroplasty is not fully understood. There is a lack of evidence concerning to the content of rehabilitation, more specifically the exercise volume. With this systematic review we would like to give an insight in possible active rehabilitation contents, including M. Gluteus Medius exercises, and their effects according to the International Classification of Functioning, Disability and Health.

This systematic review is formerly situated in an ongoing research project named: "M. Gluteus Maximus transfer: patient reported outcomes and gait (17020)". Research questions for this topic are: “What are the effects of a weakened and/or ruptured M. Gluteus Medius?” and “Which rehabilitation content and training intensity was offered to patients with a weakened and/or ruptured M. Gluteus Medius?”. This research is conducted under the authority of Prof. Dr. K. Corten, Prof. Dr. A. Timmermans and A. Bruijnes (MSc).

Currently this systematic review is part of an ongoing research project named: “Feasibility of an application for mobile monitoring of the functional status in healthy persons and persons with degenerative hip and knee disorders”. This research is conducted under the authority of Prof. Dr. A. Timmermans, Drs. J. Emmerzaal and A. Bruijnes (MSc). Measurements will be performed at REVAL (Studiecentrum voor revalidatieonderzoek - Agoralaan - Gebouw A - 3500 Hasselt).

We opt to choose the Central Format provided by Hasselt University.

The initial research questions are provided by the institution. These are further optimised in deliberation with both the students and promoters. This systematic review is conducted as a duo master thesis. We independently assess search terms, search strategies, selection of articles, quality assessment and data-extraction. When there is disagreement, matters are discussed until an agreement is reached. After reaching an agreement the research itself is written together. Both students have an equal shared part in this systematic review.

In our second master year we will take part in an ongoing research about the feasibility of an application for mobile monitoring of the functional status in healthy persons and persons with degenerative hip and knee disorders. This protocol is already provided to us. The study is currently in its start-up phase.
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PART I: LITERATURE STUDY

1. Abstract

**Background:** M. Gluteus Medius plays an important role in the rehabilitation following total hip arthroplasty. There is a lack of evidence on the content and effectiveness of active rehabilitation forms after this surgical procedure. This study aims to investigate which rehabilitation contents, including M. Gluteus Medius exercises, are commonly used and are most effective based on the ICF.

**Method:** Systematic review of randomised controlled trials published between 2007-2018. Databases used are PubMed and WOS. Search terms, search strategies, selection of articles, quality assessment and data-extraction are independently assessed by two researchers. Quality assessment is done according to the GRADE-criteria.

**Results:** Eight studies are included. Following outcomes are assessed: HHS, WOMAC, quality of life, TUG, 6MWT, gait parameters, negotiating stairs, muscle force, 30 sec sit-to-stand, HOOS, one-legged stance test, compliance, patient satisfaction, global perceived effect of treatment, PAS, pain, ROM and Merle d’Aubigné and Postel Score.

**Discussion and conclusion:** Standard, inpatient, outpatient and home-based rehabilitation implementing M. Gluteus Medius exercises are offered to persons after total hip arthroplasty. Body functions and structures level is best improved by adding supervision and progression, for activity level home-based exercises are at least equally effective to the other interventions.

**Aim of the research:** To examine the feasibility of a mobile app to monitor functional status in healthy persons and persons with degenerative hip and knee disorders.

**Operationalisation research question:** This qualitative research will be conducted in our second master year at REVAL.

**Keywords:** M. Gluteus Medius, Total Hip Arthroplasty, Active Rehabilitation, ICF, Systematic Review
2. Introduction

Gluteus Medius (GMe) pathologies occur more frequent at age 40 to 50 (Chi et al., 2015; Grimaldi et al., 2015). It is important to acknowledge the role of the GMe in the pathogenesis of pathologies such as: knee osteoarthritis, patellofemoral pain syndrome, chronic low back pain and greater trochanteric pain syndrome. Rehabilitation of GMe pathology might have a positive influence on these syndromes (Ebert, Edwards, Fick, & Janes, 2017; Harrasser et al., 2016; Lindner, Shohat, Botser, Agar, & Domb, 2015).

The GMe functions as a hip abductor and rotator and stabilises the pelvis in the frontal plane (e.g. during gait). The anterior fibres of the muscle account for internal rotation while the posterior fibres perform external rotation at the hip joint (Flack, Nicholson, & Woodley, 2012). There are two ways to confirm GMe pathology: clinical observation and medical imaging.

Inefficient gait mechanics can be seen in GMe pathologies presented as limping and/or a Trendelenburg gait (Ebert, Bucher, Ball, & Janes, 2015; Petis, Howard, Lanting, & Vasarhelyi, 2015). Two studies investigate the passive range of motion (ROM) of the hip joint with GMe pathology (Lachiewicz, 2011; Lindner et al., 2015). One study states that there is a minimally reduced passive hip flexion and internal rotation (Lindner et al., 2015). This is contradicted by another study in which there was a non-impaired passive ROM (Lachiewicz, 2011). When performing active movements against resistance, a strength reduction and/or pain can be observed (Bird, Oakley, Shnier, & Kirkham, 2001; Ebert, Retheesh, Mutreja, & Janes, 2016; Lindner et al., 2015). The following specific tests may be positive: Trendelenburg test (Bird et al., 2001; Lindner et al., 2015) and a single leg stance of <30 seconds (Ebert et al., 2015).

GMe tendinopathy in patients with peritrochanteric lateral hip pain and/or pain in the buttocks and groin can be located by magnetic resonance imaging, which is the golden standard. (Grimaldi et al., 2015; Kingzett-Taylor et al., 1999). Direct signs of a problem are thickenings of the tendon and soft tissue oedema, an indirect sign is GMe atrophy (Bird et al., 2001). Ultrasound is a cheaper and more accessible evaluation tool which can additionally detect tendon calcifications (Grimaldi et al., 2015). Results of X-rays are mostly negative in patients with chronic tears. Sometimes osteophytes on the anterior side of the greater trochanter are reported (Lachiewicz, 2011).

The pathogenesis GMe pathologies is not yet fully understood. Several hypotheses are pending:

1. Micro traumas, which may be caused by an increased intensity or frequency of tensile forces on tendons. Besides, an increased compression force on the muscle created by other muscle- and bone structures and the joint position can provoke complaints in the lateral hip region (Grimaldi & Fearon, 2015; Grimaldi et al., 2015; Lachiewicz, 2011).
2. Degenerative disorders of the hip joint e.g. osteoarthritis (Grimaldi et al., 2009).
3. Surgical management of hip pathology. Three surgical interventions who are known to result in GMe pathology are: gluteal tendon repair, internal fixation of femoral neck fractures and total hip arthroplasty (THA) (Lachiewicz, 2011). THA can be performed via three different
approaches: direct anterior, lateral and posterior. There are several advantages and disadvantages for each technique and there is a chance for creating postoperative GMe weakness, tendinopathy or ruptures (Capogna, Shenoy, Youm, & Stuchin, 2017; Petis et al., 2015). Lachiewicz (2011) indicates that an avulsion of the abductor tendons is possible after anterolateral or transgluteal THA.

4. Traumatic events. (e.g. motor accident) (Lindner et al., 2015).

GMe pathologies can be treated in several ways: pharmacological treatment, medical treatment (e.g. shockwave therapy or surgery) or active rehabilitation. Pharmacological treatment consists of corticosteroid injections, which only have a short-term effect. Shockwave therapy uses ultrasound waves to initiate and enhance the natural healing process, which is effective in the long term. (Brinks et al., 2011; J. P. Furia, J. D. Rompe, & N. Maffulli, 2009; J. D. Rompe et al., 2009) With regard to surgery, there are two options: open surgical procedures (iliotibial band release or bursectomy, trochanteric reduction osteotomy) or endoscopic procedures (iliotibial band release or bursectomy). However, it remains unclear which surgical procedure gives the most long-lasting results. (Grimaldi & Fearon, 2015; Grimaldi et al., 2015; Lindner et al., 2015)

Besides pharmacological and medical interventions, GMe pathologies can be treated with active rehabilitation (Brinks et al., 2011; J. P. Furia et al., 2009; J. D. Rompe et al., 2009). A systematic review about the effectiveness of physical therapy exercises after THA states that exercising the GMe plays an important role in rehabilitation (M. Di Monaco & Castiglioni, 2013). Yet, evidence on the effectiveness of different forms of physical therapy after THA is lacking (Lowe, Davies, Sackley, & Barker, 2015; Minns Lowe, Barker, Dewey, & Sackley, 2009). Besides, detailed information about the protocols (type of exercises) and volumes of these interventions are poorly described in interventional studies (M. Di Monaco, Vallero, Tappero, & Cavanna, 2009; Lowe et al., 2015). This systematic review aims to investigate which rehabilitation contents, including GMe exercises, are most commonly used after THA and which of them are the most effective in improving different aspects of the ICF.

Note: Figures, tables and list of abbreviations can be found in the appendix of the literature study.
3. Methodology

3.1. Research questions
The objective of this systematic review is to answer the following research questions.

1. Which active rehabilitation content including GMe exercises was offered to persons after THA?
2. What were the effects of different active exercise therapy modalities after THA according to the international classification of functioning, disability and health (ICF)-model?

The PICO for these research questions is:

- **P**: adults who underwent THA and reported with GMe pathologies and/or lateral hip pain, pre- and/or postsurgical
- **I**: active physical therapy involving the GMe muscles
- **C**: other active and physical therapies involving the GMe muscles
- **O**: outcomes must involve at least one of the aspects of the ICF-model and can possibly be influenced by active physical therapy

3.2. Literature search
The following databases were used: PubMed and Web of Science (WOS).

Based on our PICO we used the following search terms.

**PubMed**: Hip [MeSH], Buttocks [MeSH], Tendon injuries [MeSH], Muscle weakness [MeSH], Sprains and strains [MeSH], Soft tissue injuries [MeSH], Musculoskeletal pain [MeSH], Rupture [MeSH], Lacerations [MeSH], Skeletal muscle [MeSH], Gluteal [Title/Abstract], Rehabilitation [MeSH], Adult [MeSH], Therapeutics [MeSH], Musculoskeletal physiological phenomena [MeSH], Recovery of function [MeSH], Biomechanical phenomena [MeSH], Proprioception [MeSH], Human activities [MeSH], Social participation [MeSH], Hip [Title/Abstract], Surgery [Title/Abstract], Rehabilitation [Title/Abstract], Gluteus Medius [Title/Abstract], Lateral hip pain [Title/Abstract], Tendon tears [Title/Abstract], Strain [Title/Abstract], Physiotherapy [Title/Abstract], Exercise therapy [MeSH], Surgical interventions [Title/Abstract], Corticosteroid injections [Title/Abstract], No intervention [Title/Abstract] and pharmaceutics [Title/Abstract].

**WOS**: All terms were entered as (topic) and RCT (topic) was added to every search term. Search terms: hip, buttocks, tendon injuries, muscle weakness, sprains and strains, soft tissue injuries, musculoskeletal pain, rupture, lacerations, skeletal muscle, gluteal, rehabilitation, adult, therapeutics, musculoskeletal physiological phenomena, recovery of function, biomechanical phenomena, proprioception, human activities, gluteus medius, lateral hip pain, tendon tears, strain, physiotherapy, exercise therapy, surgical interventions, corticosteroid injections, no intervention and pharmaceutics.
3.3. **Selection criteria**

*Inclusion criteria:*

- Randomised controlled trial (RCT)
- Published maximum ten years ago
- Published in Dutch or English
- Adults (+18)
- Persons who already underwent THA
- Clearly described intervention- and control group
- At least one active physiotherapeutic exercise in the intervention group
- Pre- and post-intervention measures, as well as at least one postoperative measure
- At least short-term follow-up, preferably long-term

*Exclusion criteria:*

- Comorbidities that prevent proper participation in the intervention group (heart diseases, cancer, neural disorders, cognitive disorders, etc.)
- Articles who described an intervention that may, or may not include training of the GMe, in order to treat another pathology
- Inaccurate description of the following: inclusion- and exclusion criteria, protocol and follow-up.
- Low quality studies

3.4. **Quality assessment**

First each article was implemented in the risk of bias (RoB)-table, which is a part of the Grading of Recommendations Assessment, Development and Evaluation (GRADE) criteria. Using this tool, two independent assessors evaluated the following items for each included study: random sequence generation, allocation concealment, blinding of participants and personnel, blinding of outcome assessment (subjective), blinding of outcome assessment (objective), incomplete outcome data, selective reporting and other bias. These items were given a green, yellow or red score. A green score was given when bias was not present. When not specifically mentioned in the text, an item was given a yellow score. Red scores were assigned when bias was present. The item ‘other bias’ was scored green when the article’s sample size was above 30 subjects and in absence of financial funding from universities, hospitals or companies who might have an influence on the outcome of the research. Score yellow was given when the sample size was below 30 subjects or there was financial funding. A red score was assigned when both small sample size and financial funding were present.

Thereafter, 16 outcome measures were assessed according to the GRADE-criteria: study design, RoB, inconsistency, indirectness, imprecision, publication bias and other. Each outcome started as high quality of evidence because the studies were RCT’s. The quality of evidence was downgraded one or two levels when the GRADE-criteria were not met. Possible categories are: high, moderate, low or very low. Strength of the outcome measure is determined by the quality of the articles implementing this measure. (Ryan, 2016)
Besides assessing the presence of RoB and the quality evidence of the outcomes, we described the strengths and weaknesses of each included study.

3.5. Data extraction
To get to know which active rehabilitation content was offered to persons with postsurgical GMe weakness or rupture after THA we summarised the interventions in four categories. We would like to obtain information about the effects of active training on the different levels of the ICF-model. These ICF-levels were: body function and structures level, activity level, participation level, person level and environmental level. The outcome measures of interest were: gait parameters, muscle strength, pain, hip ROM, stiffness, symptoms, hip functions, functional activities and activities of daily living (ADL) (e.g. chair raises, negotiating stairs, walking, turning), quality of life, physical and mental health, compliance and patient satisfaction and global perceived effects. These outcomes were analysed by using the following measurements: 10- and 20 Meter Walk Test (10- or 20MWT), Hand Held Dynamometry (HHD), Kendall’s Criteria, Japanese Orthopaedic Association Score (JOA), goniometry, Merle d’Aubigné and Postel score, Assessment of Quality of Life (AQoL), Timed Up and Go test (TUG), Six Minute Walking Test (6MWT), One-legged stance test, negotiating stairs, 30s sit-to-stand test, Physical Activity Scale (PAS), Harris Hip Score (HHS), Western Ontario and McMaster Universities Osteoarthritis index (WOMAC), Hip Disability and Osteoarthritis Outcome Score (HOOS), EuroQol 5-dimensions (EQ5D), Short Form health survey (SF-36), questionnaire about compliance and patient satisfaction and a 5 point-scale for global perceived effect of treatment. In this way we would receive information about the effects of active training according to the ICF-model.
4. Results

4.1. Results study selection
With the previously summarised search terms we made various combinations (Table 1). Within each aspect of the PICO we combined the search terms with ‘OR’ and between the aspects we combined them with ‘AND’. After establishing the search terms for each database, we used the search terms and their combinations in both databases to make sure every article about the subject was covered. We conducted our first search in November 2017 and repeated this in March 2018. Using this method, we found a total of 1587 articles of which 848 were duplicates. From the 739 articles, 148 were derived from PubMed and 591 from WOS. These articles were individually checked by two independent assessors for compliance with our PICO and our inclusion/exclusion criteria. When there was disagreement, both assessors read the abstract. Based on title, we excluded 447 articles. Reasons for exclusion were: trial protocols, designs of an RCT, study designs other than RCT, medical, pharmacological, passive and non-physical therapy interventions as primary therapy, preventive, preoperative or non-surgical interventions, no intervention, other pathologies, neurological conditions, cancer, primary vascular and internal diseases, physiological or psychiatric disorders, children and animal studies. Two hundred and five articles were excluded based on their abstract, because of the following reasons: no active (exercise) therapy as intervention, no GMe involvement in the intervention, no THA, other study design, active intervention combined with a passive intervention whereby a valid statement about the active intervention cannot be made, non-physical therapy related outcomes, preventive interventions, psychological or psychiatric disorders, population <18 years. We found 38 studies implementing GMe exercise therapy for other pathologies such as: patellofemoral pain syndrome, anterior cruciate ligament reconstruction, hip osteoarthritis, knee osteoarthritis, general osteoarthritis, plantar fasciitis, non-specific low back pain, total knee arthroplasty, lumbar disc surgery, medial tibial stress syndrome, anterior knee pain. Those were also excluded. From the remaining 49 studies, we excluded 41 articles, based on their full text. Reasons for these exclusions were: no THA, pre-surgical interventions, control group without THA, no within group analysis, THA mixed with other surgical interventions, no pre- and post-intervention measures, no control group, outcome is not directly related to active rehabilitation, no active intervention, occupational therapy as the intervention, no implementation of GMe exercises, trial protocol and the use of a language other than Dutch, English, French or German. (Table 2) There was 90.26% correspondence about the exclusion of articles between the two independent assessors. For the remaining 9.74% a consensus was reached. At this point eight articles were left for inclusion (Figure 1).

4.2. Results quality assessment
Using the RoB-table, we evaluated each included study for RoB (Table 3). One study had a high RoB because of a red score for several domains (M. S. Austin et al., 2017). Two studies were given an unknown RoB because of several yellow scores (Galea et al., 2008; Nankaku et al., 2016). The other five studies had a low RoB (L. R. Mikkelsen et al., 2014; L. R. Mikkelsen, Mikkelsen, & Christensen, 2012; Monticone et al., 2014; Okoro et al., 2016; Umpierres et al., 2014). When implementing this tool in the GRADE-criteria we downgraded one outcome with two levels. Four of the sixteen outcomes were downgraded one level for serious RoB. The other eleven outcomes were not downgraded for
RoB. There was no inconsistency and indirectness found in the outcome measures. Imprecision was downgraded one level for each outcome measure. Publication bias was undetected for all outcome measures. We were not able to upgrade levels. Sixteen outcomes were assessed, of which 11 had a moderate quality of evidence. Four other outcomes were of low quality. One outcome had a very low quality (Table 4). Several strengths and weaknesses were found in the articles. A summary of these can be found in table 5.

4.3. Results data extraction

4.3.1. Used active rehabilitation contents including GMe exercises after THA
The four interventions used in the included articles were: standard (L. R. Mikkelsen et al., 2012; Nankaku et al., 2016; Okoro et al., 2016), inpatient (Monticone et al., 2014; Umpierres et al., 2014), outpatient (M. S. Austin et al., 2017; Galea et al., 2008; L. R. Mikkelsen et al., 2014) and home-based rehabilitation (M. S. Austin et al., 2017; Galea et al., 2008; L. R. Mikkelsen et al., 2014; L. R. Mikkelsen et al., 2012; Okoro et al., 2016). All post-operative THA interventions implemented analytical strengthening exercises, functional exercises and additional biking and walking. Stretching of the hip flexors was present in the standard and home-based rehabilitation modalities. Inpatient rehabilitation specifically implemented gait/walking training. Home-based rehabilitation was the only intervention that did not use balance training. All interventions used isometric, concentric and eccentric exercise modalities, except for the inpatient rehabilitation (Monticone et al., 2014; Umpierres et al., 2014). Inpatient, outpatient and home-based rehabilitation interventions specifically mentioned the use of open and closed kinetic chain exercises. Standard rehabilitation was performed both supervised or unsupervised while inpatient and outpatient rehabilitation were always supervised. Home-based exercises were performed unsupervised. (Table 6)

4.3.2. Effects of interventions linked to the ICF-model
The outcomes mentioned below were classified according to the ICF-model. When an outcome coincided with multiple levels we assigned the outcome to a level based on existing literature (Alviar, Olver, Brand, Hale, & Khan, 2011; Hoang-Kim, Schemitsch, Kulkarni, & Beaton, 2014). In addition, we counted the number of items to see which ICF-level was represented the most. Results of the literature and the counting were checked for analogy. All results described below are supported by table 7.

4.3.2.1. Body function and structures level
10m walk test, 20m walk test, walking speed, cadence, step length, step time, percentage in step time, single-support time, double-support time, symmetry index
Walking speed improved using home-based exercises (Galea et al., 2008; L. R. Mikkelsen et al., 2014; L. R. Mikkelsen et al., 2012). L. R. Mikkelsen et al. (2014) stated that home-based exercises with additional supervised progressive resistance training (PRT) was superior to home-based exercises alone. A significant decrease (p<0.01) in walking speed was found using standard rehabilitation without progression (L. R. Mikkelsen et al., 2012). Supervised centre-based exercises were effective in improving walking speed but are not superior to home-based exercises (p>0.05) (Galea et al., 2008).
With regard to other gait parameters, more gait parameters in total could be improved using a supervised centre-based therapy (Galea et al., 2008).

**Hand Held Dynamometry, Kendall’s criteria**
Supervised and non-supervised home-based therapy, whether or not combined with PRT or hip external rotation exercises, and a THA with or without supervision were effective in improving hip abduction strength (L. R. Mikkelsen et al., 2014; L. R. Mikkelsen et al., 2012; Nankaku et al., 2016; Umpierres et al., 2014). Conventional rehabilitation without progression did not improve hip abduction strength (Nankaku et al., 2016). Additional external rotation exercises would preserve external rotation strength compared to conventional rehabilitation in which external rotation strength significantly decreased (p<0.05) (Nankaku et al., 2016). Hip flexion strength improved (p<0.05) when using supervised in- or out-patient therapy (L. R. Mikkelsen et al., 2014; Umpierres et al., 2014). A supervised rehabilitation program was superior to a non-supervised rehabilitation program for improving hip adduction (p=0.003), internal rotation (p<0.001) and extension (p<0.001) strength (Umpierres et al., 2014).

**Japanese Orthopaedic Association Score**
The use of hip external rotation exercises in addition to conventional rehabilitation, as well as conventional rehabilitation gave a significant difference for pain (p<0.05). There was no between group information. (Nankaku et al., 2016)

**Goniometry**
Range of motion of hip flexion and abduction improved significantly (p<0.05, p<0.001) when an external rotation exercise therapy, conventional therapy or THA-protocol with supervision was applied (Nankaku et al., 2016; Umpierres et al., 2014). Hip extension, adduction, internal and external rotation improved (p<0.001) due to adding supervision to THA-protocol. Without supervision only extension (p=0.001), adduction (p<0.001) and internal rotation (p<0.001) improved. Significant differences were found between abduction and adduction in favour of the supervised intervention (Umpierres et al., 2014).

**Merle d’Aubigné and Postel Score**
When a supervised rehabilitation program was applied, there were significant improvements for motor performance evaluation (p=0.03), pain clinical evaluation (p<0.01), mobility clinical evaluation (p<0.001) and global clinical evaluation (p=0.007). Gait clinical evaluation did not improve significantly (p=0.17). Pain clinical evaluation (p<0.001) and gait clinical evaluation (p=0.004) improved significantly when no supervision was present. Non-significant p-values were found for motor performance evaluation (p=0.16), mobility clinical evaluation (p=0.08) and global clinical evaluation (p=0.10). The supervised group had more benefit on the following items: pain clinical evaluation (p=0.02), mobility clinical evaluation (p=0.01) and global clinical evaluation (p<0.01). (Umpierres et al., 2014)
Assessment of Quality of Life
The scores of the AQoL improved significantly (p=0.02) in the supervised centre-based group and the home-based-intervention groups. There were no significant differences between both groups (p=0.121). (Galea et al., 2008)

4.3.2.2. Activity level
Timed Up and Go test
Time to complete the TUG decreased significantly in the supervised centre-based group (p=0.003), home-based exercises with (p=0.0001) or without (p=0.002) PRT or when adding external rotation exercises (p<0.05) to a conventional rehabilitation protocol. Standard or conventional rehabilitation caused improvement in the Okoro et al. (2016) study (p=0.0001) but not in the Nankaku et al. (2016) study (p=0.352). Home-based exercises were superior to supervised centre-based exercises (p=0.042) at two months follow-up (Galea et al., 2008).

Six Minute Walking Test
Supervised centre-based exercises (p=0.02), home-based exercises with (p=0.0001) or without (p=0.001) PRT and standard rehabilitation (p=0.0001) ensured a significant improvement in walking distance. Standard rehabilitation was more effective than home-based exercises (p=0.004) which were equally effective as the supervised centre-based exercises (p=0.121). (Galea et al., 2008; Okoro et al., 2016)

One-legged stance test
A significant improvement (p<0.05) in the operated and non-operated leg was found in both groups at 12 weeks. No significant differences in both legs between groups were found. This means that intensified home-based exercises and standard rehabilitation were effective but not superior to one another (p>0.05). (L. R. Mikkelsen et al., 2012)

Negotiating stairs
Supervised centre-based exercises (p<0.05), standard rehabilitation (p=0.0001) and home-based exercises (p<0.05) with or without (supervised) PRT (p<0.05, p<0.05, p=0.0001) were effective in improving stair negotiating performance. Standard rehabilitation was more effective than home-based exercises with additional PRT (p=0.038) which was in turn more effective than home-based rehabilitation alone (p=0.04). The latter was equal to supervised centre-based therapy (p=0.121). (Galea et al., 2008; L. R. Mikkelsen et al., 2014; Okoro et al., 2016)

30s sit-to-stand test
Home-based therapy with or without (supervised) PRT (p<0.05, p=0.0001) and standard care (p=0.0001) had improved the amount of executed repetitions. No between group differences were found (p=0.12, p=0.239). (L. R. Mikkelsen et al., 2014; Okoro et al., 2016)

Physical Activity Scale
No significant differences were found between intensified home-based exercises and standard care (p=0.07) (L. R. Mikkelsen et al., 2012).
Harris Hip Score
One study used the HHS as an outcome measure to evaluate pain, function and hip ROM (M. S. Austin et al., 2017). Significant outcome measures (p<0.001) were found at one month, six and 12 months. There were no significant differences between groups (p=0.82). This study stated that both unsupervised home-based therapy and formal outpatient therapy were equally effective in improving the total score. A higher score meant a decrease in pain and an increase in function and hip ROM.

Western Ontario and McMaster Universities Osteoarthritis index
The WOMAC assessed pain, stiffness and function of the hip. Four studies included the WOMAC. M.S. Austin et al. (2017) and L.R. Mikkelsen et al (2012) found improvement (p<0.001) of all these aspects by doing exercises in a home-based setting without supervision while the unsupervised home-based exercise therapy in Galea et al. (2008) only improved function (p=0.002). Both intensified home-based exercises as well as non-intensified exercises proved to be effective (L. R. Mikkelsen et al., 2012). Home-based, standard and centre-based/outpatient rehabilitation were proved to be equally effective. None of these interventions were superior to one another. Monticone et al. (2014) stated that task-oriented exercises were more effective (p<0.001) than open chain exercises to improve pain, stiffness and function.

Hip Disability and Osteoarthritis Outcome Score
Home-based therapy with or without addition of supervised PRT exercises ensured an improvement of symptoms, pain, ADL, sports and recreation and quality of life (p<0.05) in the short-term. This was not retained in the long term (p>0.05). The addition of supervised PRT exercises did not necessarily ensure a greater improvement (p=0.31-0.90). (L. R. Mikkelsen et al., 2014)

EuroQol 5-Dimensions, Short Form health survey
L. R. Mikkelsen et al. (2012) used the EQ-5D to assess health status, by making use of a questionnaire and a visual analogue scale (VAS). The health status was significantly improved in the intensified home exercise group and the standard rehabilitation group. Improvements were found at four weeks follow-up for health status (p<0.001) and VAS (p<0.05). No differences were found between groups at twelve weeks for health status (p=0.89) and VAS (p=0.31). Three studies used the SF-36 to assess physical and mental health (M. S. Austin et al., 2017; Monticone et al., 2014; Umpierres et al., 2014). Some of the results were contradictory. M. S. Austin et al. (2017) stated that there was improvement of physical health in the unsupervised home-based therapy and the formal outpatient therapy. No improvements were found in mental health. This was contradicted by the following two studies. (Monticone et al., 2014) found a significant improvement for all items using task oriented and open kinetic chain exercises. A supervised rehabilitation program improved (p<0.05) bodily pain, general health, vitality, social functioning and mental health. No significant differences were found for physical functioning (p>0.99), role physical (p>0.99) and role emotional (p>0.99). For rehabilitation without supervision, significant differences (p<0.05) were found for bodily pain, vitality, social functioning and mental health. In this group no significant differences were found for physical functioning (p>0.99), role physical (p>0.99), general health (p=0.09) and role emotional (p>0.99). (Umpierres et al., 2014) A significant difference in favour of the task-oriented exercise group was found for all items except for social function (p=0.264) and emotional role
(p=0.075) (Monticone et al., 2014). One study found a significant between group difference for bodily pain in favour of the supervised rehabilitation program (p=0.01) (Umpierres et al., 2014).

4.3.2.3. Participation level
Due to our classification according to the ICF-model based on existing literature, certain outcome measures which included some items on participation level, were placed elsewhere. (Alviar et al., 2011; Hoang-Kim et al., 2014)

4.3.2.4. Person level
Compliance and patient Satisfaction and Global Perceived Effect of Treatment using a 5-point scale
There were no significant differences between intensified home-based exercises and standard rehabilitation for training compliance for performances/week (p=0.37), walking/stationary biking (p=0.19) or extra training (p=0.86). Significant differences between groups were found in subjective experience of the difficulty of the exercises (p=0.021), showing that the exercises in the intensified exercises group were experienced as too difficult in the beginning and gradually more easily. The majority of the patients in the standard rehabilitation group experienced the exercises as difficult enough in the beginning and later as too easy. No significant difference between groups about satisfaction (p=0.095) and meaningfulness (p=0.747) were found. (L. R. Mikkelsen et al., 2012) Global perceived effect of treatment was assessed by Monticone et al. (2014), using a 5-point scale. There was a between group difference (p<0.001) with a greater perceived effect in the task-oriented exercise group compared to the open kinetic chain exercise group.

4.3.2.5. Environmental level
Due to our classification according to the ICF-model based on existing literature, certain outcome measures which included some items on environmental level, were placed elsewhere. (Alviar et al., 2011; Hoang-Kim et al., 2014)
5. **Discussion**

5.1. **Reflection on the quality of the included studies and outcomes**

5.1.1. **Quality assessment of the studies**

Based on the RoB-tool, one study has a high RoB. This is due to the presence of a selection, performance and detection bias (M. S. Austin et al., 2017). Two other studies have an unknown RoB because of random sequence generation, allocation concealment, and not mentioning blinding of participants and personnel and blinding of assessment of outcome (Galea et al., 2008; Nankaku et al., 2016). The remainder of the studies have a low RoB (table 3) (L. R. Mikkelsen et al., 2014; L. R. Mikkelsen et al., 2012; Monticone et al., 2014; Okoro et al., 2016; Umpierres et al., 2014).

5.1.2. **Quality assessment of the outcomes**

The lack of inconsistency and indirectness is the result of our careful selection of articles based, on our in- and exclusion criteria. Surgical approach is not seen as an inconsistency because this is a part of interest. Imprecision is found for all outcome measures because the sum of sample sizes of the selected studies for these items is less than n=400. Because of small sample sizes it does not necessarily mean that data was withheld, so publication bias is undetected for all outcome measures. We are not able to upgrade levels because effect sizes, dose responses or plausible confounders are not mentioned. Sixteen outcomes are assessed, of which 11 have a moderate quality of evidence. Four outcomes are given a low quality of evidence score and one outcome has a very low quality of evidence.

5.2. **Reflection on the findings in function of the research questions**

5.2.1. **Reflection on used active rehabilitation contents including GMe exercises after THA**

The first aim of this study is to describe which rehabilitation contents, including GMe training, are most commonly used after THA. We notice that standard rehabilitation, inpatient and outpatient rehabilitation and home-based rehabilitation, are recently used in research including GMe exercises. When inspecting the interventions related to the surgical approach, we notice that the surgical approach is not of importance for the prescribed type of intervention in this systematic review. The only surgical approach known in the inpatient rehabilitation is the postero-lateral approach. When comparing early functional recovery, a difference is found between the direct anterior and postero-lateral approach. This difference disappears after six months follow-up (H. Y. Zhao et al., 2017). Apart from surgical approach, inpatient rehabilitation is the only intervention that does not specifically make use of eccentric exercises. While a study from M. Di Monaco et al. (2009) state that eccentric hip exercises are an important component of late-phase protocols. Exercise volume is not discussed in this review, nor described in table 6 because of heterogeneity and lack of a detailed description in all studies. When exercise volume is mentioned in an individual study, it is described in table 7. (M. S. Austin et al., 2017; Galea et al., 2008; L. R. Mikkelsen et al., 2014; L. R. Mikkelsen et al., 2012; Monticone et al., 2014; Nankaku et al., 2016; Okoro et al., 2016; Umpierres et al., 2014)
5.2.2. Reflection on effects of interventions linked to the ICF-model
The second aim of this study is to assess the effects of the active rehabilitation contents according the levels of the ICF-model. We find that there is a trend towards supervised rehabilitation contents and/or implementation of progression being more effective in improving aspects of the body functions and structures level. With regard to the activity level we find a trend towards home-based therapy being at least equally effective as standard, in- and outpatient therapy for most of the outcomes. When taking a closer look at the results for outcomes on participation, person and environmental level, we are not able to make a conclusion because a lack of strong evidence and/or only summary scores are mentioned. So, we could not extract data for the specific items belonging to these three levels.

5.2.2.1. Body function and structures level
All interventions from studies describing an outcome measure related to pain give a significant improvement (M. S. Austin et al., 2017; L. R. Mikkelsen et al., 2014; L. R. Mikkelsen et al., 2012; Monticone et al., 2014; Nankaku et al., 2016; Umpierres et al., 2014). No detailed information about pain medication is described, therefore caution is needed when interpreting the outcomes related to pain. Results of the JOA describe an improvement. However, some of the items in this questionnaire are related to the Asian lifestyle which makes it not generalisable to other cultures. (Matsumoto et al., 2012) Furthermore pain is also described in in the following questionnaires: HHS, WOMAC, HOOS, SF-36 and Merle d'Aubigné and Postel score (M. S. Austin et al., 2017; Galea et al., 2008; L. R. Mikkelsen et al., 2014; L. R. Mikkelsen et al., 2012; Monticone et al., 2014; Umpierres et al., 2014). The studies using these questionnaires specifically indicate an improvement in pain however the sub score on the item ‘pain’ is not known.

Rehabilitation with supervision ensures improvement of hip ROM in all directions measured with goniometry (Nankaku et al., 2016; Umpierres et al., 2014). Exercises to specifically improve ROM are not used in these studies. Based on these results, the principle of ‘specificity’ does not necessarily apply to improve range of motion after THA. Without supervision only extension, adduction and internal rotation improve (Umpierres et al., 2014). M. S. Austin et al. (2017) states that with regard to the HHS, hip ROM significantly improves using both unsupervised home-based therapy and supervised formal outpatient therapy. This is contradictory to the previously described results, but the quality of evidence of the HHS is very low (Table 4).

Regarding muscle strength, all supervised interventions with progression, improve the strength of hip flexion, extension, abduction, adduction and internal rotation. These improvements are independent of the surgical approach. (L. R. Mikkelsen et al., 2014; L. R. Mikkelsen et al., 2012; Nankaku et al., 2016; Umpierres et al., 2014) External rotation is preserved by the use of a specific external rotation exercise program in addition to conventional rehabilitation. Conventional rehabilitation without progression, does not improve hip abduction strength. (Nankaku et al., 2016)

Specific gait parameters can be improved by using a supervised and progressive rehabilitation program.

Using supervised PRT in addition to home-based exercises gives the best improvement for gait speed compared to other interventions (Galea et al., 2008; L. R. Mikkelsen et al., 2014; L. R. Mikkelsen et al., 2012). This is probably due to a transfer from the supervised PRT to the gait speed. When using
standard rehabilitation without progression, a decrease in gait speed is found (L. R. Mikkelsen et al., 2012). All interventions ensure an improvement in gait speed when adding supplementary walking (Galea et al., 2008; L. R. Mikkelsen et al., 2014; L. R. Mikkelsen et al., 2012). Merle d'Aubigné and Postel score is placed by us under body function and structures level according to existing literature (Alviar et al., 2011; Hoang-Kim et al., 2014). More items from this questionnaire improve using supervised interventions (Umpierres et al., 2014). According to Galea et al. (2008), patients did not experience a difference on the AQoL between home-based and supervised centre-based rehabilitation.

5.2.2.2. Activity level
For all outcomes, except for negotiation stairs, 6MWT and SF-36, home-based therapy is at least equally effective as standard therapy, in- and outpatient therapy. It can be noticed that in every rehabilitation content functional exercises related to ADL are used (M. S. Austin et al., 2017; Galea et al., 2008; L. R. Mikkelsen et al., 2014; L. R. Mikkelsen et al., 2012; Monticone et al., 2014; Nankaku et al., 2016; Okoro et al., 2016; Umpierres et al., 2014). Negotiating stairs (Galea et al., 2008; L. R. Mikkelsen et al., 2014) and 6MWT (Galea et al., 2008) support the above described finding concerning home-based therapy. This is not in accordance to the finding of Okoro et al. (2016) in which walking capacity and negotiation stairs improves more with standard rehabilitation. This could possibly be due to the type of exercises. The exercises used in the standard rehabilitation address aspects that can be helpful in improving walking capacity (e.g. weight bearing performed against gravity, postural exercises). Because of the heterogeneity of interventions which are used in the articles describing SF-36, the results are contradictory and inconclusive. Therefore, we are not able to mention which rehabilitation content is more effective or improves physical and mental health effectively. Furthermore, each study uses another surgical approach. Which could be a possible explanation for the differences in results. (M. S. Austin et al., 2017; Monticone et al., 2014; Umpierres et al., 2014)

The following described outcomes are in accordance to our previously described statement in which home-based therapy appears to be at least equally effective as the other interventions. With regard to the TUG only Galea et al. (2008) find that home-based exercises are superior to supervised centre-based exercises. Although the AQoL between the groups remains the same (Galea et al., 2008). In the two other studies using the TUG, between group results are not interpretable because they are not given or only given at one specific time point (Nankaku et al., 2016; Okoro et al., 2016).

We categorize the one-legged stance test as a test on activity level because multiple skills (e.g. muscle force, balance, muscle endurance, …) must be implemented correctly to perform this test. One-legged stance time improves in the home-based and standard therapy groups, but no differences between groups are found. Caution is needed when interpreting this result because of its low evidence based on the GRADE-criteria due to small sample size and RoB (Table 4). When looking at the amount of physical activity, the quality of life and the training compliance and patient satisfaction, no differences between groups are found. This might possibly declare the results of the one-legged stance test. (L. R. Mikkelsen et al., 2012)
All interventions are equally effective in improving 30s sit-to-stand performance. L. R. Mikkelsen et al. (2014) find improvements after ten weeks but this is not preserved at long-term follow up at six months. This is contradictory to the findings of Okoro et al. (2016), who describes an improvement at long-term follow up at 9-12 months. Because of the heterogeneity of the follow-up time a generalised conclusion concerning improvements in time cannot be made. (L. R. Mikkelsen et al., 2014; Okoro et al., 2016)

The three items (pain, range of motion, function) of the HHS improve. Unsupervised home-based therapy as well as formal outpatient therapy are equally effective. Results of the HHS need to be interpreted with caution because of its score on the GRADE, which is very low Table 4). Besides this, the HHS is known to have a floor and ceiling effect, which can limit the potential of measuring more subtle differences. (M. S. Austin et al., 2017)

Pain, stiffness and function can be measured using the WOMAC, most items are categorised under activity level (Alviar et al., 2011). These aspects can be improved using both home-based therapy as well as standard, in- and outpatient therapy (M. S. Austin et al., 2017; L. R. Mikkelsen et al., 2012). It seems that more improvement can be reached when using task-oriented exercises instead of open chain exercises. This might be declared by the results of the global perceived effect with the task-oriented exercise group having a greater perceived effect (Monticone et al., 2014). Results need to be interpreted with caution because of low evidence according to the GRADE-criteria (Table 4). The WOMAC is known for having a possible floor and ceiling effect which can limit the potential of measuring more subtle differences. (M. S. Austin et al., 2017)

The HOOS-items improve in the short-term using home-based therapy. These differences are not preserved in the long term (L. R. Mikkelsen et al., 2014). In this study the addition of supervised PRT to home-based exercises gives no additional improvement. Caution is needed when interpreting these results because of moderate evidence according to the GRADE-criteria, because of small sample sizes. (Table 4) The HOOS-items cover every ICF-level which makes it a valuable summary score, but it is only used in one study.

Health status, measured with the EQ-5D, improves at four weeks using intensified home-based exercises and standard rehabilitation. There is no difference between groups. (L. R. Mikkelsen et al., 2012)

With regard to different surgical approaches, (Engdal, Foss, Taraldsen, Husby, & Winther, 2017) conclude that there are no differences in daily physical activity early after surgery. Surgical interventions included in this study are the direct anterior, lateral and posterior approach.

5.2.2.3 Participation level

When outcome measures can be applied to more than one level of the ICF-model, we categorise the outcomes to existing literature (Alviar et al., 2011; Hoang-Kim et al., 2014) and according to the number of items related to each ICF-level. Following questionnaires contain items on participation level but are categorised and discussed elsewhere. The WOMAC, HOOS, SF-36, AQoL and EQ-5D each have items on participation level. The scores of these individual items are not discussed because only a total score is given.
5.2.2.4. Person level
The AQoL questionnaire has a few items on person level. This questionnaire describes items on body function and structures level and activity level. Most items account for body function and structures level, where the summary score is discussed. (Galea et al., 2008) Training compliance, patient satisfaction (L. R. Mikkelsen et al., 2012) and global perceived effect of treatment (Monticone et al., 2014) are difficult to generalise because they are each used in one study only. These results are not discussed here, but they are linked to other outcome measures on different ICF-levels to explain their results.

5.2.2.5. Environmental level
When outcome measures can be applied to more than one level of the ICF-model, we categorise the outcomes to existing literature (Alviar et al., 2011; Hoang-Kim et al., 2014) and according to the number of items related to each ICF-level. The following questionnaires contain items on participation level but are categorised and discussed elsewhere: the HHS and Merle d’Aubigné and Postel Score. They each have an item on environmental level. The scores of this individual item are not discussed because only a total score is given. (M. S. Austin et al., 2017; Umpierres et al., 2014)

5.3. Reflection on the strengths and weaknesses of the literature study
Our study has several strengths. Two independent assessors execute a search with their own search terms. A search is performed in November 2017 and March 2018 to make sure we implemented the latest evidence. Search strategies are compared and merged with each other. The literature search spans two databases: PubMed and WOS. When all references of both databases were joint, 848 duplicates were removed. This indicates a large overlap which means we cover as many articles as possible about the domain of interest. After duplicates are removed both assessors individually selected articles for in- and exclusion based on the extensively described in- and exclusion criteria. There is 90,26% correspondence for selection of articles, a consensus is found for the remainder 9,74%. All eight included articles are randomised controlled trials from the last ten years. A quality assessment of the included articles is executed by two independent assessors according to the GRADE-criteria, which is a practical supplement to the advice in the Cochrane handbook to assess quality of outcomes implemented in a review. Eleven of the 16 outcomes are of moderate evidence, four of them are scored with low evidence and only one is of very low evidence. All information about literature search, exclusion and quality of articles is displayed in a clear flow chart (fig 1). Data extraction is performed by two independent assessors. When there is disagreement, data is discussed until an agreement is reached. A few weaknesses can be found in our study. We are not able to describe the volumes of the interventions because lack of information hereabout in the included articles. Not all operative methods are described because lack of information in the included articles. No conclusions are made about the effect of rehabilitation content on the participation and environmental ICF-level because only summary scores of the outcomes on these levels are given. At last, caution is needed when interpreting our results because of small sample sizes.

5.4. Recommendations for further research
In general, more (recent) studies are needed about rehabilitation including GMe exercises. The sample sizes, from the studies which are included in this systematic review, are too small to make
valid generalisations about the found results. More large-sample size studies are needed in the future. Besides, some studies do not clearly describe their follow-up times, or they are from a short duration. Long-term follow-up studies would be valuable to add to this topic. As mentioned in the introduction, a detailed description of exercise content and more specifically volume is lacking. We would highly recommend future researchers to include this in their studies, so more clear and generalised guidelines about the rehabilitation can be developed. Monitoring of how much patients actually perform their exercises, would be a valuable addition to future research f.e. by implementing E-Health. The surgical method from certain studies could not be obtained. This makes interpreting results less valid because surgical approach, as mentioned in the discussion, can have an influence on the rehabilitation. Lastly, some studies only give the summary scores from their used questionnaires. This provokes difficulties when categorising effects according to the ICF-levels because some questionnaires are situated on multiple ICF-levels. We would recommend that if possible the sub scores are at least described in an added table.
6. Conclusion
In conclusion standard, inpatient, outpatient and home-based rehabilitation implementing GMex exercises were offered to persons after THA. Body functions and structures level was best improved by adding supervision and progression, for activity level home-based exercises were at least equally effective to the other interventions, for the other three levels no statement could be made.
7. Reference list: literature study


References of excluded articles:


Blood for Treatment of Proximal Hamstring Tendinopathy. *Journal of Ultrasound in Medicine*, 34(8), 1455-1463. doi:10.7863/ultra.34.8.1455


on comparative effectiveness of clinical pathways. *Int J Technol Assess Health Care, 25*(2), 113-123. doi:10.1017/s0266462309090163


Khan, R. J. K., Lam, L. O., Breidahl, W., & Blakeney, W. G. (2012). Magnetic Resonance Imaging Features of Preserved vs Divided and Repaired Piriformis During Total Hip Arthroplasty A
Randomized Controlled Trial. Journal of Arthroplasty, 27(4), 551-558. doi:10.1016/j.arth.2011.06.004


pain, physical function, and postural stability in patients with fibromyalgia: a randomized controlled trial. *Clinical Rehabilitation*, 25(9), 800-813. doi:10.1177/0269215511399476


Pourahmadi, M. R., Takamjani, I. E., Jaberzadeh, S., Sarrafzadeh, J., Sanjari, M. A., Mohsenifar, H., ... Taghipour, M. (2017). The Effect of Core Stabilization Exercise on the Kinematics and Joint Coordination of the Lumbar Spine and Hip During Sit-to-Stand and Stand-to-Sit in Patients


Unver, B., Bakirhan, S., & Karatosun, V. (2016). Does a weight-training exercise programme given to patients four or more years after total knee arthroplasty improve mobility: A randomized controlled trial. *Archives of Gerontology and Geriatrics, 64*, 45-50. doi:10.1016/j.archger.2016.01.003


Vukomanovic, A., Popovic, Z., Durovic, A., & Krstic, L. (2008). The effects of short-term preoperative physical therapy and education on early functional recovery of patients younger than 70


77
ARTHROPLASTY - A RANDOMIZED CLINICAL TRIAL. European Journal of Medical Research, 14(6), 256-263. doi:10.1186/2047-783x-14-6-256


Records identified through PubMed search  
n=373  

Records identified through WOS search  
n=1214  

Records after duplicates removed  
n=739  

First selection: excluded based on title/abstract  
n=49  

Third selection: based on full text  
n=8  

Studies included in qualitative assessment using GRADE criteria  
n=8  

Included studies  
n=8  

Records excluded  
n=690  

Records excluded  
n=41  

- trial protocol  
- no Dutch, English, French or German  
- no THA-surgery  
- mixed surgical interventions  
- no control group  
- pre-surgical/non-active interventions  
- occupational therapy as main intervention  
- outcome not directly related to active rehabilitation  
- no pre-post intervention measures  
- no within-group analysis  

8. Appendix: literature study

Figure 1. Flow chart in- and excluded articles PubMed and WOS
Table 2

Excluded studies and reason for exclusion (n=X)

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<th>Reason for exclusion</th>
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<td>Trial protocols, designs of an RCT or designs other than RCT</td>
<td>n=88</td>
<td>(J. Haxby Abbott et al., 2009; Akazawa, Okawa, Tamura, &amp; Moriyama, 2017; Ayanniyi, Ukpai, &amp; Adeniyi, 2010)</td>
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<td></td>
<td></td>
<td>(Aggarwal, Shashikanth, &amp; Marwaha, 2014; Awad, Cheung, Al-Allaq, Conroy, &amp; McCartney, 2013; Banerjee &amp; McLean, 2011; Becchi et al., 2008;</td>
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Pharmacological interventions  n=35
(Anthony & Ding, 2017; Arden et al., 2016; Arjmandi et al., 2014; Benson et al., 2009; Bern et al., 2007; Chlebowski et al., 2013; S. Cho et al., 2010; H. Clarke et al., 2015; Doria, Buonocore, Michelotti, Nobile, & Marzatico, 2013; Durmus, Alayli, Aliyazicioglu, Buyukakincak, & Canturk, 2013; Flodin et al., 2015; Heres et al., 2012; G. S. Jensen, Lenninger, Beaman, Beaman, Taylor, & Benson, 2015; S.-P. Jung et al., 2013; Kadooka et al., 2013; Kelley, Adams, Mulliken, & Dalury, 2013; Lei, Guo, Wang, Zhang, & Hua, 2017; Lyles et al., 2007; Mak, Mason, Klein, & Cameron, 2016; Neves et al., 2011; Oremus, Sostaric, Trkulja, & Haspi, 2014; Rabago, Mundt, Zgieska, & Grettie, 2015; Remerand et al., 2009; Shane et al., 2012; Snijders et al., 2011; Stanczyk, Archer, Rubin, & Foegh, 2013; Sullivan et al., 2012; Thakur, Thakur, Narayan, & Sinha, 2008; Wenz, Hornung, Cramer, Schroeder, & Hoffmann, 2017; Wilson, Auroux, Eloy, Merman, & Chelly, 2014; Yasuda et al., 2012; Q. Zhao, Li, Jiang, & Hu, 2016; Zoric et al., 2014)

Passive interventions  n=19
(Araujo, de Souza Guerino Macedo, Ferreira, Shigaki, & da Silva, 2016; Ashraf et al., 2014; Braid et al., 2008; Broadbent et al., 2010; Cheatham, Stull, & Kolber, 2017; Goldberg et al., 2014; Hogler et al., 2017; Hsieh & Lee, 2016; Jamtvedt et al., 2010; Kelly, Racinais, Tanner, Grantham, & Chalabi, 2010; Kivlan, Garcia, Clemente, Phelps, & Martin, 2015; Lansdown, Howard, Brealey, & MacPherson, 2009; J. Liu, Li, Cao, & Wang, 2015; P. W. M. Marshall, Cashman, & Cheema, 2011; Schiller et al., 2016; Springer, Lafer, Becher, &
<table>
<thead>
<tr>
<th>Intervention Type</th>
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<th>Studies</th>
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<td>Non-physical therapy related interventions</td>
<td>25</td>
<td>(Aaboud et al., 2016; Andersson, Hulander, Rothenberg, &amp; Iversen, 2017; Bay et al., 2017; Benito-Ruiz et al., 2009; Blanc-Bisson, Dechamps, Gouspillou, Dehail, &amp; Bourdel-Marchasson, 2008; Courteix et al., 2015; Hinman, Heywood, &amp; Day, 2007; Hinman et al., 2016; A. F. Jacobson et al., 2016; Lechner et al., 2011; Messier, Mihalko, Legault, et al., 2013; Minns, Marsh, Chuck, &amp; Todd, 2007; Myint et al., 2013; Nicoll, Rowlands, Fazakerly, &amp; Kellett, 2015; Rizwan et al., 2011a; Rizwan et al., 2011b; Rizzo et al., 2014; Roure, Oddos, Rossi, Vial, &amp; Bertin, 2011; Sattari &amp; Ashraf, 2011; Sharia, Lam, Kargarfard, Tamrin, &amp; Danaee, 2017; Siavash, Naseri, &amp; Rahimi, 2016; Srbely, Dickey, Bent, Lee, &amp; Lowerison, 2010; Yilmaz, Dikmen, Kokturk, &amp; Dedeoglu, 2016; Yoon et al., 2013)</td>
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<tr>
<td>Preventive, preoperative or non-surgical interventions</td>
<td>5</td>
<td>(Aerts et al., 2015; Oliver, Healey, &amp; Haines, 2010; K. Sanchez, Eloumri, Rannou, &amp; Poiradeau, 2010; I. Svege, Nordsletten, Fernandes, &amp; Risberg, 2015; Allan Villadsen, 2016)</td>
</tr>
<tr>
<td>No intervention, descriptive study</td>
<td>51</td>
<td>(Alfirevic, Milan, &amp; Livio, 2012, 2013; Ambardekar, Shochet, Bracken, Coyaji, &amp; Winkoff, 2014; Bai, 2009; Beyer-Westendorf, Bogorad, Tautenhahn, Marten, &amp; Schellong, 2013; Bucheker, Lindinger, Pfusterschmied, &amp; Mueller, 2013; Burgers et al., 2016; Curwin, Allt, Szpilfogel, &amp; Makrides, 2013; Marco Di Monaco et al., 2014; Falvey, Mangione, &amp; Stevens-Lapsley, 2015; A. M. Fearon et al., 2015; Gonzalez Montalvo et al., 2011; Grana et al., 2016; Hawkew, 2017; Heikkinen, Vihriaelae, Vainionpaae, Korpelainen, &amp; Jaemsae, 2007; Holm, Kristensen, Husted, Kehlet, &amp; Bandholm, 2011; Hunter, Thelen, &amp; Dhaher, 2009; C. Jackson, Emck, Hunston, &amp; Jarvis, 2009; Jansen, Mens, Backx, &amp; Stam, 2009; Kemmler &amp; von Stengel, 2013; Koh et al., 2017; Liebs, Kloos, Herzberg, Ruether, &amp; Hassenpflug, 2013; Lyle, Valero-Cuevas, Gregor, &amp; Powers, 2015; P. W. M. Marshall, Lovell, &amp; Siegler, 2016; Mat et al., 2015; Merk, Winkler, Best, &amp; Horstmann, 2008; Mudumbai et al., 2016; Nakase et al., 2013; Ni, Mooney, Harriell, Balachandran, &amp; Signorile, 2014; P. R. Nielsen, Andreasen, Asmussen, &amp; Tonnesen, 2008; Niemeyer et al., 2015; Palsson &amp; Graven-Nielsen, 2012; Pommengaard et al., 2012; Rampersaud et al., 2014; Reinhold, Witt, Jena, Brinkhaus, &amp; Willich, 2008; Serner et al., 2014; S. T. Skou et al., 2016b; Steffen et al., 2016; Stiles, Griew, &amp; Rowlands, 2013; Stubbs et al., 2010; Tuakli-Wosornu, Selzer, Losina, &amp; Katz, 2016; Uy, Kurrle, &amp; Cameron, 2008; M.-Y. Wang et al., 2013; White et al., 2010; N. H. Williams et al., 2009; Woolcott, Khan, Mitrovic, Anis, &amp; Marra, 2012; Wyers et al., 2010; Zielinski et al., 2014)</td>
</tr>
<tr>
<td>Other pathologies</td>
<td>102</td>
<td>(Aasvang et al., 2017; Aghazadeh et al., 2015; Agosti, Chandler, Anderton, &amp; Clark, 2013; Akamatsu et al., 2017; Ang et al., 2010; Bade, Kittelson, Kohrt, &amp; Stevens-Lapsley, 2014; Bagatin et al., 2013; Baldon, Piva, Silva, &amp; Serrao, 2015; Bejek, Paroczai, Szendroi, &amp; Kiss, 2011; Bentsen, Rustoen, Kloostad, &amp; Vatine, 2013; Srbely, Vernon, Lee, &amp; Polgar, 2013; Teut et al., 2012)</td>
</tr>
</tbody>
</table>
Cancer n=6 (Bourke et al., 2011; Gamboa, Rehmus, & Haller, 2010; Greenlee et al., 2013; Ligibel et al., 2008; Nikander et al., 2012; Nuta et al., 2016)

Primary vascular and internal diseases n=12 (Healy, Beasley, & Weatherall, 2010; Heyes, Tucker, Michael, & Wallace, 2015; O’Shea, Taylor, & Paratz, 2007; Parmentier, Raymond, Dinnen, Lusby, & Singh, 2013; Peoples et al., 2011; Somov, Makarova, & Makarova, 2015; Sumin, Bezdenezhnykh, Baidina, Popova, & Khairatdinova, 2011; van Buuren et al., 2013; J. Yuan et al., 2016; Zanfardino et al., 2014; Zanoni, Galvao, Cliquet Junior, & Saad, 2015)

Psychological/psychiatric disorders n=11 (Cleton et al., 2014; Fleischhacker et al., 2012; Hough et al., 2009; Kroenke et al., 2009; Kroenke et al., 2012; Kroenke et al., 2011; Papadopoulos et al., 2014; Rossenu et al., 2015; Seitz et al., 2014; Turncliff, Hard, Du, Risinger, & Ehrich, 2014)

Children n=6 (Bartels et al., 2014; Garcia Bartels et al., 2014; Garcia Bartels et al., 2012; Kanti et al., 2014; Lavender et al., 2012; Xu et al., 2013)

Animal study n=3 (Clayton, Kaiser, Lavagnino, & Stubbs, 2012; Gallant et al., 2014; Mayer-Wagner et al., 2010)

Excluded based on abstract

<table>
<thead>
<tr>
<th>Reason for exclusion</th>
<th>#studies</th>
<th>Auteur(s), year</th>
</tr>
</thead>
<tbody>
<tr>
<td>No active (exercise) therapy n=86 (Alves Araujo, Guerino Macedo, Ferreira, Shigaki, &amp; da Silva, 2016; Auffarth et al., 2011; Barlow, Donovan, Hart, &amp; Hertel, 2015; Benjamin, Andersen, Herndon, &amp; Suman, 2015; Bennell et al., 2011; Beselga, Neto, Alburquerque-Sendin, Hall, &amp; Oliveira-Campelo, 2016; Bolgla, Earl-Boehm, Emery, Hamstra-Wright, &amp; Ferber, 2015; A. M. Castro-Sanchez et al., 2011; C.-M. Cheng et al., 2012; Choi, Hoffer, &amp; Robinovitch, 2010; Christiansen, 2008; Cipriani, Terry, Haines, Tabibnia, &amp; Lyssanova, 2012; de Carvalho et al., 2016; Deyle, Gill, Allison, Hando, &amp; Rochino, 2012; L. Donovan, Hart, &amp; Hertel, 2015; Luke Donovan et al., 2016; Dowsey et al., 2014; Erickson, Thomas, Gribble, Doebel, &amp; Pietrosimone, 2015; Eschen, Kring, Brix, Ban, &amp; Troelsen, 2012; Fasen et al., 2009; Foster, Voss, Hatch, &amp; Frimodig, 2015; Foucher &amp; Freels, 2015; John P. Furia, Jan D. Rompe, &amp; Nicola Maffulli, 2014; Ceca, Elvira, Guzman, &amp; Pablos, 2017; M. K. Cho, Kim, Chung, &amp; Hwang, 2015; Claerbout et al., 2012; Duval, Luttin, &amp; Lam, 2011; Dyball, Taylor, &amp; Dodd, 2011; Ferland, Lepage, Moffet, &amp; Maltais, 2012; Ghedira et al., 2017; Groah, Lichy, Libin, &amp; Ljungberg, 2010; Helayel, Bussman, da Conceicao, &amp; de Oliveira Filho, 2008; Herrero et al., 2010; K. Jung et al., 2015; Kojovic, Djuric-Jovicic, Dosen, Popovic, &amp; Popovic, 2009; Kumar, Chakrapani, &amp; Kedambadi, 2016; Lau &amp; Pang, 2009; Leech, Kinnaird, Holleran, Kahn, &amp; Hornby, 2016; Lidbeck, Tedroff, &amp; Bartonek, 2015; Maguire, Sieben, Frank, &amp; Romkes, 2010; Maria Castro-Sanchez et al., 2011; Miyara et al., 2014; Ni &amp; Signorile, 2017; Ni, Signorile, Balachandran, &amp; Polta umpai, 2016; M. Y. C. Pang, Zhang, Li, &amp; Jones, 2013; Polese et al., 2013; Sheffler et al., 2015; Simon, do Pinho, dos Santos, &amp; Pagnussat, 2014; Straudi et al., 2017; Wegener, Wegener, Smith, Schott, &amp; Burns, 2016)</td>
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</table>
No GMe involvement in the intervention  n=37

<table>
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<tr>
<th>Study Design</th>
<th>n=</th>
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<tr>
<td>No THA</td>
<td>36</td>
</tr>
<tr>
<td>Other study design</td>
<td>17</td>
</tr>
<tr>
<td>Active intervention combined with a passive intervention whereby a valid statement about the active intervention cannot be made</td>
<td>14</td>
</tr>
<tr>
<td>Non-physical therapy related</td>
<td>11</td>
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</tbody>
</table>

For No THA, n=36 include:

For Other study design, n=17 include:

For Active intervention combined with a passive intervention whereby a valid statement about the active intervention cannot be made, n=14 include:
- J. Haxby Abbott et al., 2015; J. H. Abbott et al., 2013; Amiri-Khorasani, Abu Osman, & Yusof, 2011; Brantingham et al., 2012; Chen, Chen, Jan, & Lin, 2015; de Castro Lacaze, Sacco, Rocha, de Braganca Pereira, & Casarotto, 2010; Dwyer et al., 2015; Kostopoulos & Rizopoulos, 2008; Koybasi, Borman, Kocaoglu, & Ceceli, 2010; Niitsu et al., 2016; Pereira Avelar et al., 2011; Jan D. Rompe et al., 2009; Veenhof et al., 2007; Wyon, Smith, & Koutedakis, 2013.

For Non-physical therapy related, n=11 include:
- Bolton et al., 2012; Bourne, Duhig, et al., 2017;
| outcomes                                                                 | McKenzie et al., 2017; Mjaaland, Kivle, Svenningsen, Pripp, & Nordsletten, 2015; Nahm et al., 2012; Pedersen et al., 2008; Robinson, Wagstaff, Sanghera, & Kerry, 2014; O. Wolf, Mattsson, Milbrink, Larsson, & Mallmin, 2010; Olof Wolf, Mattsson, Milbrink, Larsson, & Mallmin, 2013; Woollard et al., 2011; Yip et al., 2007 |
| Preventive interventions                                                 | n=2 (Hance Clarke, Woodhouse, Kennedy, Stratford, & Katz, 2011; Zeng et al., 2015) |
| Psychological/psychiatric disorders                                      | n=1 (Seitz et al., 2016) |
| Population <18 years                                                     | n=1 (Whittaker & Emery, 2015) |

### Excluded based on other pathologies in title and abstract

<table>
<thead>
<tr>
<th>Reason for exclusion</th>
<th>#studies</th>
<th>Auteur(s), year</th>
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<tbody>
<tr>
<td>Anterior cruciate ligament reconstruction</td>
<td>n=1</td>
<td>Bell, Kulow, Stiffler, &amp; Smith, 2014</td>
</tr>
<tr>
<td>Hip osteoarthritis</td>
<td>n=1</td>
<td>Fukumoto et al., 2014</td>
</tr>
<tr>
<td>Knee osteoarthritis</td>
<td>n=4</td>
<td>(Lun, Marsh, Bray, Lindsay, &amp; Wiley, 2015; Lund et al., 2008; Yennan, Suputtiyada, &amp; Yuktanandana, 2010; Zakir et al., 2016)</td>
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<tr>
<td>Total knee arthroplasty</td>
<td>n=5</td>
<td>(Liao et al., 2015; Loyd et al., 2017; Negus et al., 2015; S. T. Skou et al., 2016a; Toussignant et al., 2011)</td>
</tr>
<tr>
<td>Medial tibial stress syndrome</td>
<td>n=1</td>
<td>(Sharma, Weston, Batterham, &amp; Spears, 2014)</td>
</tr>
<tr>
<td>Anterior knee pain</td>
<td>n=1</td>
<td>(Telles et al., 2016)</td>
</tr>
<tr>
<td>Patellofemoral pain syndrome</td>
<td>n=20</td>
<td>(Avraham et al., 2007; Baldon Rde, Piva, Scattone Silva, &amp; Serrao, 2015; Baldon Rde, Serrao, Scattone Silva, &amp; Piva, 2014; Baldon et al., 2015; Baldon, Serrao, Scattone Silva, &amp; Piva, 2014; Baldon, Serrao, Silva, &amp; Piva, 2014; Bazett-Jones, Huddleston, Cobb, O'Connor, &amp; Earl-Boehm, 2017; Dolak et al., 2011; dos Anjos Rabelo et al., 2017; Drew, Conaghan, Smith, Selfe, &amp; Redmond, 2017; Ferber, Bolgia, Earl-Boehm, Emery, &amp; Hamstra-Wright, 2015; Thiago Yukio Fukuda et al., 2012; T. Y. Fukuda et al., 2012; Fukuda et al., 2010; Glaviano &amp; Saliba, 2016; Ismail, Gamaleldein, &amp; Hassa, 2013; Khayambashi, Mohammadkhani, Ghaznavi, Lyle, &amp; Powers, 2012; T. H. Nakagawa et al., 2008; Theresa Helissa Nakagawa et al., 2008; Razeghi, Etemadi, Taghizadeh, &amp; Ghaem, 2010; Selfe et al., 2013)</td>
</tr>
<tr>
<td>General osteoarthritis</td>
<td>n=1</td>
<td>(Lange et al., 2009)</td>
</tr>
<tr>
<td>Non-specific low back pain</td>
<td>n=1</td>
<td>(Kendall, Emery, Wiley, &amp; Ferber, 2015)</td>
</tr>
<tr>
<td>Lumbar disc surgery</td>
<td>n=1</td>
<td>(Ogutuler Ozkara et al., 2015)</td>
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</table>

### Excluded based on full text

<table>
<thead>
<tr>
<th>Reason for exclusion</th>
<th>#studies</th>
<th>Auteur(s), year</th>
</tr>
</thead>
<tbody>
<tr>
<td>Text: no THA</td>
<td>n= 4</td>
<td>(Arumugam, Milosavljevic, Woodley, &amp; Sole, 2015; K. L. Bennell et al., 2014; S. G. Kim &amp; Lee, 2015; Pakkala et al., 2012)</td>
</tr>
<tr>
<td>Text: pre-surgical intervention</td>
<td>n=4</td>
<td>(Bitterli, Sieben, Hartmann, &amp; de Bruin, 2011; Ferrara et al., 2008; Lyp et al., 2016; A. Villadsen, Overgaard, Holsgaard-Larsen, Christensen, &amp; Roos, 2014)</td>
</tr>
<tr>
<td>Text: control group does not receive hip surgery</td>
<td>n=1</td>
<td>(Cavill et al., 2016)</td>
</tr>
<tr>
<td>Text: No within group analysis</td>
<td>n=3</td>
<td>(Coulter, Perriman, Neeman, Smith, &amp; Scarvell, 2017; Salpakoski et al., 2014; P. Thingstad et al., 2016)</td>
</tr>
<tr>
<td>Text: <strong>mixed THA and internal fixation population</strong></td>
<td>n=4</td>
<td>(Edgren et al., 2015; Kronborg, 2017 #3401) (Shyu et al., 2016; Turunen, Salpakoski, et al., 2017)</td>
</tr>
<tr>
<td>Text: <strong>mixed THA and TKA population</strong></td>
<td>n=3</td>
<td>(Gooch et al., 2009; Liebs, Herzberg, Ruther, Russlies, &amp; Hassenpflug, 2016; Mahomed et al., 2008)</td>
</tr>
<tr>
<td>Text: <strong>no pre- and post-intervention measures</strong></td>
<td>n=2</td>
<td>(Husby et al., 2010; Okamoto et al., 2016)</td>
</tr>
<tr>
<td>Text: <strong>no control group</strong></td>
<td>n=3</td>
<td>(Host et al., 2007; Lone R. Mikkelsen et al., 2017; Westby, 2012)</td>
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<tr>
<td>Text: <strong>outcome is not directly related to active rehabilitation</strong></td>
<td>n=5</td>
<td>(C. Jensen, Aagaard, &amp; Overgaard, 2011; Meneghini &amp; Smits, 2009; Petersen, Andersen, &amp; Soballe, 2008; Suetta et al., 2008; Turunen, Salpakoski, et al., 2017)</td>
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<tr>
<td>Text: <strong>no active intervention</strong></td>
<td>n=2</td>
<td>(Busato et al., 2016; Saltvedt et al., 2012)</td>
</tr>
<tr>
<td>Text: <strong>the specific intervention which is investigated is occupational therapy</strong></td>
<td>n=1</td>
<td>(Martin-Martin et al., 2014)</td>
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<tr>
<td>Text: <strong>no implementation of gluteus medius in the intervention</strong></td>
<td>n=8</td>
<td>(Jakovljevic &amp; Vauhnik, 2011; Mendelsohn, Overend, Connelly, &amp; Petrella, 2008; Oosting et al., 2012; Shyu et al., 2013; Sylliaas, Brovold, Wyller, &amp; Bergland, 2012; Tseng, Liang, et al., 2016; Tseng, Shyu, &amp; Liang, 2012; Tseng, Shyu, Liang, &amp; Tsai, 2016)</td>
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<tr>
<td>Text: <strong>trail protocol, no outcomes</strong></td>
<td>n=1</td>
<td>(Monaghan, Grant, Hing, &amp; Cusack, 2012)</td>
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<tr>
<td>Text: <strong>other language than Dutch, English, French or German</strong></td>
<td>n=1</td>
<td>(Vukomanovic, Popovic, Durovic, &amp; Krstic, 2008)</td>
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<tr>
<td>Study</td>
<td>Random sequence generation (selection bias)</td>
<td>Allocation concealment (selection bias)</td>
</tr>
<tr>
<td>-------------------------------</td>
<td>---------------------------------------------</td>
<td>----------------------------------------</td>
</tr>
<tr>
<td>(Matthew S. Austin et al., 2017)</td>
<td>+</td>
<td>+</td>
</tr>
<tr>
<td>(Galea et al., 2008)</td>
<td>+</td>
<td>?</td>
</tr>
<tr>
<td>(L. R. Mikkelsen et al., 2014)</td>
<td>+</td>
<td>+</td>
</tr>
<tr>
<td>(L. R. Mikkelsen et al., 2012)</td>
<td>?</td>
<td>+</td>
</tr>
<tr>
<td>(Nankaku et al., 2016)</td>
<td>?</td>
<td>?</td>
</tr>
<tr>
<td>(Okoro et al., 2016)</td>
<td>+</td>
<td>?</td>
</tr>
<tr>
<td>(Umpierre et al., 2014)</td>
<td>+</td>
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- **No bias**: +
- **Not mentioned**: ?
- **Bias**: o
Table 4
GRADE for critical assessment of outcome measures

<table>
<thead>
<tr>
<th>HHS (Matthew S. Austin et al., 2017)</th>
<th>GRADE criteria</th>
<th>Rating</th>
<th>Footnotes</th>
<th>Quality of the evidence</th>
</tr>
</thead>
<tbody>
<tr>
<td>Study design</td>
<td>RCT (starts as high quality)</td>
<td>Start with high quality (RCT)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Risk of Bias</td>
<td>Very serious (-2)</td>
<td>No allocation concealment. No blinding of patients, personnel or outcome.</td>
<td></td>
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<tr>
<td>Inconsistency</td>
<td>No serious inconsistency</td>
<td>/</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Indirectness</td>
<td>No serious indirectness</td>
<td>/</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Imprecision</td>
<td>Serious (-1)</td>
<td>Continuous outcomes information is likely to be insufficient, if total number of participant is less than n=400. n=108, so the evidence was downgraded one level.</td>
<td></td>
<td>Very low</td>
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<tr>
<td>Publication Bias</td>
<td>Undetected</td>
<td>Not strongly suspected</td>
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<td></td>
</tr>
<tr>
<td>Other</td>
<td>/</td>
<td>/</td>
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</tbody>
</table>

<table>
<thead>
<tr>
<th>WOMAC (Matthew S. Austin et al., 2017; Galea et al., 2008; L. R. Mikkelsen et al., 2012; Monticone et al., 2014)</th>
<th>GRADE criteria</th>
<th>Rating</th>
<th>Footnotes</th>
<th>Quality of the evidence</th>
</tr>
</thead>
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<tr>
<td>Study design</td>
<td>RCT (starts as high quality)</td>
<td>Start with high quality (RCT)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Risk of Bias</td>
<td>Serious (-1)</td>
<td>No blinding of participants and personnel or this was unknown for each text. In one study (Matthew S. Austin et al., 2017) there was no blinding of outcome assessment, in another study (Galea et al., 2008) this was unknown. Quality of evidence was downgraded one level.</td>
<td></td>
<td>Low</td>
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<tr>
<td>Inconsistency</td>
<td>No serious inconsistency</td>
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<tr>
<td>Indirectness</td>
<td>No serious indirectness</td>
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<tr>
<td>Imprecision</td>
<td>Serious (-1)</td>
<td>Continuous outcomes information is likely to be insufficient, if total number of participant is less than n=400. n=275, so the evidence was downgraded one level.</td>
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<tr>
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<table>
<thead>
<tr>
<th>AQLQ, EQ-5D, SF 36 (Matthew S. Austin et al., 2017; Monticone et al., 2014; Umpierres et al., 2014) (Galea et al., 2008; L. R. Mikkelsen et al., 2012)</th>
<th>GRADE criteria</th>
<th>Rating</th>
<th>Footnotes</th>
<th>Quality of the evidence</th>
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<tr>
<td>Study design</td>
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<td>Start with high quality (RCT)</td>
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<td></td>
</tr>
<tr>
<td>Risk of Bias</td>
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<td>/</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Inconsistency</td>
<td>No serious inconsistency</td>
<td>/</td>
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</tbody>
</table>
### Indirectness
- **No serious indirectness**

### Imprecision
- **Serious** (-1)
  - Continuous outcomes information is likely to be insufficient, if total number of participant is less than n=400. n=358, so the evidence was downgraded one level.

### Publication Bias
- **Undetected**
- **Not strongly suspected**

### Other
- /
- /

#### TUG (Galea et al., 2008; Nankaku et al., 2016; Okoro et al., 2016)

<table>
<thead>
<tr>
<th>GRADE criteria</th>
<th>Rating</th>
<th>Footnotes</th>
<th>Quality of the evidence</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Study design</strong></td>
<td>RCT (starts as high quality)</td>
<td>Start with high quality (RCT)</td>
<td></td>
</tr>
<tr>
<td><strong>Risk of Bias</strong></td>
<td>No serious risk of bias</td>
<td>/</td>
<td></td>
</tr>
<tr>
<td><strong>Inconsistency</strong></td>
<td>No serious inconsistency</td>
<td>/</td>
<td></td>
</tr>
<tr>
<td><strong>Indirectness</strong></td>
<td>No serious indirectness</td>
<td>Outcomes in the studies were measured at different times, but this is not serious enough to downgrade one level.</td>
<td></td>
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<tr>
<td><strong>Imprecision</strong></td>
<td>Serious (-1)</td>
<td>Continuous outcomes information is likely to be insufficient, if total number of participant is less than n=400. n=76, so the evidence was downgraded one level.</td>
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<tr>
<td><strong>Publication Bias</strong></td>
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<td></td>
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<tr>
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#### 6MWT (Galea et al., 2008; Okoro et al., 2016)

<table>
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<tr>
<th>GRADE criteria</th>
<th>Rating</th>
<th>Footnotes</th>
<th>Quality of the evidence</th>
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<td><strong>Study design</strong></td>
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<td>Outcomes in both studies were measured at different times, but this is not serious enough to downgrade one level.</td>
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<td><strong>Other</strong></td>
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</table>
10MWT, 20MWT, walking speed, cadence, step length, step time, percentage in step time, single-support time, double-support time, symmetry index (step length, stem time, single- and double-support time) (L. R. Mikkelsen et al., 2012) (Galea et al., 2008; L. R. Mikkelsen et al., 2014)

<table>
<thead>
<tr>
<th>GRADE criteria</th>
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Negotiating stairs (Galea et al., 2008; L. R. Mikkelsen et al., 2014; Okoro et al., 2016)

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</table>

HHD, Kedall’s criteria (L. R. Mikkelsen et al., 2014; L. R. Mikkelsen et al., 2012; Nankaku et al., 2016; Umpierrez et al., 2014)

<table>
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<tr>
<th>GRADE criteria</th>
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<tr>
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<tr>
<td>Other</td>
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</table>
### 30s sit-to-stand test (L. R. Mikkelsen et al., 2014; Okoro et al., 2016)

<table>
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</table>

### HOOS (L. R. Mikkelsen et al., 2014)

<table>
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<th>Rating</th>
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<th>Quality of the evidence</th>
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<tr>
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### One-legged stance (L. R. Mikkelsen et al., 2012)

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<td>Risk of Bias</td>
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<td>No blinding of participants and personnel. No random sequence generation, incomplete outcome date, other bias is unknown</td>
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</tr>
<tr>
<td>Imprecision</td>
<td>Serious (-1)</td>
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<tr>
<td>Publication Bias</td>
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<td>Not strongly suspected</td>
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<tr>
<td>Other</td>
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<tr>
<td>Compliance, patient satisfaction, global perceived effect of treatment using a 5-point-scale (L. R. Mikkelsen et al., 2012; Monticone et al., 2014)</td>
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<td>---------------------------------------------------------------</td>
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<table>
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<tr>
<th><strong>PAS (L. R. Mikkelsen et al., 2012)</strong></th>
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</thead>
<tbody>
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<td><strong>Study design</strong></td>
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<table>
<thead>
<tr>
<th><strong>JOA (Nankaku et al., 2016)</strong></th>
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<td><strong>Study design</strong></td>
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<td><strong>Publication Bias</strong></td>
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<td><strong>Other</strong></td>
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</table>
### Goniometry (Nankaku et al., 2016; Umpierres et al., 2014)

<table>
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<th>GRADE criteria</th>
<th>Rating</th>
<th>Footnotes</th>
<th>Quality of the evidence</th>
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<td>Study design</td>
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</tr>
<tr>
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### Merle d’Aubigné and Postel score (Umpierres et al., 2014)

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<tr>
<td>Imprecision</td>
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Table 5
Strengths and weaknesses analysis

<table>
<thead>
<tr>
<th>Author(s), Date</th>
<th>Strengths</th>
<th>Weaknesses</th>
</tr>
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</table>
| (M. S. Austin et al., 2017) | - Subjects analysed (n=108)  
- Patients were randomised using an Excel random number generator  
- Long-term follow up (6-12 months) | - No blinding of participants, personnel and outcome assessors  
- No concealed allocation  
- A substantial number of patients were noncompliant with the allocated intervention  
- Two different approaches were used to perform THA  
- Selection bias may have influenced the cohort  
- Subjects may grade themselves as having a maximal or minimal score on self-reported outcomes, therefore the HHS, WOMAC and SF-36 have been reported to have floor and ceiling effects |
| (Galea et al., 2008) | - Patients were randomly assigned to the intervention or control group | - Small sample size, subjects analysed (n=23)  
- No information was given about the randomisation sequence, the blinding and the allocation concealment  
- No real control group was used in the study, therefore the program’s true effect is untested  
- Possible self-report bias in the recording of the exercise sessions in the intervention group  
- No information was given about the surgical approach |
| (L. R. Mikkelsen et al., 2014) | - Patients were randomly assigned to groups using a block randomisation  
- Subjects analysed (n=73)  
- Allocation was concealed using a simple shuffling envelope procedure  
- Patient, therapist and outcome assessors were blinded  
- Exclusion of the preoperative best functioning patients  
- Well-described intensity and execution of the exercises | - Potential selection bias and risk of attention bias |
| (L. R. Mikkelsen et al., 2012) | - Subjects are random assigned to groups  
- Allocation was concealed  
- Blinding of outcome assessors  
- Subjects analysed (n=44) | - No information was given about the randomisation sequence  
- No blinding of patients and therapists  
- Participants’ additional training activities might have affected their outcomes |
Follow-up time is relatively short (12 weeks)
- Because it ended up as a pilot study, it is not possible to make conclusions about the efficacy of the intervention
- Measurement errors
- Limited test battery

(Monticone et al., 2014)
- Patients were randomised according to a random sequence generation and allocation was concealed
- Blinding of outcome assessment
- Subjects analysed (n=100)
- Limited number of drop-outs
- RCT was internally valid
- Long term follow-up (12 months)
- No blinding of participants and personnel
- Not generalizable to all patients undergoing a first THA or surgical revisions
- Use of self-reported measures
- Relationship between self-reported measures and physical measures/test was not investigated
- No pre-surgical scores of disability, pain, ADL and quality of life
- Surgical approach not mentioned or obtained by email

(Nankaku et al., 2016)
- 100% compliance of subjects
- Random sequence generation and type of blinding not mentioned
- Allocation concealment not mentioned
- Subjects analyse (n=28)
- Investigated intervention only lasted 4 weeks
- No blinding of patients and personnel
- Long term follow-up (9-12 months)
- No long-term follow-up (4 weeks)

(Okoro et al., 2016)
- Patients were randomised according to a random sequence generation
- Blinding of outcome assessment
- Long term follow-up (9-12 months)
- No blinding of participants and personnel
- Allocation concealment not mentioned
- Subjects analysed (n=26)
- Compliance was a self-reported measure
- Additional training activities to the intervention could not be controlled for
- 25% loss-to follow up
- Limited generalizability
- Hip abduction exercises were included but the main focus were knee-extension exercises

(Umpierres et al., 2014)
- Patients were randomised according to a random sequence generation
- Blinding of outcome assessment
- Subjects analysed (n=106)
- Merle d'Aubigné and Postel score is validated to measure functional capacity
- Merle d'Aubigné and Postel
- No blinding of participants and personnel
- Short-term follow-up (2 weeks)
- Allocation concealment not mentioned
- Kendall's criteria can (negatively) be influenced by pain
- Measurements were obtained by different researchers and the
- Lack of a standard method to measure muscle strength
- Patient comorbidities were not included
- Gait evaluation was only reported as gait speed
- Results not generalizable to other surgical approaches

<table>
<thead>
<tr>
<th>Score and SF-36 are effective and reliable</th>
<th>Lack of a standard method to measure muscle strength</th>
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<tbody>
<tr>
<td></td>
<td>Patient comorbidities were not included</td>
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<tr>
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<td>Gait evaluation was only reported as gait speed</td>
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<td></td>
<td>Results not generalizable to other surgical approaches</td>
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</table>
Table 6

Used active rehabilitation contents including GMe exercises after THA

<table>
<thead>
<tr>
<th>Intervention</th>
<th>Exercise type</th>
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<tbody>
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<td><strong>Standard rehabilitation</strong></td>
<td></td>
</tr>
<tr>
<td>(L. R. Mikkelsen et al., 2012; Nankaku et al., 2016; Okoro et al., 2016)</td>
<td>- Gluteal muscle sets, leg sliding, straight leg raising, bridging, knee extension in sitting with low resistance, hip abduction in supine position without resistance, strengthening exercises for hip external rotators (supine, side lying with hip and knee flexed and prone with hip in neutral ab/adduction and knee 90° flexed)</td>
</tr>
<tr>
<td></td>
<td>- Exercises without external resistance</td>
</tr>
<tr>
<td></td>
<td>- Weight bearing performed against gravity (half squat, bilateral heel raises)</td>
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<tr>
<td></td>
<td>- Balance: move bilateral to unilateral support</td>
</tr>
<tr>
<td></td>
<td>- Functional without external loading</td>
</tr>
<tr>
<td></td>
<td>- Postural exercises focusing on strengthening overstretched and weak muscles</td>
</tr>
<tr>
<td></td>
<td><em>Modality</em></td>
</tr>
<tr>
<td></td>
<td>- Isometric, concentric, eccentric</td>
</tr>
<tr>
<td></td>
<td><strong>Stretching exercise</strong></td>
</tr>
<tr>
<td></td>
<td>- Stretching of hip flexors</td>
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<tr>
<td></td>
<td><strong>Supplementary exercises</strong></td>
</tr>
<tr>
<td></td>
<td>- Biking</td>
</tr>
<tr>
<td></td>
<td>- Walking</td>
</tr>
<tr>
<td><strong>Inpatient rehabilitation</strong></td>
<td></td>
</tr>
<tr>
<td>(Monticone et al., 2014; Umpierres et al., 2014)</td>
<td>- Strengthening of the gluteal and thigh muscles</td>
</tr>
<tr>
<td></td>
<td>- Strength exercises: flexion, extension, abduction, external rotation, isotonic and isometric quadriceps strengthening, hamstring curls</td>
</tr>
<tr>
<td></td>
<td>- Gait/walking training</td>
</tr>
<tr>
<td></td>
<td>- Balance: turning, sudden start/stop, changing speed/direction</td>
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<tr>
<td></td>
<td>- Functional training: sit-to stand, ascending/descending stairs, climbing obstacles, important ADL-strategies, recovering functional abilities</td>
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<tr>
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<td><em>Modality</em></td>
</tr>
<tr>
<td></td>
<td>- Open and closed kinetic chain exercises</td>
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<td>- Isometric, concentric</td>
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<td></td>
<td><strong>Supplementary exercises</strong></td>
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<tr>
<td></td>
<td>- Stationary cycling (strength and mobility)</td>
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<td><strong>Remark</strong></td>
</tr>
<tr>
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<td>- Supervised THA-protocol: supervised by a multidisciplinary hip group supported by a physical therapist</td>
</tr>
<tr>
<td></td>
<td>- Unsupervised THA-protocol: supervised by a multidisciplinary hip group only</td>
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</tbody>
</table>
A booklet with ergonomic advice can be given in addition to the inpatient exercises.

### Outpatient rehabilitation

(M. S. Austin et al., 2017; Galea et al., 2008; L. R. Mikkelsen et al., 2014)

<table>
<thead>
<tr>
<th>Exercise type</th>
</tr>
</thead>
<tbody>
<tr>
<td>- Warming up on stationary bike</td>
</tr>
<tr>
<td>- Strengthening and endurance: hip abduction</td>
</tr>
<tr>
<td>- PRT: hip extension and abduction</td>
</tr>
<tr>
<td>- Balance exercises: active single-leg stance</td>
</tr>
<tr>
<td>- Functional exercises: sit-to-stand, figure-of-eight path walk, climbing steps, side stepping</td>
</tr>
</tbody>
</table>

**Modality**
- Isometric, concentric, eccentric
- Open and closed kinetic chain exercises

**Supplementary exercises**
- Walking
- Biking

**Remark**
- Patients can be given a list of suggested physical therapy home-exercises in addition to the outpatient rehabilitation.

### Home-based rehabilitation

(M. S. Austin et al., 2017; Galea et al., 2008; L. R. Mikkelsen et al., 2014; L. R. Mikkelsen et al., 2012; Okoro et al., 2016)

<table>
<thead>
<tr>
<th>Exercise therapy</th>
</tr>
</thead>
<tbody>
<tr>
<td>- Unloaded hip flexion, hip extension, hip abduction, knee flexion, knee extension</td>
</tr>
<tr>
<td>- Exercises performed with a resistance band for the muscle groups most commonly affected by THA</td>
</tr>
<tr>
<td>- Functional exercises: step exercises, sit-to-stand, block stepping, stair climbing, walking, lateral weight transfer exercises</td>
</tr>
</tbody>
</table>

**Modality**
- Isometric, concentric, eccentric
- Open and closed kinetic chain exercises

**Stretching exercise**
- Stretching of hip flexors

**Supplementary exercises**
- Walking
- Biking

**Remark**
- Patients can be given detailed physical therapy manual with written basic instructions and illustrations
- A demonstration of exercises prior to discharge can be given to the patients.
### Table 7

Data extraction of included articles

<p>| Surgical approach: combination of direct lateral or direct anterior approach |
|---|---|---|---|
| <strong>Author</strong> | <strong>Patient</strong> | <strong>Content</strong> | <strong>Results</strong> |
| (Matthew S. Austin et al., 2017) | n=120* | IG: Unsupervised home exercise group | HHS (Activity level) |
| | IG (n=60) | Exercise type | Significant within group differences were found for the IG (p&lt;0.001) and CG (p&lt;0.001) between baseline and 1 month. This significant difference was also found between baseline and the 6-12 month follow up for both groups with p&lt;0.001. No significant difference between groups at 1 month, 6 and 12 months postoperatively when controlling for confounders (p=0.82). |
| | CG (n=60) | - Patients received a detailed physical therapy manual with written explanations and images | |
| | | - Demonstration of exercises prior to discharge | |
| | | <strong>Modality</strong> | - No information |
| | | <strong>Volume</strong> | - 3x/d for 10 w |
| | CG: Formal outpatient therapy | Exercise type | WOMAC (Activity level) |
| | | - In-home physical therapy | Significant within group differences were found for the IG (p&lt;0.001) and CG (p&lt;0.001) between baseline and 1 month. This significant difference was also found between baseline and the 6-12 month follow up for both groups with p&lt;0.001. No significant difference between groups at 1 month, 6 and 12 months postoperatively when controlling for confounders (p=0.80). |
| | | - Formal outpatient therapy | |
| | | - Patients received a list of suggested physical therapy home-exercises | |
| | | <strong>Modality</strong> | - No information |
| | | <strong>Volume</strong> | - 2w in-home therapy - 2-3x/w for 8w |
| | SF-36: Physical Health Component Summary (Activity level) | Significant within group differences were found for the IG (p&lt;0.001) and CG (p&lt;0.001) between baseline and 1 month. This significant difference was also found between baseline and the 6-12 month follow up for both groups with p&lt;0.001. No significant difference between groups at 1 month, 6 and 12 months postoperatively when controlling for confounders (p=0.90). |
| | SF-36: Mental Health Component Summary (Activity level) | Within group differences were not significant with p=0.70. No significant difference between groups at 1 month, 6 and 12 months postoperatively when controlling for confounders (p=0.34). |</p>
<table>
<thead>
<tr>
<th>Author</th>
<th>Number of patients:</th>
<th>Content</th>
<th>Results</th>
</tr>
</thead>
</table>
| (L. R. Mikkelsen et al., 2014) | 73*                | IG + CG Before discharge patients received physical therapy aiming at independency in gait, transfer, personal care and home-based exercise. | 20-MWT  *(Body function and structures)*  
Both groups improved significantly from baseline to 10 weeks (p<0.05) but not at 6 months follow-up (p>0.05).  
Significant difference between groups (p=0.008), in favour of the intervention group. |
| IG (n=37)               |                     | **IG: home-based exercises with supervised progressive resistance training**  
*Exercise type*  
- Home-based exercises (unloaded hip flexion, hip extension, hip abduction, knee flexion, knee extension)  
- Warming-up on stationary bike  
- Supervised progressive resistance training (hip extension and hip abduction)  
- Encouraged to supplement exercises with aerobic training (walking, biking)  
*Modality*  
- 3s CON, 1s ISO, 3s EXC during full possible ROM  
*Volume*  
- Warming-up: 5 – 10 min  
- PRT: 2x/w for 10 weeks, 30-40 min (12 RM (week 1), 10 RM (week 2-5), 8 RM (week 6-10), 3 sets with 60s of rest between sets)  
- Unloaded exercises: 10 repetitions 2x/d for 5d/w  
- >48h rest between sessions |
| CG (n=36)               |                     | **HHD isometric hip abduction**  *(Body function and structures level)*  
Both groups improved significantly from baseline to 10 weeks (p<0.05).  
This was not found at 6 months follow-up (p>0.05)). No significant difference between groups (p=0.26). |
|                         |                     | **HHD isometric hip flexion**  *(Body function and structures level)*  
Hip flexion strength improved significantly from baseline to 10 weeks (p<0.05) in the intervention group. This was not found at 6 months follow-up (p>0.05)). The control group did not improve significantly (p>0.05)  
No between group differences were found (p=0.29). |
|                         |                     | **30s sit-to-stand test**  *(Activity level)*  
Both groups improved significantly from baseline to 10 weeks (p<0.05). This was not found at 6 months follow-up (p>0.05). No significant difference between groups (p=0.12).  
Remark: patients were not measured at 4 weeks follow-up. |
|                         |                     | **Stair climb performance**  *(Activity level)*  
Both groups improved significantly from baseline to 10 weeks (p<0.05) and at 6 months follow-up (>0.05).  
Remark: patients were not measured at 4 weeks follow-up.  
Significant difference between groups (p=0.04). |
<table>
<thead>
<tr>
<th><strong>CG</strong>: Home-based exercises without supervision</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Exercise type</strong></td>
</tr>
<tr>
<td>- Home-based exercises (unloaded hip flexion, hip extension, hip abduction, knee flexion, knee extension)</td>
</tr>
<tr>
<td>- Encouraged to supplement exercises with aerobic training (walking, biking)</td>
</tr>
<tr>
<td><strong>Modality</strong></td>
</tr>
<tr>
<td>- No information</td>
</tr>
<tr>
<td><strong>Volume</strong></td>
</tr>
<tr>
<td>- 10 repetitions 2x/d for 7d/w</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th><strong>HOOS</strong> (Activity level)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Both groups improved significantly at 10 weeks for the following subscales: symptoms, pain, ADL, sport/recreation and quality of life (p&lt;0.05). These differences were not found at 12 months follow-up (p&gt;0.05).</td>
</tr>
<tr>
<td>Remark: sport/recreation was not measured at 2 and 4 weeks follow-up. No significant difference between groups (p=0.31 – 0.90).</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th><strong>10-MWT</strong> (Body function and structures level)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Significant increase was found in the intervention group at 12 weeks (p&lt;0.05). In the control group there was found a significant decrease at 12 weeks (p&lt;0.01). There was no significant difference between groups 12 weeks postoperative (p=0.50).</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th><strong>HHD Isometric hip abduction strength of the operated and non-operated leg</strong> (Body function and structures level)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Significant increase for both groups at 12 weeks postoperatively for the operated and non-operated leg (p&lt;0.05). No significant differences were found between groups at 12 weeks follow-up for the operated leg (p=0.82) and the non-operated leg (p=0.50).</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th><strong>One-legged stance on the operated and non-operated leg</strong> (Activity level)</th>
</tr>
</thead>
<tbody>
<tr>
<td>There was a significant improvement for both groups at 12 weeks (p&lt;0.05) compared to baseline in the operated and non-operated leg. No significant differences between groups 12 weeks postoperative for the operated leg (p=0.88) and the non-operated leg (p=0.77).</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th><strong>Number of patients</strong></th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>L. R. Mikkelsen et al., 2012</strong></td>
</tr>
<tr>
<td>(L. R. Mikkelsen et al., 2012)</td>
</tr>
<tr>
<td><strong>IG</strong> (n=25)</td>
</tr>
<tr>
<td><strong>CG</strong> (n=21)</td>
</tr>
<tr>
<td><strong>IG + CG</strong></td>
</tr>
<tr>
<td>During hospital stay, both groups received three supervised sessions in groups of 2-4 patients. The training was continued at home.</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th><strong>IG</strong>: Intensified home-based exercises</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Exercise type</strong></td>
</tr>
<tr>
<td>- Step exercises</td>
</tr>
<tr>
<td>- Exercises performed with a resistance band for the muscle groups most commonly affected by THA</td>
</tr>
<tr>
<td>- Stretching of hip flexors</td>
</tr>
<tr>
<td>- Walking and biking</td>
</tr>
<tr>
<td><strong>Modality</strong></td>
</tr>
<tr>
<td>- CON/EXC (resistance bands), ISO (gluteal sets), no information on stretching</td>
</tr>
<tr>
<td><strong>Volume</strong></td>
</tr>
<tr>
<td>- 10 repetitions 2x/d</td>
</tr>
<tr>
<td>- Progression after 4 weeks by increasing speed and range of movement</td>
</tr>
<tr>
<td>Exercise type</td>
</tr>
<tr>
<td>---------------</td>
</tr>
<tr>
<td>CG: Standard rehabilitation</td>
</tr>
<tr>
<td>CG: home-based PRT</td>
</tr>
</tbody>
</table>

(Okoro et al., 2016) Number of patients: n=49*
- Strengthening exercises (sitting knee extension)

**Modality**
- Mix of open and closed kinetic chain exercises
- CON, ECC

**Volume**
- 5x/w for 6 weeks
- To achieve progression overload number of repetitions increased according to the following scheme:
  - 0-3, 4-6, 7-10
- Further progression by using ankle weights and foam blocks

**CG: Standard rehabilitation**

**Exercise type**
- Weight bearing performed against gravity
- Functional exercises without external loading
- Bed-based exercises (buttock squeezes, leg sliding, straight leg raising, bridging)
- Postural exercises focusing on strengthening overstretched and weak muscles

**Modality**
- CON, ECC

**Volume**
- 6 weeks
- No further information

---

**30s sit-to-stand test**
(Activity level)
Significant improvement in both groups (p=0.0001).
No between group differences (p=0.239).

**6MWT**
( Activity level)
Significant improvement in both groups (p=0.0001).
Significant difference between groups at 9-12m (p=0.004) in favour of the control group.

**Stair climbing performance**
(Activity level)
Significant improvement in both groups (p=0.0001).
Significant difference between groups (p=0.038) in favour of the control group.
**Surgical approach: anterolateral approach**

<table>
<thead>
<tr>
<th>Author</th>
<th>Patient</th>
<th>Content</th>
<th>Results</th>
</tr>
</thead>
<tbody>
<tr>
<td>(Nankaku et al., 2016)</td>
<td>28*</td>
<td><strong>IG: Hip external rotation exercise</strong></td>
<td><strong>JOA</strong> <em>(Body function and structures level)</em></td>
</tr>
<tr>
<td></td>
<td>IG (n=14)</td>
<td><strong>Exercise type</strong></td>
<td>Significant differences for both groups <em>(p&lt;0.05)</em> between pre- and post- intervention results. No between group information.</td>
</tr>
<tr>
<td></td>
<td>CG (n=14)</td>
<td>- Strengthening exercises for hip external rotators performed in three different body positions (supine, side lying with hip and knee flexed and prone with hip in neutral ab/adduction and knee 90° flexed)</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>- Conventional rehabilitation: weight bearing exercises to achieve ambulation with a cane (move bilateral to unilateral support)</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>- Gluteal muscle sets, bridging, heel slides, knee extension in sitting with low resistance, hip abduction in supine position without resistance, bilateral heel raises, half squat</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td><strong>Modality</strong></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>- CON/EXC (elastic bands, gravity), ISO (gluteal sets, bridging)</td>
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<td></td>
<td></td>
<td><strong>Volume</strong></td>
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<tr>
<td></td>
<td></td>
<td>- 8-12 repetitions, 3 sets, 5x/w</td>
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<td></td>
<td></td>
<td>- Resting time equivalent to one set</td>
<td></td>
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<tr>
<td></td>
<td></td>
<td>- Progression: active assisted → active → low resistance (resistance bands)</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td><strong>CG: Conventional rehabilitation</strong></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>- Conventional rehabilitation: weight bearing exercises to achieve ambulation with a cane (move bilateral to unilateral support)</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>- Gluteal muscle sets, bridging, heel slides, knee extension in sitting with low resistance, hip abduction in supine position without resistance,</td>
<td></td>
</tr>
</tbody>
</table>
bilateral heel raises, half squat

**Modality**
- CON/EXC (gravity), ISO (gluteal sets, bridging)

**Volume**
- Intervention for 4 weeks, no further information
- No progression

<table>
<thead>
<tr>
<th>Surgical approach: postero-lateral approach</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Author</strong></td>
</tr>
<tr>
<td>(Umpierres et al., 2014)</td>
</tr>
<tr>
<td>Number of patients:</td>
</tr>
<tr>
<td>n=106*</td>
</tr>
<tr>
<td></td>
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</table>

**Goniometry (hip)**
(Body function and structures level)

For the intervention group there were significant improvements (p<0.001) between pre- and postoperative results for hip flexion, extension, adduction, abduction, internal and external rotation. In the control group significant differences were found for extension (p=0.001), adduction (p=0.001) and internal rotation (p=0.001). There were no significant differences for flexion (p=0.15), abduction (p=0.08) and external rotation (p=0.07).

Significant differences between groups for adduction (p=0.002) and abduction (p=0.01) in favour of the intervention group.

**Muscle strength (Kendall’s criteria)**
(Body function and structures level)

There were significant differences in both groups for all values (p<0.05): flexion, extension, abduction, adduction, internal/external rotation and knee flexion/extension.

Significant differences between groups for flexion (p<0.001), extension (p<0.001), adduction (p=0.003), abduction (p=0.002), internal rotation (p<0.001), external rotation (p<0.001) in favour of the intervention group.

**Merle d’Aubigné and Postel scores**
(Body function and structures level)

Significant differences (p<0.05) in the intervention group pre- and postoperatively were found for motor performance evaluation, pain clinical evaluation, mobility clinical evaluation and global clinical evaluation. No significant differences for gait clinical evaluation (p=0.17).
In the control group significant differences (p<0.05) for pain clinical evaluation and gait clinical evaluation. No significant differences for motor performance evaluation (p=0.16), mobility clinical evaluation (p=0.08) and global clinical evaluation (p=0.10). Significant between group difference for pain clinical evaluation (p=0.02), mobility clinical evaluation (p=0.01) and global clinical evaluation (p<0.001) in favour of IG.

**SF-36**
(Activity level)

Significant differences (p<0.05) in the intervention group pre- and postoperatively were found for bodily pain, general health, vitality, social functioning and mental health. No significant differences were found for physical functioning (p>0.99), role physical (p>0.99) and role emotional (p>0.99).

In the control group significant differences (p<0.05) were found for bodily pain, vitality, social functioning and mental health. In this group no significant differences were found for physical functioning (p>0.99), role physical (p>0.99), general health (p=0.09) and role emotional (p>0.99). Significant between group difference for bodily pain (p=0.01) in favour of the intervention group was found.

### Surgical approach: unknown

<table>
<thead>
<tr>
<th>Author</th>
<th>Patient</th>
<th>Content</th>
<th>Results</th>
</tr>
</thead>
<tbody>
<tr>
<td>(Galea et al., 2008)</td>
<td>23*</td>
<td><strong>IG + CG</strong> 5-6-day common program of functional tasks (gait stairs, transfers that address circulation/ROM/muscle strength)</td>
<td>Gait parameters (Body function and structures level) Significant increase in the IG were fond for walking speed, cadence, step length (p&lt;0.05). Significant reduced step time, percentage in stance time, single-support time (affected and unaffected limb) and double-support time (p&lt;0.05). Significant improvement for symmetry index (step length) with p&lt;0.05. No significant improvement for symmetry index (step time, single-support time and double-support time) with p&gt;0.05. Significant improvement in the CG were found for walking speed, cadence, step length (p&lt;0.05). Unchanged step time, percentage in stance time and double-support time for the control group (p&gt;0.05). Significantly reduced single-support time. Significant improvement for symmetry index (step length) with p&lt;0.05. No significant improvement for symmetry index (step time, single-support time and double-support time) with p&gt;0.05.</td>
</tr>
<tr>
<td>IG (n=11)</td>
<td></td>
<td><strong>IG: Supervised centre-based exercise group</strong></td>
<td></td>
</tr>
<tr>
<td>CG (n=12)</td>
<td></td>
<td><strong>Exercise type</strong></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>- Functional exercises (sit-to-stand, figure-of-eight path walk, climbing steps, side stepping)</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>- Balance exercises (active single-leg stance)</td>
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</tr>
<tr>
<td></td>
<td></td>
<td>- Strengthening and endurance (hip)</td>
<td></td>
</tr>
</tbody>
</table>
abduction, heel raise)

**Modality**
- Mix of open and closed kinetic chain exercises
- CON and ECC exercises executed against gravity

**Volume**
- Exercises executed for max. 5 min, stopping when feeling pain or tired
- Progression was set by a physical therapist
- Most exercises were progressed by increasing speed and therefore number of repetitions

**CG: Home-based exercise group**

**Exercise type**
- Patients received an illustrated guide with the same exercises as IG, with basic instructions and illustrations

**Modality**
- Mix of open and closed kinetic chain exercises
- Mix of concentric and eccentric exercises executed against gravity

**Volume**
- Exercises executed for max. 5 min, stopping when feeling pain or tired
- No advice was given about progression

No significant differences between groups (p>0.05).

**AQuoL**
*(Body function and structures level)*
Both groups improved significantly on the AQoL (p=0.02).
No significant difference between groups (p=0.121).

**TUG**
*(Activity level)*
Significant within group improvements between pre and post results were found for the IG (p=0.003) and the CG (p=0.002).
There was a significant difference between groups at 2 months (p=0.042) in favour of the CG.

**6MWT**
*(Activity level)*
There was a significant increase in distance between pre and post results in the IG (p=0.02) and the CG (p=0.001).
There was no significant between group difference (p=0.121).

**Stair climbing**
*(Activity level)*
Both groups showed significant improvements in stair climbing (stair time and power) with p<0.05.
No significant differences between groups (p=0.121).

**WOMAC**
*(Activity level)*
There was a significant difference in the IG for pain (p=0.07) and function (p=0.0001). There was no significant difference in stiffness (p=0.26).
There was a significant difference in the CG for function (p=0.002). There was no significant difference in pain (p=0.08) and stiffness (p=0.34).
There was no significant difference between groups (p=0.121) for all 3 items.

(Monticone et al., 2014)

<table>
<thead>
<tr>
<th>Number of patients:</th>
<th>IG: Task-oriented exercises</th>
<th>WOMAC</th>
</tr>
</thead>
<tbody>
<tr>
<td>n=100*</td>
<td>Exercise type</td>
<td>(Activity level)</td>
</tr>
<tr>
<td>IG (n=50)</td>
<td>Functional training (sit-to stand, ascending/descending stairs,</td>
<td>There was a significant difference in both groups (p&lt;0.001) between pre- and post-training and follow-up in physical function, pain, stiffness, numeric</td>
</tr>
<tr>
<td>CG (n=50)</td>
<td>climbing obstacles, important ADL-strategies, recovering functional abilities and balance (turning, sudden start/stop, changing speed/direction))</td>
<td></td>
</tr>
<tr>
<td>---</td>
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<td></td>
</tr>
<tr>
<td>- Strength and mobility: stationary cycling</td>
<td></td>
<td></td>
</tr>
<tr>
<td>- Patients received a booklet with ergonomic advice</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Modality**
- Closed kinetic chain exercises

**Volume**
- increasing loads on the operated limb (walking in place, bilateral and unilateral knee flexion while standing)

**CG: open kinetic chain exercises**

**Exercise type**
- Strength exercises (flexion, extension, abduction, external rotation, isotonic and isometric quadriceps strengthening, hamstring curls)
- Walking training

**Modality**
- Open kinetic chain exercises
- Concentric exercises
- Isometric quadriceps settings

**Volume**
- No information

*baseline characteristics were tested for differences between groups

rating scale and functional independence measure. There was a significant between group difference (p<0.001) in favour of the intervention group.

**SF-36**

(Activity level)
There was a significant difference in both groups (p<0.05) between pre-and post-training and follow-up in physical function, physical role, bodily pain, general health, vitality, social function, emotional role and mental health.

Significant between group difference for physical function (p<0.001), physical role (p=0.002), bodily pain (p<0.001), general health (p<0.001), vitality (p=0.030) and mental health (p=0.015). No significant difference between groups for social function (p=0.264) and emotional role (p=0.075).

**Global perceived effect of treatment using a 5-point scale**

(person level)
Between group differences were significant (p<0.001) with greater perceived effect in the IG.
### Table 8

**List of abbreviations**

<table>
<thead>
<tr>
<th>Abbreviation</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>ADL</td>
<td>Activities of Daily Living</td>
</tr>
<tr>
<td>AqoL</td>
<td>Assessment of Quality of Life</td>
</tr>
<tr>
<td>CG</td>
<td>Control group</td>
</tr>
<tr>
<td>CON</td>
<td>Concentric</td>
</tr>
<tr>
<td>ECC</td>
<td>Eccentric</td>
</tr>
<tr>
<td>EQ-5D</td>
<td>EuroQol 5-Dimensions</td>
</tr>
<tr>
<td>GMe</td>
<td>M. Gluteus Medius</td>
</tr>
<tr>
<td>GRADE</td>
<td>Grading of Recommendations Assessment, Development and Evaluation</td>
</tr>
<tr>
<td>HHD</td>
<td>Hand Held Dynamometry</td>
</tr>
<tr>
<td>HHS</td>
<td>Harris Hip Score</td>
</tr>
<tr>
<td>HOOS</td>
<td>Hip Disability and Osteoarthritis Outcome Score</td>
</tr>
<tr>
<td>ICF</td>
<td>International Classification of Functioning, Disability and Health</td>
</tr>
<tr>
<td>IG</td>
<td>Intervention group</td>
</tr>
<tr>
<td>ISO</td>
<td>Isometric</td>
</tr>
<tr>
<td>JOA</td>
<td>Japanese Orthopaedic Association Score</td>
</tr>
<tr>
<td>PAS</td>
<td>Physical Activity Scale</td>
</tr>
<tr>
<td>PICO</td>
<td>Patient, Intervention, Comparison, Outcome</td>
</tr>
<tr>
<td>PRT</td>
<td>Progressive resistance training</td>
</tr>
<tr>
<td>RCT</td>
<td>Randomised Controlled Trial</td>
</tr>
<tr>
<td>RoB</td>
<td>Risk of Bias</td>
</tr>
<tr>
<td>ROM</td>
<td>Range of Motion</td>
</tr>
<tr>
<td>SF-36</td>
<td>Short form-36 item health survey</td>
</tr>
<tr>
<td>THA</td>
<td>Total Hip Arthroplasty</td>
</tr>
<tr>
<td>TUG</td>
<td>Timed Up and Go Test</td>
</tr>
<tr>
<td>WOS</td>
<td>Web of Science</td>
</tr>
<tr>
<td>WOMAC</td>
<td>Western Ontario &amp; McMaster Universities Osteoarthritis Index</td>
</tr>
<tr>
<td>6MWT</td>
<td>Six Minute Walking Test</td>
</tr>
<tr>
<td>10- or 20-MWT</td>
<td>10- or 20 Meter Walk Test</td>
</tr>
</tbody>
</table>
PART II: RESEARCH PROTOCOL

1. Introduction

The research protocol itself is designed by Dra. J. Emmerzaal as part of her PhD. We only had a part in this critical appraisal and not in the design of the protocol. All credits go to Dra. J. Emmerzaal for designing the protocol and A. Bruijnes (MSc) for obtaining the approval of the Medical Ethical Committee. We will try to contribute to this PhD by researching the feasibility of a mobile app to measure functional status in healthy persons and patients with degenerative knee or hip disorders. This protocol is provided to us and can be found in the appendix (Study 2). The following text is our own critical appraisal about this research protocol.
2. **Aim of the research**

The aim of this research is to investigate the feasibility of a mobile application to monitor functional status in healthy persons and in persons with degenerative hip and knee disorders.

2.1. **Research question**

1. To what extent is the use of a smartphone with added sensors to register functional status (i.e. level of activity and load profile), plausible?
2. To what extent do persons with degenerative hip and knee disorders expect that a mobile application, combined with extra sensors, will positively influence their treatment outcome?
3. To what extent is the use of a smartphone application (added with sensors) user-friendly?
4. To what extent is the technology of a smartphone application accepted by the patients?
5. Which information can be added to the smartphone application to give meaningful feedback to healthy persons and persons with degenerative hip and knee disorders to support the rehabilitation process?
6. Which suggestions can be given in relation to the design of the application; what would facilitate its use?

2.1.1. **Critical appraisal research question**

1. A positive aspect of this study is that the accuracy of a smartphone, and a smartphone combined with in extra sensor is researched. Existing literature states that smartphones have a built in accelerometer (Adusumilli, Joseph et al. 2017). Compared to pedometers, accelerometers have a higher reliability for measuring physical activity. (Bartholdy, Gudbergsen et al. 2018) Accelerometers can measure: frequency, intensity and duration (Song, Semanik et al. 2010), time-on-body, total energy expenditure, sedentary time, active time and amount of steps/day (Holsgaard-Larsen and Roos 2012), spatiotemporal gait parameters (Kobsar, Osis et al. 2016), inclination of body segments, body displacement and activity level (Chen, Chen et al. 2015). It has a good validity for discriminating between ‘active’ and ‘sedentary’ in a standardised as well as a non-standardised setting. (Bartholdy, Gudbergsen et al. 2018) When an accelerometer is supplemented with a gyroscope and magnetometer the accuracy for estimating the gravity vector improves. (Chen, Chen et al. 2015). This could be a useful addition to our research and measurements, because gravity is an important influencer of the joint load.
2. It is positive that this aspect is investigated. It might be possible to develop an application that is valid and reliable, but when there are no positive effects on the rehabilitation, its usefulness is questionable.
3. A smartphone application has to be user friendly. If not patients will be reserved to use it. So it is positive that this is investigated as well.
4. Apart from usefulness, the acceptance must be researched as well. When you develop a valid, reliable and useful application but patients are hold back to use it, the aim of the application will not be reached.
5. It is positive that feedback from the patients is obtained about what they expect from a sort-like application. By doing this, computer scientists can fine tune the application to the specific needs and desires of this population.

6. The design of the application can also contribute to user-friendliness. Therefore it is positive that persons can give feedback on this aspect.

### 2.2. Hypothesis

We formed several hypothesis concerning the six research questions:

1. When placing the smartphone in a correct and standardised position we believe that functional activities can be recognised and measured. With the current technology of sensors present in smartphones, we believe that registration of functional status is possible. For measuring the load profile and performing certain activities, it might be necessary to use an extra sensor. For example, the gravity vector can be more accurately estimated by adding a gyroscope and a magnetometer. So, we hypothesis that adding these two sensors to the built in accelerometer, will provide us with a more accurate estimation of the load profile.

2. We believe that a mobile application can have a positive influence on rehabilitation in the home-setting. Usefulness in a hospital-setting can be questioned. Patients must adhere to a fixed scheme and are often less independent. In this way, it could be possible that personal daily goals, set on the application, cannot be reached even though they complete all the treatments given in the hospital. This can possibly be solved by adding specific individual goals for inpatient persons.

3. The smartphone must be worn all day long. Therefore smartphones must be small and compact so they can fit in the patient's pocket. Besides, when adding more sensors, the set-up must still be quick and easy. For the application itself, clear and simple tabs will be needed. Furthermore, data expenditure or use of battery must be low.

4. We hypothesise that a mobile application will be more accepted by frequent smartphone users. An extra question about how often participants use their smartphone might therefore be a valuable addition.

5. We believe that patients are in need of simple, clear and meaningful information about their daily achievements and physical active status. Professionals will be needing more detailed information about the physiological and biomechanical parameters and the active status.

6. Since the lay-out and user-friendliness are strongly influenced by personal preference, we cannot form a hypothesis.
3. Methodology

3.1. Research design
A quantitative and qualitative descriptive study

3.2. Participants
According to the protocol 60 participants should be recruited (20 healthy persons, 10 knee osteoarthritis patients awaiting total knee arthroplasty, 10 knee osteoarthritis patients who underwent total knee arthroplasty at least 6 weeks ago, 10 hip osteoarthritis patients awaiting total hip arthroplasty and 10 hip osteoarthritis patients who underwent total hip arthroplasty at least 6 weeks ago). The power is not calculated. This would be a valuable addition to this research.

3.2.1. Inclusion criteria
- Healthy subjects (n=20):
  o Age ≥ 18 years
  o Able to comprehend, speak and read Dutch
  o Prepared to work with a smartphone application
  o No musculoskeletal complaints or other complaints limiting movement patterns during activities of daily living
- Diagnosed unilateral knee and hip disorders (pre-operative, n=20; postoperative, n=20)
  o Age ≥ 18 years
  o Diagnosed with unilateral knee or hip osteoarthritis (degree 4)
  o Intermittent or constant pijn (VAS ≥ 2/10)
  o No total knee (n=10) or hip (n=10) arthroplasty or ≥ 6 weeks to 3 months post total knee (n=10) or hip (n=10) arthroplasty
  o Able to walk for 10 minutes and to negotiate stairs
  o No other musculoskeletal complaints or complaints limiting movement patterns during activities of daily living
  o Able to comprehend, speak and read Dutch
  o Prepared to work with a smartphone application

3.2.1.1. Critical appraisal inclusion criteria
The age of 18 was set to not exclude certain participants. We hypothesise that the average age will be higher because of higher age in THA persons. Besides, be willing to work with a smartphone is necessary for participation. We consider this an important inclusion criteria. When someone is not willing to use a smartphone, or has never used one, it might be possible that the application will get a worse score for usability. Furthermore, one must be diagnosed with unilateral knee or hip osteoarthritis. When testing the accuracy of this application, it might be valuable to make a comparison between the affected and non-affected side. This raises two new questions: ‘Will the smartphone and the application be able to measure just one leg?’ and ‘When registering data from both legs, will it be possible to select the information of the affected leg only?’. 
3.2.2. Exclusion criteria
Not mentioned in the original protocol.

3.2.2.1. Critical appraisal exclusion criteria
It might be interesting to set an exclusion criterion for persons with psychological or cognitive conditions. These conditions could possibly interfere with one’s mental capacity and therefore the use of an application can be more complicated. Exclusion of neurological conditions should also be considered, because this condition might influence the movement patterns.

3.2.3. Recruitment
Healthy persons will be recruited from family and friends. Knee and hip osteoarthritis patients will be recruited from Jessa Ziekenhuis Hasselt and Ziekenhuis Oost-Limburg Genk. Besides, persons having interest in taking part in this research are provided with an informative flyer. Recruitment of patients will be performed by A. Bruijnes (MSc).

3.2.3.1. Critical appraisal recruitment
This study aims to assess the feasibility of a mobile application, used in a hospital- and home-setting. When recruiting persons from Jessa Ziekenhuis Hasselt and Ziekenhuis Oost-Limburg Genk, we need to make sure we include inpatient as well as outpatient persons. Otherwise, when only implementing inpatient persons, a conclusion of functionality in the home-based setting cannot be made. Perhaps recruitment of persons is also possible via independent physiotherapy practices.

3.3. Medical ethics
This protocol is successfully defended by A. Bruijnes (MSc) and thus approved by the Medical Ethical Committee.

3.4. Intervention
To answer the questions for our part of this research, we will conduct the following interventions. Patients will perform a predetermined movement protocol at Hasselt University. A context, in which participants will pretend they wore a mobile phone with sensors in a home environment, will be outlined. By showing a standardised video it will be explained to the participants why the information of the application could possibly be meaningful to them. Afterwards, the persons will be asked to speak aloud all (positive and negative) concerns about using the application. This will be recorded to use later in data-analysis. Questionnaires about credibility of therapy and expectancy of treatment, prestation- and exercise expectations, social influence and facilitating circumstances and usability will be completed by the participants. These questionnaires have been adjusted to match the research questions as closely as possible. Additional questions about the use of the application will be asked. They can be found in the protocol (Appendix research protocol, study 2).
3.5. Outcomes

3.5.1. Primary outcomes
- Credibility and Expectancy Questionnaire (devilly & borkovec, 2000): evaluation of credibility of a certain therapy and expectations of treatment effects.
- The unified theory of Technology Acceptance Questionnaire (Venkatesh, 2003): evaluation of acceptance of technology through four domains (expectancy of prestation and effort, social influence and facilitation circumstances).
- The Usefulness, Satisfaction and Ease of use (USE) questionnaire (Lund, 2001): evaluation of utility.

3.5.2. Secondary outcomes
- Additional questions, which can be found in the appendix (study 2)
- Clustered information from the interviews

3.5.3. Critical appraisal outcomes
Primary and secondary outcomes were not defined. Outcomes mentioned above are classified according to our opinion.

3.6. Data analysis
To answer our questions the protocol states that a descriptive data-analysis will be performed.

3.6.1. Critical appraisal analysis
According to our opinion it may be possible to add a comparative data-analysis by using the Kruskall-Wallis test (non-parametric). This might be valuable to compare results between the groups. Qualitative data-analysis will be used to process and cluster the information from the interviews. Both a quantitative and qualitative assessment of the outcomes will be done. Assessing the ability of the smartphone and sensors to measure the amount and way of movement in combination with the assessment of usability and meaningfulness gives a broad perspective on the effectiveness of the application.
4. Time planning
Patients will be recruited until January 2019. Afterwards, data will be processed and conclusions will be written before May 2019.
5. Reference list: research protocol


6. Appendix: research protocol

Protocol
Haalbaarheid van een mobiele applicatie voor monitoring van functionele status

Titel
Haalbaarheid van een applicatie voor mobiele monitoring van de functionele status bij gezonde personen en bij personen met degeneratieve heup- en knie-aandoeningen

Achtergrond

Doelstellingen en onderzoeksvragen

Doelstellingen
Het eerste doel is om data te verzamelen over bewegingsgedrag van gezonde personen, zodat deze data gebruikt kunnen worden om algoritmes te trainen voor het herkennen van functionele activiteiten. Tevens kunnen deze data gebruikt worden als normwaarden waarmee het bewegingsgedrag van patiënten kan worden vergeleken, hetgeen zinvol is voor het geven van feedback aan patiënten en zorgverleners.
Een tweede doel is om gebruikersvereisten in kaart te brengen van gezonde personen, personen met degeneratieve heup- en knieaandoeningen, en de zorgverleners die betrokken worden bij het revalidatieproces.

Onderzoeksvragen
- In welke mate herkent een smartphone functionele activiteiten zoals uitgevoerd in gestandaardiseerde omstandigheden door gezonde deelnemers en door mensen met degeneratieve heup- en knie-aandoeningen?
- Wat is de haalbaarheid van het gebruik van een smartphone met extra sensoren voor registratie van de functionele status, i.e. activiteitenniveau en belasting profiel?
Welke informatie moet een app bevatten om zinvolle feedback te geven aan gezonde personen, personen met degeneratieve heup- en knie- aandoeningen en kinesitherapeuten die betrokken zijn bij de revalidatie van personen met degeneratieve heup- en knie-aandoeningen?

Om deze onderzoeksvragen te beantwoorden zullen 3 studies opgezet worden

1 Haalbaarheid van de herkenning van functionele activiteiten tijdens monitoring in de thuissituatie.

2 Haalbaarheid van en gebruikersvereisten voor het gebruik van een app voor het monitoren van de functionele status van gezonde personen, mensen met degeneratieve knieaandoeningen, mensen met degeneratieve heupaandoeningen.

3 Bevraging van zorgverleners (kinesitherapeuten, orthopedisten, …) met betrekking tot gebruikersvereisten van een app voor het mobiel registreren van de functionele status van personen met degeneratieve heup- en knie- aandoeningen.

Studie 1: Haalbaarheid van de herkenning van functionele activiteiten tijdens monitoring in de thuissituatie

Onderzoeksvragen

- In welke mate herkent een smartphone met de speciaal ontwikkelde applicatie activiteiten in een gestandaardiseerde setting bij gezonde deelnemers en bij mensen met degeneratieve heup- en knieaandoeningen?
- In welke mate herkent een smartphone met de speciaal ontwikkelde applicatie functionele activiteiten in de thuissituatie op basis van activiteiten die werden gemeten in gestandaardiseerde omstandigheden door gezonde deelnemers en door mensen met degeneratieve heup- en knie- aandoeningen?
- Welke informatie moet de smartphone app nog bijkomend bevatten om zinvolle feedback te kunnen geven aan gezonde personen en personen met degeneratieve heup- en knie- aandoeningen om het revalidatieproces te ondersteunen?
- Welke suggesties zijn er nog naar vormgeving van de app; wat zou het gebruik nog makkelijker maken?

Proefpersonen

In deze studie zullen 100 personen worden gerekruiteerd (60 gezonde personen, 10 personen met knie osteoarthritis die op de wachtlijst staan voor een totale knie prothese, 10 knie osteoarthrosis patiënten minimaal 3 maanden en 6 weken na de totale knie prothese operatie, 10 personen met heup osteoarthritis die op de wachtlijst staan voor een totale heup prothese operatie, 10 heup osteoarthrosis patiënten minimaal 3 maanden 6 weken na de totale heup prothese operatie). De gezonde populatie zal worden gerekruiteerd via sociale netwerken van de onderzoekers en van studenten Universiteit Hasselt. De knie en heup osteoarthritis-patiënten zullen worden gerekruiteerd via Prof. Dr. Corten (orthopedist ZOL) en via Mevr. Amber Bruijnes (onderzoek coördinator dienst orthopedie ZOL). De patiënten zullen worden benaderd door Mevr. Bruijnes. Als onderzoek coördinator heeft zij toegang tot
patiënten patiëntendossiers en kan zij op die manier de patiënten rekruteren die aan de inclusiecriteria voldoen. Daarnaast zullen er proefpersoon flyers beschikbaar zijn voor geïnteresseerde personen zodat ze al een beeld kunnen krijgen over wat de studie inhoudt.

Hieronder staan de inclusie criteria opgesomd:

Gezonde personen (N = 60)
- Leeftijd ≥ 18 jaar
- Begrijpen, spreken en lezen van de Nederlandse taal
- Bereid om met een smartphone app te werken
- Geen musculoskeletale klachten of andere klachten die het bewegingspatroon kunnen beïnvloeden tijdens activiteiten van het dagelijkse leven

Personen met degeneratieve heup of knieaandoeningen (peroperatief, N = 10; post-operatief, N = 10)
- Leeftijd ≥ 18 jaar
- Gediagnosticeerd met unilaterale knie of heup artrose (graad 4)
- Intermittente of constante pijnklachten (VAS ≥ 2/10)
- Geen totale knie/heup prothese operatie ondergaan (peroperatief, N = 10/10) of ≥ 6 weken en 3 maanden na de totale knie/heup prothese operatie (postoperatief, N = 10/10)
- In staat om 10 minuten meter te wandelen en de trap op en af te lopen
- Geen andere musculoskeletale klachten of andere klachten die het bewegingspatroon kunnen beïnvloeden tijdens activiteiten van het dagelijkse leven
- Begrijpen, spreken en lezen van de Nederlandse taal
- Bereid om met een smartphone te werken

Methodologie
Deze studie heeft twee luiken, luik één vindt plaats in een gestandaardiseerde setting, en luik twee vindt bij de mensen thuis plaats.

Aan de deelnemers van het eerste luik wordt gevraagd om eenmalig onderstaand protocol te doorlopen, terwijl men 3-5 smartphones (type Samsung J5) met de ontwikkelde applicatie draagt in hiervoor bestemde tasjes die rond de lende gedragen worden. Data van de volgende sensoren worden geregistreerd: 3D accelerometer (50 Hz or 50 samples per seconde), GPS (1hz), 3D gyroscoop (50 Hz) en magnetometer (50 Hz). Ook zullen de quaternion data geregistreerd worden. Deze metingen vinden plaats in Universiteit Hasselt, campus Diepenbeek voor gezonde personen en in Ziekenhuis Oost Limburg, dienst Orthopedie voor mensen met degeneratieve heup- en knieaandoeningen. Na het doorlopen van de verschillende activiteiten wordt aan de deelnemers een smartphone meegeggeven die de activiteit thuis registreert via de app die ontwikkeld werd door de Mobile Health Unit van Universiteit Hasselt

Het volgende activiteiten protocol zal worden doorlopen:
<table>
<thead>
<tr>
<th>Activiteit</th>
<th>Omschrijving</th>
</tr>
</thead>
<tbody>
<tr>
<td>Wandelen</td>
<td>Gedurende 10 minuten wandelen op zelfgekozen snelheid</td>
</tr>
<tr>
<td>Trappen afdalen</td>
<td>Trappen afdalen volgens gewoonlijke patroon (indien mogelijk zonder leuning vasthouden)</td>
</tr>
<tr>
<td>Trappen opstijgen</td>
<td>Trappen bestijgen volgens gewoonlijke patroon (indien mogelijk zonder leuning vasthouden)</td>
</tr>
<tr>
<td>Van zit naar stand</td>
<td>Zitten op een stoel voor ± 3 seconden, tot stand komen (± 3 seconden), terug gaan zitten (± 3 seconden). Dit wordt herhaald voor 3 verschillende stoelhoogtes.</td>
</tr>
<tr>
<td>Fietsen</td>
<td>Er wordt 10 minuten gefietst op een fietsergometer ZONDER weerstand aan zelf gekozen snelheid</td>
</tr>
</tbody>
</table>

Daarna wordt er aan de deelnemers gevraagd om deel te nemen aan luik twee in de niet gestandaardiseerde setting. Er wordt tevens aan de deelnemers gevraagd om gedurende 7 dagen, tijdens zoveel mogelijk van de wakkere uren een smartphone (type Samsung J5) met de ontwikkelde applicatie mee te dragen die bevestigd wordt ter hoogte van de heup door middel van een heuptasje. De smartphone wordt meegegeven door de onderzoekers. Alle data van de deelnemers wordt gecodeerd opgeslagen op de server van de Mobile Health Unit (UHasselt). Naast het opvolgen van de data van de accelerometer, de magnetometer, en gyroscoop wordt ook bijgehouden in welke mate mensen de instructie voor het smartphone gebruik hebben opgevolgd (aantal uren per dag dat de smartphone gedragen werd). 

Deze studie is puur observationeel, de beweeg data wordt alleen gebruikt als validatie middel voor de smartphone met ontwikkelde applicatie. De deelnemers krijgen tijdens hun deelname geen inzicht of feedback op hun beweegpatronen.

Na deelname aan de studie wordt gevraagd aan de deelnemers om volgende vragen te beantwoorden. Deze vragen zijn opgesteld als inventarisatie van de behoeften van de doelgroep met betrekking tot het gebruik van deze applicatie. De antwoorden op deze vragen zullen gebruikt worden om de applicatie verder te ontwikkelen:

- In welke mate zou u het haalbaar vinden om tijdens uw activiteiten van het dagelijks leven een smartphone mee te dragen zodat uw functionele status geregistreerd kan worden?
- In welke mate zou u het zinvol vinden om feedback te krijgen over hoeveel per dag u wandelt, trappen doet, fietst, op staat uit uw stoel?
- Over welke activiteiten zou u nog graag informatie krijgen:
  - Met betrekking tot de hoeveelheid activiteit die u uitvoert:
    - ..........................................................
o Met betrekking tot de kwaliteit van de bewegingsuitvoering:

• In welke mate zou u bereid zijn om, naast het bijhouden van de smartphone, ook sensoren te dragen (er wordt als voorbeeld actigraph sensoren getoond; velcro strap bevestiging leden en heuptasje)

• Hoeveel sensoren zou u maximaal bereid zijn om te dragen, samen met de smartphone?
  o 1
  o 2
  o 3
  o Meer dan 3

• Hoeveel tijd bent u bereid om te spenderen aan het bekijken van de smartphone feedback?
  o ... minuten

• Bent u bereid om eventueel persoonlijke data in te geven op dagelijkse basis, zoals een eventuele pijnscore?
  o Ja
  o Neen

• Bent u bereid om eventueel een kalibratiemeting te laten uitvoeren in het labo van universiteit Hasselt om de kwaliteit van uw bewegingen te laten evalueren om een meer accurate evaluatie van uw belastingsprofiel toe te laten?

• Bent u bereid om uw data rond functionele status te delen met uw behandelende arts/kinesitherapeut zodat hij/zij u advies kan geven m.b.t. het optimaliseren van uw functionele status?

**Data-analyse**

De data die verzameld worden tijdens de metingen van luik één in de gestandaardiseerde metingen setting in Universiteit Hasselt en Ziekenhuis Oost Limburg laten toe aan het Computer Science Departement van KU Leuven (Jesse Davis en Tim Op De Beeck) om algoritmes op te stellen en te trainen valideren die de uitgevoerde activiteiten herkennen op basis van de ruwe data zoals geregistreerd door een mobiele telefoon. Deze algoritmes kunnen nadien toegepast worden op de data die verzameld worden via het mobiele data-collectie platform van Mobile Health Unit (MHU) in de thuissituatie. In deze studie zal worden nagegaan in welke mate activiteiten in de thuissituatie kunnen herkend worden door de opgestelde algoritmes. Voorafgaand aan de metingen is de smartphone met applicatie nog niet in staat om de activiteiten te herkennen. Het eindproduct van deze studie is een smartphone met de ontwikkelde applicatie die gevalideerd is voor het meten en herkennen van activiteiten in de thuissituatie bij patiënten met degeneratieve heup- en knie- aandoeningen. De antwoorden op de vragen worden verwerkt met descriptieve data-analyse technieken (weergave gemiddelde scores en standaarddeviatie).
Studie 2: Haalbaarheid van het gebruik van van een app voor het monitoren van de functionele status van gezonde personen, mensen met degeneratieve knie aandoeningen, mensen met degeneratieve heup aandoeningen

Onderzoeksvragen

- In welke mate is het gebruik van een smartphone met extra sensoren voor registratie van de functionele status, i.e. activiteiten niveau en belasting profiel, geloofwaardig?
- In welke mate verwachten mensen met degeneratieve heup-, en knie- aandoeningen dat de smartphone app, in combinatie met extra sensoren, hun behandeluitkomst positief zal kunnen beïnvloeden?
- In welke mate is de toepassing van de app (met sensoren) gebruiksvriendelijk?
- In welke mate wordt de technologie van de smartphone app met sensoren aanvaard door de patiënten?
- Welke informatie moet de smartphone app nog bijkomend bevatten om zinvolle feedback te kunnen geven aan gezonde personen en personen met degeneratieve heup en knieaandoeningen om het revalidatieproces te ondersteunen?
- Welke suggesties zijn er nog naar vormgeving van de app; wat zou het gebruik nog makkelijker maken?

Proefpersonen

In deze studie zullen 60 personen worden gerekruiteerd (20 gezonde personen, 10 knie osteoarthritis patiënten die op de wachtlijst staan voor een totale knieprothese, 10 knie osteoarthritis patiënten minimaal 6 weken 3 maanden na de totale knie prothese operatie, 10 heup osteoarthritis patiënten die op de wachtlijst staan voor een totale heup prothese operatie, 10 heup osteoarthritis patiënten minimaal 3 maanden 6 weken na de totale heup prothese operatie). De gezonde populatie zal worden gerekruiteerd via familie en bekenden. De knie en heup osteoarthritis patiënten zullen worden gerekruiteerd via het Jessa Ziekenhuis Hasselt en Ziekenhuis Oost-Limburg Genk.

De inclusiecriteria zijn gelijk aan deze van studie 1. De rekrutering van de patiënten gaat wederom via Mevr. Amber Bruijnes. Wederom zijn er proefpersoon flyers beschikbaar voor de rekrutering van geïnteresseerde personen zodat ze al een beeld kunnen krijgen over wat de studie inhoudt.

Methode

Er wordt gevraagd aan de proefpersoon om eenmalig een bewegingsprotocol te doorlopen in Universiteit Hasselt (zie supra studie 1). Nadien zal de proefpersoon de feedback op zijn/haar bewegingen bekijken. Er wordt een context geschetst waarbij de proefpersoon zich probeert in te beelden dat de data afkomstig zijn van het dragen van een mobiele telefoon en sensoren in de thuissituatie. Er wordt ook uitgelegd aan de proefpersoon waarom deze informatie mogelijk zinvol kan zijn voor hem/haar. Hiervoor wordt een standaard video getoond zodat de uitleg dezelfde is voor al de proefpersonen. Vervolgens wordt aan de proefpersoon gevraagd om luidop alle (positieve en
negatieve) bedenkingen weer te geven tijdens het gebruik van de app (thinking aloud methode, Fonteyn et al 1993). Dit proces wordt op video opgenomen om data-analyse nadien toe te laten.

Na gebruik van de app worden volgende vragenlijsten ingevuld. De vragenlijsten zijn aangepast om zo goed mogelijk aan te sluiten bij onze onderzoeksvragen:

- **Credibility and Expectancy Questionnaire (Devilly & Borkovec 2000):** evalueert de geloofwaardigheid van een bepaalde therapievorm, evenals de verwachte behandel effecten.
- **The Unified Theory of Technology Acceptance Questionnaire (Venkatesh 2003):** evalueert de acceptatie van technologie door vier domeinen (prestatie verwachtingen, inspannings verwachtingen, sociale invloed en faciliterende omstandigheden) te ondervragen.
- **The Usefulness, Satisfaction and Ease of use (USE) vragenlijst (Lund 2001):** meet de bruikbaarheid voor gebruikers.

Naast het invullen van de vragenlijsten zullen de volgende vragen worden gesteld:

- **In welke mate zou u het haalbaar vinden om tijdens uw activiteiten van het dagelijks leven een smartphone mee te dragen zodat uw functionele status geregistreerd kan worden?**
- **In welke mate zou u het zinvol vinden om feedback te krijgen over hoeveel per dag u wandelt, trappen doet, fiets, opstaat uit uw stoel?**
- **In welke mate zou u het zinvol vinden om feedback te krijgen over uw gewrichts belastingsprofiel tijdens het wandelen, trappen doen, fietsen, opstaan uit uw stoel?**
- **Over welke activiteiten zou u nog graag informatie krijgen:**
  - Met betrekking tot de hoeveelheid activiteit die u uitvoert:
    - …………………………………………………
  - Met betrekking tot de kwaliteit van de bewegingsuitvoering:
    - …………………………………………………
- **Welke van onderstaande feedback toepassing(en) zijn wenselijk voor u (u mag er meerdere aankruisen indien van toepassing)**
  - Real time feedback: op elk moment feedback over functionele status
  - Elke dag feedback (op 1 gekozen tidstip) is ok
  - Wekelijks een feedback update is ok
- **Welk van onderstaande feedback mogelijkheden wenst u (u mag er 1 of meerdere aanduiden)**
  - Een vergelijking van mijn functionele status met deze van gezonde personen is wenselijk
  - Een overzicht van mijn functionele status ten opzichte van de andere dagen deze week
  - Een overzicht van mijn functionele status ten opzichte van vorige weken
- **In welke mate zou u bereid zijn om, naast het bijhouden van de smartphone ook sensoren te dragen (er wordt als voorbeeld actigraph sensoren getoond; velcro strap bevestiging leden en heuptasje)**
- **Hoeveel sensoren zou u maximaal bereid zijn om te dragen samen met de smartphone?**
• Hoeveel tijd bent u bereid om te spenden aan het bekijken van de smartphone feedback?
• Bent u bereid om eventueel persoonlijke data in te geven op dagelijkse basis, zoals een eventuele pijnsscore?
  o Ja
  o Neen
• Bent u bereid om eventueel een calibratiemeting te laten uitvoeren in het labo van universiteit Hasselt om de kwaliteit van uw bewegingen te laten evalueren om een meer accurate evaluatie van uw belastingsprofiel toe te laten?
• Bent u bereid om uw data rond functionele status te delen met uw behandelende arts zodat hij/zij u advies kan geven m.b.t. het optimaliseren van uw functionele status?

Data Analyse
De video opname van de thinking aloud procedure zal uitgetypt worden. Een kwalitatieve data analyse techniek zal worden toegepast om informatie te clusteren. Voor de overige data wordt een descriptieve data analyse uitgevoerd.

Studie 3: Bevraging van kinesitherapeuten met betrekking tot gebruikersvereisten van een app voor het mobiel registreren van de functionele status van personen met degeneratieve heup- en knie-aandoeningen

Proefpersonen
• Kinesitherapeuten die betrokken zijn bij de revalidatie van mensen met degeneratieve heup- en knieaandoeningen (n=20)
• Orthopedisch specialisten (n=5)
• Andere zorgverleners, e.g. huisartsen (n=20)

De zorgverleners (n=45) zullen gerekruiteerd worden via studenten 2de bach Revalidatiewetenschappen en Kinesitherapie (module 2.4. mini-onderzoek) en via contacten van collega’s van Ziekenhuis Oost Limburg en UHasselt. De orthopedisch specialisten worden gerekruiteerd in ZOL en via netwerken van de specialisten. Daarnaast zullen er proefpersoon flyers uitgedeeld worden aan geïnteresseerde personen zodat ze al een beeld kunnen krijgen over wat de studie inhoudt.

Methode
De smartphone applicatie wordt uitgelegd aan de zorgverlener via een video die via een link kan toegestuurd worden aan de betrokken deelnemers.

Na het bekijken van deze video link wordt gevraagd om volgende vragenlijsten in te vullen. Deze vragenlijsten zijn aangepast om zo goed mogelijk aan te sluiten bij onze onderzoeksvragen:
- Credibility and Expectancy Questionnaire (Devilly & Borkovec 2000): evaluateert de geloofwaardigheid van een bepaalde therapievorm, evenals de verwachte behandelresultaten.
- The Unified Theory of Technology Acceptance Questionnaire (Venkatesh 2003): evaluateert de acceptatie van technologie door vier domeinen (prestatieverwachtingen, inspanningsverwachtingen, sociale invloed en faciliterende omstandigheden) te ondervragen.

Ook wordt gevraagd om volgende vragen te beantwoorden:

- In welke mate zou u het zinvol vinden om feedback te krijgen over hoeveel per dag uw patiënt wandelt, trappen doet, fiets, opstaat uit uw stoel?
- In welke mate zou u het zinvol vinden om feedback te krijgen over het gewrichtsbelastingsprofiel van uw patiënt tijdens het wandelen, trappen doen, fietsen, opstaan uit uw stoel?
- Over welke activiteiten zou u nog graag informatie krijgen:
  - Met betrekking tot de hoeveelheid activiteiten die uw patiënt uitvoert:
    …………………………………………
  - Met betrekking tot de kwaliteit van de bewegingsuitvoering van uw patiënt:
    …………………………………………
- Welke extra informatie over de patiënt kan nuttig zijn voor het optimaliseren van zijn revalidatietraject (bv. pijnbeleving, werkhervatting, slaappatroon…).
  …………………………………………
- Op welke manier zou u graag feedback geven aan uw patiënt (bv. telefonisch, semi-automatisch via gestandaardiseerde berichten op de smartphone, opstellen van gepersonaliseerde trainingsschema’s/oefeningen, …)
- Hoeveel tijd wenst u per patiënt te besteden aan het ontvangen en reageren op de feedback?
- Kan het geven van feedback aan de patiënt mogelijk een deel van de behandelingen in de praktijk vervangen? Zo ja, hoe zou u dit dan tarieven zien?

Data-analyse
Beschrijvende statistiek en kwalitatieve data analyse technieken zullen worden toegepast om de gegevens te verwerken

Literatuur referenties


## VOORTGANGSFORMULIER WETENSCHAPPELIJKE STAGE DEEL 1

<table>
<thead>
<tr>
<th>DATUM</th>
<th>INHOUD OVERLEG</th>
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Masterproefcoördinatie Revalidatiewetenschappen en Kinésitherapie Prof. M. Vanvuchelen Agoraaloon Gebouw A Room 0.01 Campus Diepenbeek
mvdhoen.vanvuchelen@uhasselt.be
Masterproefcoördinatie Revalidatiewetenschappen en Kinesitherapie
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Agoralaan Gebouw A, Room 0.01
Tel. 011 29 21 28

BEOORDELING VAN DE WETENSCHAPPELIJKE STAGE-DEEL 1

Wetenschappelijke stage deel 1 (Masterproef deel 1 - MP1) van de Master of Science in de revalidatiewetenschappen en de kinesitherapie bestaat uit twee delen:

1) De literatuurstudie volgens een welomschreven methodiek.
2) Het opstellen van het onderzoeksprotocol ter voorbereiding van masterproef deel 2.

Omschrijving van de evaluatie:

1) 80% van het eindcijfer wordt door de promotor in samenspraak met de copromotor gegeven op grond het product en van het proces dat de student doorliep om de MP1 te realiseren, met name het zelfstandig uitvoeren van de literatuurstudie en het zelfstandig opstellen van het onderzoeksprotocol, alsook de kwaliteit van academisch schrijven.
2) 20% van het eindcijfer wordt door de interne jury gegeven op grond van het ingeleverde product en de mondelinge presentatie waarin de student zijn/haar proces toelicht.

In de beoordeling dient onderscheid gemaakt te worden tussen studenten die, in samenspraak met de promotor, een nieuw onderzoek uitwerkten en studenten die instapten in een lopend onderzoek of zich baseren op voorgaande masterproeven of onderzoeksprojecten. Van deze laatste worden bijkomende inspanningen verwacht zoals bv. het bijsturen van de eerder geformuleerde onderzoeksvraag, de kritische reflectie over het onderzoeksdesign, het uitvoeren van een pilotexperiment.

Beoordelingskader:

<table>
<thead>
<tr>
<th>Beoordelingskader: criteria op 20</th>
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<tr>
<td>18-20 Excellentie modelmasterproef</td>
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<tr>
<td>16-17 Uitmuntende masterproef</td>
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<tr>
<td>14-15 Zeer goede masterproef die zich onderscheidt van de andere masterproeven</td>
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<tr>
<td>12-13 Goede masterproef</td>
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<tr>
<td>10-11 Voldoende masterproef die op een aantal vlakken zwak scoort</td>
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<tr>
<td>8-9 Onvoldoende masterproef die niet aan de minimumnormen voldoet</td>
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<td>6-7 Ernstig onvoldoende masterproef of een masterproef die slechts één van beide bevat</td>
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<td>≤ 5 Ernstig onvoldoende en onvolledige masterproef</td>
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ZELFEVALUATIERAPPORT

Onderstaand zelfevaluatierapport is een hulpmiddel om je wetenschappelijke stage-deel 1 zelfstandig te organiseren. Bepaal zelf je deadlines, evalueer en reflecteer over je werkwijze en over de diepgang van je werk. Check de deadlines regelmatig. Toets ze eventueel af bij je (co)promotor. Succes!

Prof. M. Vanvuchelen, coördinerende verantwoordelijke wetenschappelijke stages
**Naam & Voornaam STUDENT:** Lotte Vermeulen  
**Naam & Voornaam (CO)PROMOTOR & PROMOTOR:** Prof. Dr. Annick Timmermans, Prof. Dr. K. Corten, A. Bruijnes (MSc), Drs. J. Emmerzaal  
**TITEL masterproef (Nederlandstalig of Engels):** ‘Effects of Exercise Therapy after Total Hip Arthroplasty: A Systematic Review’

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De inleiding van de literatuurstudie logisch opbouwen

Verspreid over de hele masterproef

De methodesectie van de literatuurstudie transparant weergeven

Februari 2018

De resultatensectie afstemmen op de onderzoeksvragen

Februari 2018

In de discussiesectie de bekomen resultaten in een wetenschappelijke tekst integreren en synthetiseren

Maart 2018

Het onderzoeksprotocol deskundig technisch uitschrijven

Juni 2018

Referenties correct en volledig weergeven

Juni 2018

ZELFSTUREND EN WETENSCHAPPELIJK DENKEN EN HANDELEN

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ZELFEVALUATIERAPPORT

WETENSCHAPPELIJKE STAGE - DEEL 1

Naam & Voornaam STUDENT: Vienna Mertens

Naam & Voornaam (CO)PROMOTOR & PROMOTOR: Prof. Dr. Annick Timmermans, Prof. Dr. K. Corten, A. Bruijnes (MSc), Drs. J. Emmerzaal

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### ACADEMISCHE SCHRIJVEN

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<td>Goed</td>
<td>Voldoende</td>
</tr>
<tr>
<td>Initiatief en verantwoordelijkheid opnemen ten aanzien van de realisatie van de wetenschappelijke stage</td>
<td>Goed</td>
<td>Goed</td>
<td>Goed</td>
</tr>
<tr>
<td>Kritisch wetenschappelijk denken</td>
<td>Goed</td>
<td>Goed</td>
<td>Goed</td>
</tr>
<tr>
<td>De contacten met de promotor voorbereiden en efficiënt benutten</td>
<td>Goed</td>
<td>Goed</td>
<td>Goed</td>
</tr>
<tr>
<td>De richtlijnen van de wetenschappelijke stage autonoom opvolgen en toepassen</td>
<td>Goed</td>
<td>Voldoende</td>
<td>Goed</td>
</tr>
<tr>
<td>De communicatie met de medestudent helder en transparant voeren</td>
<td>Goed</td>
<td>Goed</td>
<td>Goed</td>
</tr>
<tr>
<td>De communicatie met de promotor/copromotor helder en transparant voeren</td>
<td>Voldoende</td>
<td>Voldoende</td>
<td>Voldoende</td>
</tr>
<tr>
<td>Andere verdiensten:</td>
<td>/</td>
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Richting: master in de revalidatiewetenschappen en de kinesitherapie-revalidatiewetenschappen en kinesitherapie bij musculoskeletale aandoeningen
Jaar: 2018

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Voor akkoord,

Mertens, Vienna Vermeulen, Lotte

Datum: 15/06/2018