LITERATURE REVIEW

Effectiveness Of Muscle Strengthening Interventions In Patient With Grade 4 Osteoarthritis Following Total Knee Replacement Surgery : A Systematic Review And Meta-Analysis

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ABSTRACT

Background: Osteoarthritis (OA) is the most prevalent kind of arthritis affects joints and one of the main causes of disability. Patients diagnosed with advanced OA in their knees typically undergo total knee arthroplasty (TKA). Strength training is tool for reducing muscle weakness, enhancing ability in functional ambulation after TKA, according to many systematic reviews and meta-analyses.

Objective: The aim is to investigate the importance of muscle-strengthening in individuals who had TKA surgery.

Methods: A systematic literature search of three online databases was performed for randomized controlled trials (RCT) evaluating effects of strength training on functional ambulation by six-minute walk test (6MWT)/ timed-up and go (TUG) test after TKA surgery. Data were pooled by random-effect meta-analyses and presented as standard mean difference (SMD). PRISMA criteria and Cochrane risk-of-bias approach was applied to each research determine the evidence quality. Results: Eleven RCT were identified. A meta-analysis indicated that post operative 6MWT showed no significant difference between standard therapy and muscle-strengthening, but demonstrated that muscle-strengthening produced better outcomes in TUG test than standard therapy.

Conclusion: Muscle strengthening interventions in patient with grade 4 osteoarthritis following total knee replacement surgery could increases physical function such as decrease time to complete timed-up and go test

Keywords: Muscle strengthening, Osteoarthritis, Total Knee Replacement, Post operative, Effectiveness.

ABSTRAK

Latar Belakang: Osteoartritis (OA) adalah jenis artritis yang paling umum yang memengaruhi sendi dan merupakan salah satu penyebab utama kecacatan. Pasien yang didiagnosis dengan OA lanjut pada lutut mereka biasanya menjalani artroplasti total lutut (TKA). Latihan kekuatan merupakan alat untuk mengurangi kelemahan otot, meningkatkan kemampuan atletik dalam ambulasi fungsional setelah TKA, menurut tinjauan sistematis dan meta-analisis.

Tujuan: Tujuan dari tinjauan sistematis dan meta-analisis ini adalah menyelidiki pentingnya penguatan otot pada individu yang telah menjalani operasi TKA.

Metode: Pencarian literatur sistematis pada tiga database online dilakukan untuk uji coba terkontrol secara acak (RCT) yang mengevaluasi efek latihan kekuatan pada ambulasi fungsional dengan uji jalan enam menit (6MWT)/ uji bangun-dan-jalan (TUG) setelah operasi TKA. Data dikumpulkan dengan meta-analisis efek acak& disajikan sebagai perbedaan rata-rata standar (SMD). Kriteria PRISMA dan pendekatan risiko bias Cochrane diterapkan pada setiap penelitian untuk menentukan kualitas bukti.
Hasil: Sebelas RCT diidentifikasi. Meta-analisis menunjukkan bahwa 6MWT pasca operasi tidak menunjukkan perbedaan signifikan antara terapi standar& penguatan otot, namun menunjukkan bahwa penguatan otot menghasilkan hasil yang lebih baik pada uji TUG dibandingkan terapi standar.

Kesimpulan: Intervensi penguatan otot pada pasien osteoartritis tingkat 4 pasca operasi penggantian lutut total dapat meningkatkan fungsi fisik seperti mengurangi waktu untuk menyelesaikan tes time-up and go.

Kata Kunci: Penguatan otot, Osteoartritis, Penggantian Lutut Total, Pasca operasi, Efektivitas.

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INTRODUCTION

Osteoarthritis (OA) is the most prevalent kind of arthritis that affects joints and one of the main causes of disability.[1] Over 240 million individuals worldwide and up to 32 million in the United States alone are thought to be impacted by OA. About half of people over 65 have OA, with women experiencing a higher incidence of the disease (18%) after menopause than men (9.6%).[2] OA typically progresses slowly and continues for a prolonged amount of time.[3] OA usually results in damage to the surrounding tissues and joints, which are essential for movement. Meniscus, ligaments, tendons, synovium, and articular cartilage are all included in this. While OA can affect any joint in the body, it most commonly affects the feet, hips, hands, and knees.[2]

OA is divided into two categories: primary and secondary OA. Idiopathic OA, also name for primary OA, is the term used to describe the degenerative changes in joints brought on by hereditary disorders

without any established underlying causes. Injury or risk factors are linked to secondary OA. A few conditions that are connected to secondary OA include obesity, diabetes, food, physical activity, rheumatoid arthritis, and other disorders affecting the metabolism or bones.[4,5]

Standard pharmacotherapy of osteoarthritis involves oral, topical, or intraarticular options and always a lifelong therapy. However, long-term usage of OA-relieving medicines could cause negative effects on various organs specifically in the kidney, gastrointestinal tract, and cardiovascular system. Currently, the major objectives of OA management are to improve overall quality of life, lessen disability, and relieve unpleasant symptoms. Exercise, strength training, and weight control are some of the non-pharmacological treatment options for OA.[6] Patients diagnosed with advanced OA in their knees typically undergo total knee arthroplasty (TKA). Six months after surgery, TKA is thought to be a useful management strategy for symptom reduction, quality of life improvement, and returning patients to preoperative functional levels.[7] However, if an appropriate post-operative strengthening plan is not followed, complete knee replacement surgery may not yield the same results in and of itself.

Strength training is a useful tool for reducing muscle weakness and enhancing athletic ability.[8] Strength training is safe and non-inferior to other therapies in functional ambulation after TKA, according to many systematic reviews and meta-analyses.[9,10] Moreover after TKA, the American Physical Therapy Association (APTA) strongly advises strength training to enhance knee extension, muscle strength, mobility, and balance. Strengthening exercises use weights or resistance to work the muscles around the knee, such as the quadriceps, hamstrings, inner thighs, and outer thighs.[11] The 6-minute walk test (6MWT) has been found by the Osteoarthritis Research Society International (OARSI) recommendations to be a useful tool for evaluating physical function in individuals with knee OA.[12]

To assess overall functional mobility, the Timed Up and Go (TUG) test is a dependable, economical, safe, and time- efficient method.[13] These two indicators have been widely documented as good parameters for assessing function after TKA.

There is considerable disagreement over how to strengthen muscles after TKA and the majority of current research produces conflicting results. Consequently, the purpose of this meta- analysis is to evaluate the importance of muscle strengthening in individuals who have had TKA surgery.

METHODS

A systematic review using a meta-analysis statistical approach was the study's design.

Eligibility criteria

The following criteria were met for the studies to be eligible: (1) the study design had to be an randomized controlled trial (RCT); (2) the participants had to be undergoing TKA for knee OA; (3) post-operative exercise intervention was carried out; (4) the participants' body function and/or activity was evaluated by the researchers using metrics like 6MWT and TUG; and (5) the paper had to be published in English. The control group's eligibility requirements were not established. In terms of choosing each article, the two researchers made separate decisions.

Search strategy

PRISMA criteria were adhered to in this research. "Arthroplasty, replacement, knee," "osteoarthritis, knee," and

"resistance training, strength training, weight bearing exercise, eccentric exercise, concentric exercise, isotonic exercise, weight lifting exercise" were the search terms we used to search all trial registers and databases (PubMed, Cochrane, Wiley). The mix of free text words and medical subject heading terms included in Table 1 made up the search strategy. Duplications were eliminated after the articles were imported into Zotero 6.0.36.

After another author (IPDP) had extracted the data, one author (PKMPD) confirmed the choice of the articles. An overview of the search process is given in the PRISMA flowchart (Chart 1). The studies that compared patients who had TKA with post-operative muscle-strengthening to another group that followed a conventional rehabilitation plan met the inclusion criteria. Studies that were not comparative or had results that were not meaningful were not included.

Data extraction

Two reviewers independently determined whether the papers qualified by utilizing a pre- made data extraction form. The main result of the data analysis was the 6MWT, which represents a person's walking distance in 6 minutes and is comparable to real-world scenarios. The TUG test was chosen as the backup plan. Participants in this test must get up from a seated posture, walk 3 meters, turn around, and then return to their seats. An improvement in the result is indicated by a reduction in the time required to complete TUG.

Risk of bias

Two researchers (PKMPD and IPDP) assessed the risk of bias independently using the Cochrane risk-of-bias approach. The risk of bias associated with each experiment was assessed and classified as high, low, or unclear. This included blinding participants and staff to the research technique, blinding result evaluation, and random sequence creation.

Statistical analysis

Review Manager 5.4 was used to conduct the statistical analysis (The Cochrane Collaboration, 2020). 95% confidence intervals (CI) were used using standardized mean differences (SMD). When $p \leq 0.05$ or $I2 > 50\%$, there is significant heterogeneity, according to the Q tests and I2 statistics used to assess heterogeneity. The fixed-effect model was selected in the absence of the latter, which was handled by the random-effects model. The cutoff point for statistical significance was $p=0.05$. The cutoff point for statistical significance was $p=0.05$.

RESULTS

Characteristic of the included studies

This meta-analysis contained eleven papers [14–24] in last ten years. Each of the RCT matched the requirements for inclusion. In this study, 405 participants followed a muscle- strengthening program, while 398 participants had normal rehabilitation. (Table 1) provides an overview of the key features of the included studies. A summary of the Bias assessment findings can be found in (Figure 2A, B).

6MWT

Information on post-operative 6MWT results came from six studies with 333 participants. The outcomes (SMD, 23.78; 95% CI -16.21–63.76, p=0.24, (Figure 3A)) showed no significant difference between standard therapy and muscle-strengthening.

TUG

Data on post-operative TUG outcomes were published from eight trials

involving 510 individuals. The outcomes demonstrated that muscle-strengthening produced better outcomes than standard therapy (SMD, -1.65; 95% CI -2.13–1.17, p=<0.01, (Figure 3B)).

DISCUSSION

In general oral and topical NSAIDs, including COX-2 inhibitors, are strongly recommended first-line treatments for OA due to their ability to improve pain and function but are associated with increased risks in patients with certain comorbidities (e.g., heightened cardiovascular risks). Intra-articular corticosteroid injections are generally recommended for OA management and have relatively minor adverse effects. There is an immediate demand in clinical practice for an OA symptom-relieving treatment strategy that is desirable for long-term use with minimum adverse effects.[6] TKA is becoming a more common surgical procedure in the modern world. However, there is a persistent chronic muscle weakness linked to this surgery in the hip abductor and quadriceps muscle groups. Eighty to eighty-five percent of patients are said to be satisfied after surgery; nevertheless, a tiny percentage of patients have post-operative pain and functional ambulation restrictions because of muscle weakness and damage, as well as deficiencies in neuromuscular activation. After surgery, this impairment may continue for more than three years.[21,25]

Despite the fact that quadriceps weakness is a defining feature of OA, strength rapidly decreases in the initial weeks following TKA. This results directly from the surgery, immobility, atrophy, and most importantly, suppression of the neuromuscular system. The TUG and 6MWT show that quadriceps strength predicts 28 and 37% of the variability, respectively, suggesting that quadriceps strength is a more reliable indicator of functional performance after TKA. As such, it is essential to treat deficiencies in quadriceps strength after TKA.[26]

According to current evidence, early training or fast-track rehabilitation can reduce dysfunction and minimize the duration of hospitalization. Muscle weakness and immobility would result from neuromuscular activation deficits, which would last until training. Strengthening exercises that use weights or resistance to work the muscles around the knee, such as the quadriceps, hamstrings, inner thighs, and outer thighs have a beneficial effect.[11] Early strength training stimulates neuromuscular control soon after surgery, preventing more muscle atrophy and increasing muscle force and walking speed by 147% and 112%, respectively, in just two weeks.[27]

A prior study by Sled et al., found that when quadriceps strengthening was used, individuals with OA in the knee joint reported reduced discomfort and better functional outcomes. This study's findings suggested that the mechanical alterations surrounding the knee joint may be primarily attributed to the proximal hip muscles.[28] Our findings, however, did not reveal a distinction in the 6MWT between the two rehabilitation approaches. The variations in the rehabilitation methods between those researches may be the cause of some of the contradicting results that were found.

The study's findings indicate that muscle-strengthening following discharge may help with performance-based tests such as TUG scores. This was also emphasized in the study by Petterson et al.,[29] which contrasted the results of protocols for progressive strengthening with an embedded cohort of patients (the standard of care group) who did not undergo progressive strengthening following TKA. Compared to a group receiving conventional treatment, participants in the progressive strengthening group had significantly

higher quadriceps strength and improved performance on performance-based tests (such as TUG) following TKA.

Clinical professionals who are organizing the post-discharge exercise regimen for patients with knee OA having TKA will find our data useful. These findings also crucial for clinicians to know since insurers might be concerned about a rise in medical expenses as a result of the ongoing exercise intervention. Exercise can improve quality of life in many ways including physical, mental, and social health especially in patient knee OA having TKA. Nonetheless, compared to controls, individuals who exercised muscle-strengthening had greater improved physical function.

LIMITATION

The study has a number of limitations.[1] Strength training is not less effective than normal rehabilitation for enhancing strength and functional ambulation, according to prior research. According to our findings, strength training did not significantly increase 6MWT when compared to either conventional care or no treatment at all. Only two of the six investigations, meanwhile, produced statistically meaningful findings.

Therefore, additional research is necessary to draw a firm judgment.[2] Our review did not include certain research that were not published in a language other than English. Some intervention researchers operating in non-English speaking nations may have had some of their work published in regional journals, according to a comprehensive examination of such researchers. If certain research that were not published in a language other than English were included, the conclusions of this review are thought to have changed significantly.

CONCLUSION

We looked at the most efficient way to strengthen muscles in TKA patients. According to a meta-analysis, functional performance was significantly enhanced by muscle strengthening following discharge in addition to routine post-operative care. Muscle strengthening interventions in patient with grade 4 osteoarthritis following total knee replacement surgery could increases physical function such as decrease time to complete timed-up and go test. The best times to exercise after surgery before being released, however, were not determined.

CONFLICT OF INTEREST

The author declare that author do not have a conflict of interest and we do not have affiliations or relationships with any organization or entity that could raise biased questions or statements in the discussion and conclusion sections of the paper.

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SUPPLEMENTARY

Main characteristics of the included studies

No	Author	Study Design	Population	Interventions	Control	Outcome	Results
1	Jakobsen (2014)	RCT	72 patients	The progression of the control group (CG) (35 patients) involved increasing the loads and decreasing the repetitions of both leg press and knee extension exercises.	Treatment protocols often include a warm-up, stretches, range-of-motion exercises, functional training, balancing training, and ice (37 patients).	6WMT	According to 6WMT, there was no significant difference between the patients who received the intervention at baseline and those who did not.
2	Vuorenmaa (2014)	RCT	108 patients	Exercises that strengthen the quadriceps and hamstrings isometrically at various angles of the knee joint, such as hopping up and down, climbing on tiptoes, hack squatting, and squatting (53 patients)	Standard treatment includes standing hip abductor and extensor exercises (using the weight of an extremity as resistance), active and passive knee range of motion exercises, and ice (55 patients).	TUG	Knee flexion strength was considerably higher in the exercise group at the 12-month follow-up.
3	Bily (2016)	RCT	55 patients	Strength training using a leg press machine with a computerized linear motor From strictly isokinetic training to eccentric concentric training (26 patients)	Exercises for improving scar and joint mobility include ergometer cycling, manual treatment, soft tissue techniques, range-of-motion exercises, isometric and dynamic strengthening exercises, and gait-retraining activities. without resistance: quadriceps setup, straight leg raise, seated knee extension, etc. (29 patients)	TUG	After training, there was no significant difference between the two groups in terms of strength, discomfort, or functional results.
4	Harikesavan (2017)	RCT	20 patients	Walking, control group (CG) + hip abductor strengthening exercises, isometric hip abductor strengthening exercises, calm exercises for hip abductors, standing wall isometric hip abduction, calm exercises with resistance using TheraBand, unilateral hip abduction performed standing (from no resistance to ankle weights), and functional exercises (10 patients)	Early mobilization techniques to maximize function include decreasing discomfort and swelling, increasing knee flexion and extension range of motion, and performing gradual quadriceps strengthening exercises (10 patients).	6WMT TUG	When comparing the hip abductor strengthening group's improvement in hip abduction strength and single leg stand test at three months and a year to standard rehabilitation alone, the results were better.
5	Jorgensen (2017)	RCT	55 patients	Knee flexion (added from week 3) and leg press and extension movements on strength training machines (Technogym®, Cesena, Italy) during the warm-up. Higher loads and sets for advancement (31 patients)	Exercise regimen at home that was primarily focused on knee range of motion and blood and lymph circulation (24 patients)	6WMT	In terms of increasing leg extension power of the operated leg, progressive resistance training two days a week combined with five days of at-home exercise was not more effective than seven days of at-home exercise.

6	Calatayud (2017)	RCT	44 patients	Two groups of patients underwent self-weight training for fifteen minutes, with each group repeating the exercise and joint activity twenty times (22 patients)	Routine nursing (22 patients)	TUG	The intervention group performed better on all functional tests than the control group.
7	Husby (2018)	RCT	41 patients	Walking or ergometer cycling as a warm-up maximum strength training (MST): leg presses and knee extensions in the operated leg alone. The load was increased to 5 kg for leg presses and 0.5–1 kg for knee extensions (21 patients) when participants could complete 6RM.	Standard rehabilitation (SR) entails writing a training diary (20 patients), calling the project leader once a week, and attending two to three physiotherapy sessions per week for eight weeks.	6WMT	From the 7-day to the 10-week follow-up, participants undergoing MST showed significantly higher improvements in leg press and knee extension muscle strength compared to those managed with SR; however, no differences in functional performance were observed.
8	Schache (2019)	RCT	105 patients	Hip abduction while lying on one side, prone hip extension, sideways walking, standing hip abduction, and hip hitching (54 patients) are additional hip strengthening exercises performed with the same standard of care as CG.	Regular maintenance: strengthen the quadriceps, expand the range of motion of the active knee flexion, strengthen the hamstrings, expand the range of motion of the knee extension, and strengthen and supple the calf muscles. Extra routine care: moving from a seated position to a standing, marching, and walking one (51 patients)	6WMT TUG	At 6 weeks or 26 weeks, there was no significant difference between the experimental and control groups in terms of improvements in hip strength or any other secondary end measure.
9	Do (2020)	RCT	40 patients	TheraBand exercises for the hips include warm-ups, supine extension bridges, sideways walking, standing hip adductions, and hip external rotations. TheraBand exercises for the quadriceps include warm-ups, seated knee extensions, supine straight leg raises, and quarter wall squats (20 patients).	Active range of motion exercises of the knees (20 patients)	6WMT TUG	Compared to the quadriceps and control groups, the hip group had more notable improvements in pain and performance on the Single Leg Stance Test and Alternate Step Test. The hip group improved the most in single and double stance during the gait examination.
10	Liao (2020)	RCT	60 patients	Warm-up for one minute, elastic resistance training for forty minutes, and cool-down for ten minutes. Exercises using elastic resistance include the leg press, leg curl, hip circumduction, sitting shoulder press, and seated chest press (30 patients).	Education, medication, stretching, range-of-motion exercises (both active and passive), and functional reconditioning exercises are all part of the standard care (30 patients)	TUG	Following a 12-week period of training in elastic resistance exercises following surgery, the experimental group showed a noticeably higher alteration in their lean mass in the appendix than the control group.
11	Lee (2021)	RCT	38 patients	A dynamic balance program that included five days a week, thirty minutes of physical therapy for six weeks (19 patients)	Physical therapy only (19 patients)	TUG	The experimental group's physical function and balancing abilities dramatically improved as compared to the control group.

Table 1. Search strategy.

PubMed	((((arthroplasty, knee replacement [MeSH Terms]) OR (knee replacement[Title/Abstract])) OR (knee arthroplasty[Title/Abstract])) OR (Knee Prosthesis[Title/Abstract])) AND (((((((Resistance Training[MeSH Terms]) OR (Strength Training[Title/Abstract])) OR (Weight-Bearing Exercise[Title/Abstract])) OR (eccentric exercise[Title/Abstract])) OR (concentric exercise[Title/Abstract])) OR (isotonic exercise[Title/Abstract])) OR (Weight Lifting Exercise[Title/Abstract]))
Cochrane	(arthroplasty, knee replacement OR knee replacement OR knee arthroplasty OR Knee Prosthesis) AND (Resistance Training OR Strength Training OR Weight-Bearing Exercise OR eccentric exercise OR concentric exercise OR isotonic exercise OR Weight Lifting Exercise)
Wiley	(arthroplasty, knee replacement OR knee replacement OR knee arthroplasty OR Knee Prosthesis) AND (Resistance Training OR Strength Training OR Weight-Bearing Exercise OR eccentric exercise OR concentric exercise OR isotonic exercise OR Weight Lifting Exercise)

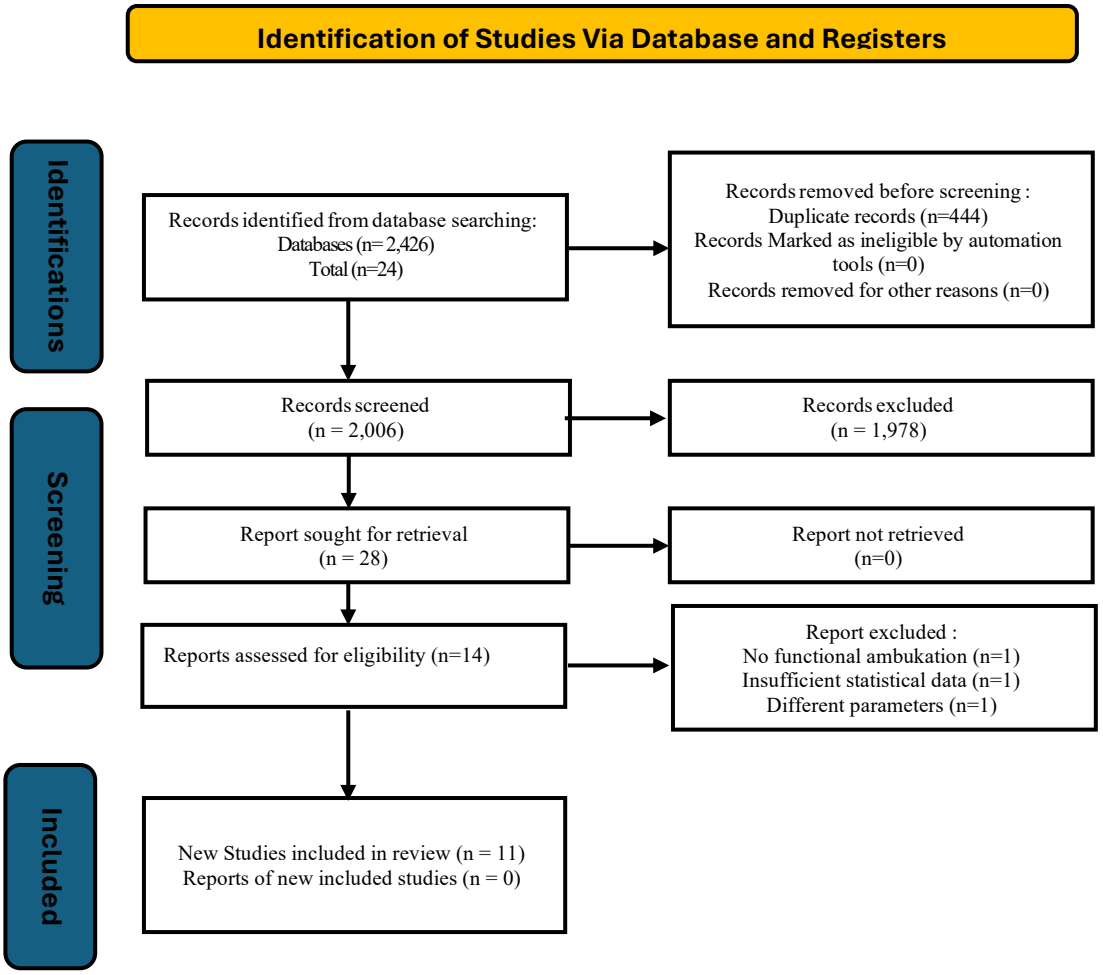


Figure 1. PRISMA flowchart for article selection process.

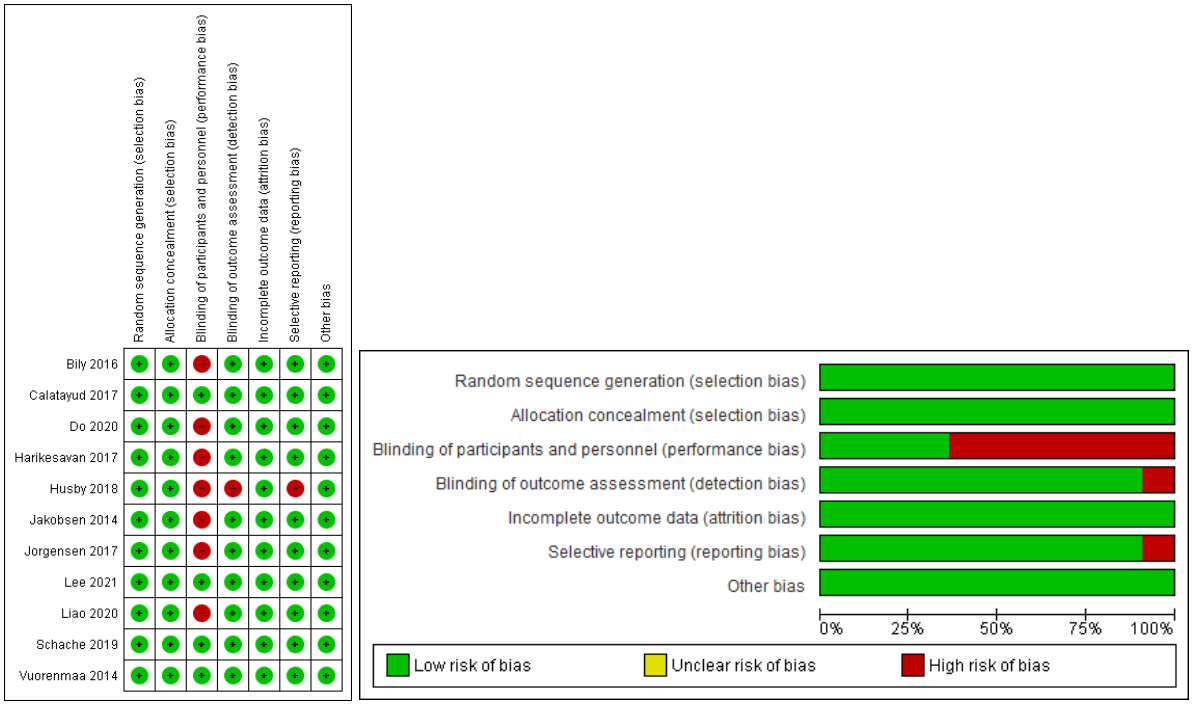
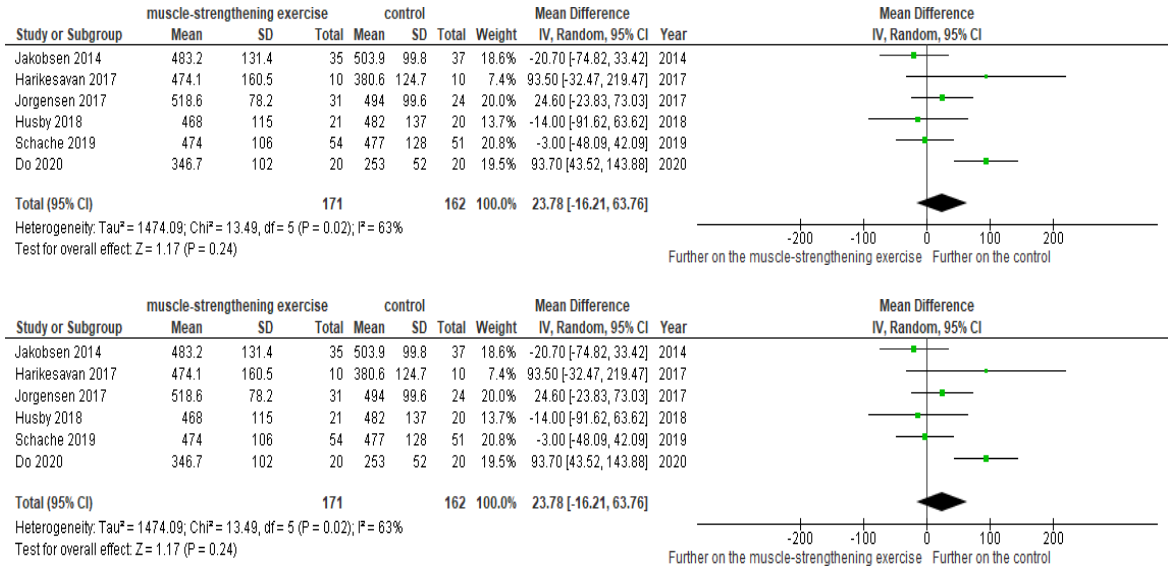


Figure 2. Bias risk item for every study that is included. (B) The percentages for the risk of bias item are displayed for all considered studies.



muscle-strengthening exercise
control
Mean Difference
Mean Difference
Study or Subgroup Mean SD Total Mean SD Total Weight IV, Random, 95% CI Year
IV, Random, 95% CI
Jakobsen 2014 483.2 131.4 35 503.9 99.8 37 18.6% -20.70 [-74.82, 33.42] 2014
Harikesavan 2017 474.1 160.5 10 380.6 124.7 10 7.4% 93.50 [-32.47, 219.47] 2017
Jorgensen 2017 518.6 78.2 31 494 99.6 24 20.0% 24.60 [-23.83, 73.03] 2017
Husby 2018 468 115 21 482 137 20 13.7% -14.00 [-91.62, 63.62] 2018
Schache 2019 474 106 54 477 128 51 20.8% -3.00 [-48.09, 42.09] 2019
Do 2020 346.7 102 20 253 52 20 19.5% 93.70 [43.52, 143.88] 2020
Total (95% CI) 171 162 100.0% 23.78 [-16.21, 63.76]
Heterogeneity: Tau² = 1474.09; Chi² = 13.49, df = 5 (P = 0.02); I² = 63%
Test for overall effect: Z = 1.17 (P = 0.24)
-200
-100
0
100
200
Further on the muscle-strengthening exercise
Further on the control

Figure 3. (A): Forest plot illustrating how typical therapy and muscle strengthening after surgery using 6MWT. (B): Forest plot demonstrating how conventional therapy and muscle