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Review

Motor Control Exercises Compared to Strengthening Exercises for Upper- and Lower-Extremity Musculoskeletal Disorders: A Systematic Review With Meta-Analyses of Randomized Controlled Trials

Simon Lafrance, PT, MSc[1,2], Philippe Ouellet, PT, MSc[2], Reda Alaoui[2], Jean-Sébastien Roy, PT, PhD[3,4], Jeremy Lewis, PT, PhD[5,6,7], David Høyrup Christiansen, PT, PhD[8,9], Blaise Dubois, PT[10], Pierre Langevin, PT, MClSc[3,4], François Desmeules, PT, PhD[1,2,*]

[1]School of Rehabilitation, Faculty of Medicine, University of Montreal, Montreal, Quebec, Canada
[2]Maisonneuve-Rosemont Hospital Research Center, University of Montreal Affiliated Research Center, Montreal, Quebec, Canada
[3]Department of Rehabilitation, Faculty of Medicine, Université Laval, Quebec City, Quebec, Canada
[4]Center for Interdisciplinary Research in Rehabilitation and Social Integration (CIRRIS), Quebec City, Quebec, Canada
[5]School of Health and Social Work, University of Hertfordshire, Hertfordshire, United Kingdom
[6] Therapy Department, Central London Community Healthcare National Health Service Trust, London, United Kingdom
[7]Department of Physical Therapy and Rehabilitation Science, Qatar University, Doha, Qatar
[8]Department of Occupational Medicine, Regional Hospital West Jutland University Research Clinic, Herning, Denmark
[9]Department of Clinical Medicine, Health, Aarhus University, Aarhus, Denmark
[10]The Running Clinic, Quebec City, Quebec, Canada

*Address all correspondence to Dr Desmeules at: f.desmeules@umontreal.ca

Abstract

Objective. The purpose of this review was to compare the efficacy of motor control exercises (MCEs) to strengthening exercises for adults with upper- or lower-extremity musculoskeletal disorders (MSKDs).

Methods. Electronic searches were conducted up to April 2020 in Medline, Embase, Cochrane CENTRAL, and CINAHL. Randomized controlled trials were identified on the efficacy of MCEs compared to strengthening exercises for adults with upper- or lower-extremity MSKDs. Data were extracted with a standardized form that documented the study characteristics and results. For pain and disability outcomes, pooled mean differences (MDs) and standardized mean differences (SMDs) were calculated using random-effects inverse variance models.

Results. Twenty-one randomized controlled trials (n = 1244 participants) were included. Based on moderate-quality evidence, MCEs lead to greater pain (MD = −0.41 out of 10 points; 95% CI = −0.72 to −0.10; n = 626) and disability reductions (SMD = −0.28; 95% CI = −0.43 to −0.13; n = 713) when compared to strengthening exercises in the short term; these differences are not clinically important. When excluding trials on osteoarthritis (OA) participants and evaluating only the trials involving participants with rotator cuff–related shoulder pain, shoulder instability, hip-related groin pain, or patellofemoral pain syndrome, there is moderate quality evidence that MCEs lead to greater pain (MD = −0.74 out of 10 points; 95% CI = −1.22 to −0.26; n = 293) and disability reductions (SMD = −0.40; 95% CI = −0.61 to −0.19; n = 354) than strengthening exercises in the short term; these differences might be clinically important.

Conclusions. MCEs lead to statistically greater pain and disability reductions when compared to strengthening exercises among adults with MSKDs in the short term, but these effects might be clinically important only in conditions that do not involve OA. Inclusion of new trials might modify these conclusions.

Impact. These results suggest that MCEs could be prioritized over strengthening exercises for adults with the included non-OA MSKDs; however, results are unclear for OA disorders.

Keywords: Exercise Therapy, Motor Control and Motor Learning, Muscle Strength, Musculoskeletal Pain, Physical Therapists

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Introduction

Musculoskeletal disorders (MSKDs) are the most common cause of long-term pain and physical disability around the world.[1] MSKDs 1-year prevalence is estimated at 14.9% in male and 17.6% in female patients.[2] In the United States, the economic cost of MSKDs is estimated at up to $635 billion annually, exceeding the economic costs of cancers, cardiovascular, or metabolic diseases.[3] Although low-back and neck disorders are the most common MSKDs encountered, upper- or lower-extremity disorders such as rotator cuff (RC)-related shoulder pain, elbow extensors or Achilles tendinopathies, knee osteoarthritis (OA), or patellofemoral pain syndrome (PFPS) are highly prevalent and may be difficult to treat.[3]

Conservative management of common MSKDs often includes pharmacological treatments and rehabilitation involving exercises, education, and psychological interventions.[4–7] Although exercise therapy is effective and consistently recommended, it remains unclear which types of exercise are more effective to treat MSKDs.[4–7] Common exercise approaches include motor control exercises (MCEs) and strengthening exercises since neuromuscular control impairments as well strength deficits are often reported in adults with various MSKDs.[8–11] The rationale behind MCEs is to focus on specific muscle activation to improve neuromuscular control, joint stability, and movement quality while strengthening exercises are used to address strength deficits and to gradually load joints, tendons, and other contractile tissues.[12,13] With normalization of these deficits, tissue adaptation, and nervous system changes, MCEs and strengthening exercises lead to reductions in pain and disability.[14–18]

A previous meta-analysis, published in 2017, comparing specific exercises such as MCEs and general resistance exercises for adults with RC-related shoulder pain, reported that there is insufficient evidence to determine the superiority of specific resistance exercise approaches.[19] However, another review on RC-related shoulder pain determined the superiority of scapula-focused exercise programs, including MCEs, compared to general physical therapy (strengthening exercises, manual therapy, stretching, and electrophysiological modalities) in terms of pain and disability.[20] For PFPS, core and hip exercises were also found to be superior to knee-focused exercises in terms of pain and disability.[21] For low back pain (LBP), 2 Cochrane reviews (one for acute and one for chronic LBP) appraised the available evidence regarding the efficacy of MCEs compared to other types of exercises.[22,23] For adults with acute LBP, based on the low quality of evidence, the authors concluded that there were no significant differences between MCEs and other forms of exercises such as general or directional preference exercises.[23] The other review for participants with chronic LBP reported statistically significant differences, but no clinically important differences, for pain and disability in favor of MCEs when compared to other forms of exercises such as general, strengthening, or directional preference exercises.[22] It remains unclear, however, whether MCEs are more effective than strengthening exercises to treat adults with MSKDs, and this has never been systematically appraised for upper- and lower-extremity MSKDs.

The aim of this systematic review and meta-analysis is therefore to appraise and update the available evidence on the efficacy of MCE compared to strengthening exercises for adults with upper- or lower-extremity MSKDs.

Methods

The review protocol is available online on Prospero (https://www.crd.york.ac.uk/prospero/) (CRD42019144967).

Data Sources and Searches

Electronic searches were conducted in 4 databases (Medline, Embase, Cochrane Central, and CINAHL) using terms related to the population of interest (musculoskeletal disorders), interventions (exercise, strengthening, or MCEs) and study design, (randomized controlled trial; RCT) (see supplementary material for full search strategy). The original searches were performed up to February 2019 and were updated up to April 2020. The reference lists of identified published studies and of previous systematic reviews were checked for any additional eligible trials.

Study Selection

Two reviewers (S.L. and P.O.) independently reviewed titles and abstracts to identify trials of interest. Consensus of the 2 reviewers was needed to include the studies. A third reviewer (F.D.) was available if a consensus was not achieved by the 2 initial reviewers. Eligibility criteria were adapted from the systematic review published by Shire et al.[19] Articles were included if they met the following inclusion criteria: 1) participants were adults diagnosed with an MSKD involving the upper or lower extremity that could involve joint, muscle, or tendon structures; 2) one of the interventions included MCEs delivered by a health care professional; 3) one of the interventions included nonmotor control strengthening exercises; 4) at least one outcome measure was related to pain, disability, or health-related quality of life; 5) follow-up was at least 6 weeks after random assignment; 6) the study design was an RCT; and 7) the trial was published either in English or in French.

Based on several definitions from the literature,[19,22] for the purpose of this review, MCEs were defined as exercises targeting the activation of specific musculature, neuromuscular control exercises, dynamic muscular stabilization exercises, proprioceptive exercises, specific movements, or movement control exercises. MCEs also had to involve a form of resistance such as body weight, elastic resistance, and/or weights. For our definition, we considered exercises approaches such as the Movement System Impairment and the Motor Control Training approaches described by Hides et al[24] as MCEs. More general strengthening or stretching exercises could be included in the program as long as MCEs represented the majority of the exercise program. Strengthening exercises needed to involve a form of resistance such as body weight, elastic resistance, weights, and/or machine weights but without any emphasis on motor control. Stretching exercises could also be included in the programs as long as resistance exercises represented the majority of the exercise program.

Studies were excluded if they included participants with 1) a spine-related MSKD; 2) fibromyalgia; 3) cancer; 4) an acute traumatic injury; 5) a postoperative condition; 6) a systemic inflammatory and/or an autoimmune disorder; 7) pregnancy or postpartum women; or 8) wheelchair users. Trials evaluating an isokinetic strengthening program were also excluded because it is rare that this approach is offered to patients over the entire course of their rehabilitation program.

Data Extraction

Data of included studies were extracted with a standardized form that documented the number of participants, participants' characteristics, the types of interventions, outcome measures, and the length of the follow-up. If data were missing or incomplete, corresponding authors were contacted.

Quality Assessment

The risk of bias of the included RCTs was assessed using the Cochrane Risk of Bias tool[25] by 2 independent evaluators (S.L. and R.A. or S.L. and P.O.). The final score was obtained through consensus. In case of disagreement, a third reviewer (P.O. or F.D.) was available to achieve consensus. For each trial a total final score was also calculated and transformed in percentage allowing a summary measure of the overall risk of bias. Trials with an overall score of 75% or higher were considered at a low risk of bias, trials with an overall score between 50% and 74% were considered at an unclear risk of bias, and trials with an overall score below 50% were considered at a high risk of bias.

Data Synthesis and Analysis

Results from trials with similar outcome measures such as pain, disability, or health-related quality of life were pooled into separate meta-analyses. Pooled mean differences (MDs) with 95% CIs were calculated using Review Manager (RevMan 5.3, Cochrane Collaboration, Copenhagen, Denmark). When different scales were used for an outcome, standardized mean differences (SMDs) were calculated. For all meta-analyses, short-term was defined as 6 to 13 weeks and mid-term as 4 to 9 months following random assignment.[22] The α level was set at .05. The inverse variance method was used to weigh each study and was calculated using random-effect modeling. Visual inspection of the forest plots was performed. For SMD effect size interpretation, 0.2 was considered as small, 0.5 as moderate, and 0.8 as large.[26] Only meta-analyses without a significant degree of heterogeneity were kept and reported (χ^2 $P > .10$ and $I^2 < 60\%$). When necessary, data were imputed according to strategies suggested by the Cochrane Collaboration.[27] Subgroup analyses according to groups of pathologies were performed and analyzed separately. Funnel plots were inspected to assess the probability of publication bias. Qualitative synthesis was performed for studies not pooled in meta-analyses.

The GRADE (Grading of Recommendations, Assessment, Development, and Evaluations) approach was used for grading the quality of evidence and for making final recommendations. For RCTs, certainty is initially considered as high and is rated down based on risk of bias, imprecision, inconsistency, indirectness, and publication bias, and is rated up for large magnitude of the effect, dose-response gradient, and if plausible residual confounding is likely to decrease the magnitude of the effect.[28,29]

Role of the Funding Source

The funder played no role in the design, conduct, or reporting of this study.

Results

Of the 53 potentially relevant articles identified through titles and abstract review, 21 RCTs (n = 1244 participants; 24 articles) met the eligibility criteria after full-text review (Fig. 1). Characteristics of included studies are present in the Supplementary Table.

Population

From the 21 RCTs (n = 1244) included, 14 involved participants with lower-extremity and 7 with upper-extremity MSKDs. Participants of included trials had the following diagnoses: knee OA (n = 730; 8 RCTs),[30–39] PFPS (n = 171; 5 RCTs),[40–44] RC-related shoulder pain (n = 178; 4 RCTs),[45–49] shoulder multidirectional instability (n = 41; 1 RCT),[50] traumatic anterior shoulder instability (n = 56; 1 RCT),[51] hip-related groin pain such as femoroacetabular impingement syndrome or labral tears (n = 46; 1 RCT), [52] and first carpometacarpal joint OA (n = 22; 1 RCT).[53] The mean age of participants in included trials ranged from 21.6 to 64.6 years. The mean duration of symptoms ranged from 6.1 to 84.0 months, except for one study that included participants 3 to 6 weeks postshoulder dislocation[51] (Suppl. Table).

Interventions

Sixteen RCTs compared MCEs involving specific muscular contractions, neuromuscular exercises, coordination, balance, proprioception, and/or movement control exercises compared to strengthening exercises.[31–33,35–39,41–47,49–51,53] Of these 16 RCTs, 3 specifically compared the Movement System Impairment approach developed by Sahrmann[54] to strengthening exercises for participants with RC-related shoulder pain,[48] hip-related groin pain,[51] or PFPS[42]; 2 RCTs included interventions involving coordination, proprioception ,and balance exercises compared to strengthening exercises for knee OA.[35,38] Five RCTs assessed the benefits of adding MCEs to a strengthening exercise program for adults with RC-related shoulder pain,[45] PFPS,[40] or knee OA[30,34,39] (Suppl. Table).

Outcome Measures

Fifteen RCTs used the visual analog scale or the numerical rating scale for pain assessment.[30–34,36–38,40–45,48–52] The details of the pain questions were often not reported by the authors. Nineteen RCTs used a validated disability questionnaire such as the Shoulder Pain and Disability Index (SPADI), Western Ontario and McMaster Universities Osteoarthritis Index (WOSI), Disabilities of the Arm, Shoulder and Hand (DASH), Hip Disability and Osteoarthritis Outcome Score (HOOS), Knee Injury and Osteoarthritis Outcome Score (KOOS), Western Ontario and McMaster Universities Osteoarthritis Index (WOMAC), or Lower Extremity Functional Scale (LEFS).[30–45,48,50–53] Six RCTs used self-reported health-related quality of life questionnaires such as the AQoL 2, KOOS life activity, EuroQol- 5 Dimension (EQ-5D), or the 36-Item Short Form Survey Instrument (SF-36)[31–33,35,42,51,52] (Suppl. Table).

Risk of Bias of Included Studies

Three RCTs were considered to have a low risk of bias,[41,43,50] 13 to have an unclear risk of bias,[30–37,40,46–49,51–53] and 5 to have a high risk of bias[38,39,42,44,45] (Fig. 2 and Suppl. Fig. 5). The Cochrane risk-of-bias tool mean score across the 21 RCTs was 59% ± 19%. Owing to the nature of the intervention, blinding of participants was achieved in only 3 RCTs.[41,43,53] Fourteen RCTs were considered to have a high risk of bias for incomplete outcome data reporting.[30,39,53] One RCT was

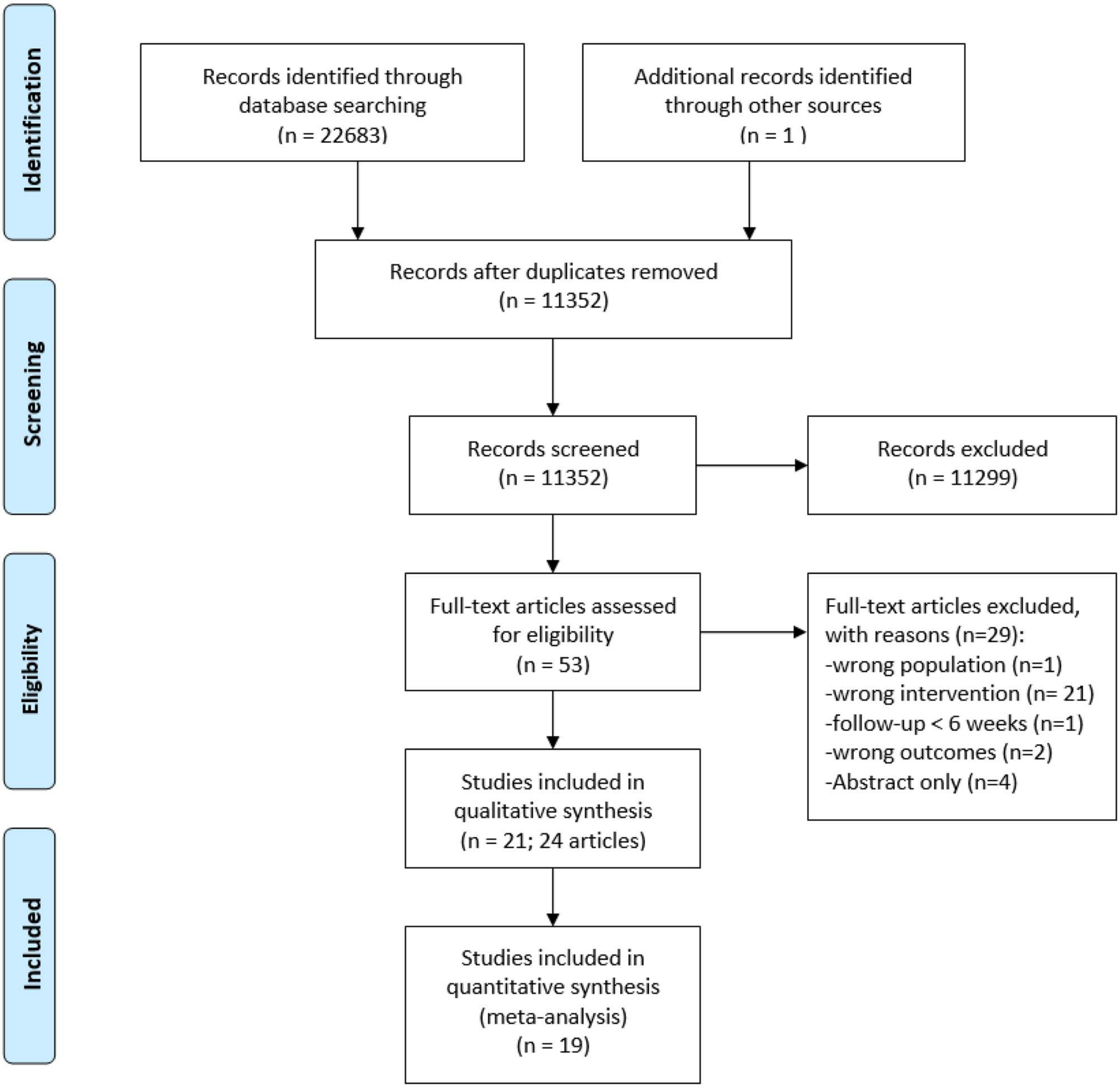

Figure 1. Schematic Breakdown of Literature Search Results.

considered at high risk of other bias because of significant baseline differences between groups.[46,47]

Pain Outcomes

Fifteen RCTs assessed the efficacy of MCEs compared to strengthening exercises on pain using the visual analog scale or numerical rating scale in adults with upper- and lower-extremity MSKDs. However, 3 RCTs reported only graphical results[38,44] or median scores,[53] and full results were not available from the authors. Therefore, these trials could not be pooled into meta-analyses. Twelve RCTs were pooled together.[31–33,35–37,41–43,48–52] Although between-group difference did not reach reported minimal clinically important differences (MCIDs) of 1.0 to 1.4 out of 10 points for the included MSKDs (knee OA, RC disorders, and PFPS)[55–58]; MCEs led to a statistically significant greater pain reduction when compared to strengthening exercises in the short term (MD = −0.41 out of 10 points; 95% CI = −0.72 to −0.10; n = 626; P = .009; Fig. 3). No significant difference was observed in the mid-term, and significant heterogeneity was present (χ^2 P = .001 and I^2 = 85%, see Fig. 3).

A subgroup analysis excluding all OA trials was also performed (RC-related shoulder pain, shoulder instability, hip-related groin pain, and PFPS). Although between-group mean difference did not reach reported MCIDs, a greater significant mean pain reduction in favor of MCEs was reported in the short term (MD = −0.74 out of 10 points; 95% CI = −1.22 to −0.26; n = 293; P = .002; Suppl. Fig. 6A). Another subgroup analysis including only knee OA trials reported no significant difference in pain reduction between the 2 groups in the short term (MD = −0.23 out of 10 points; 95% CI = −0.56 to 0.09; n = 333; P = .15; Suppl. Fig. 6B).

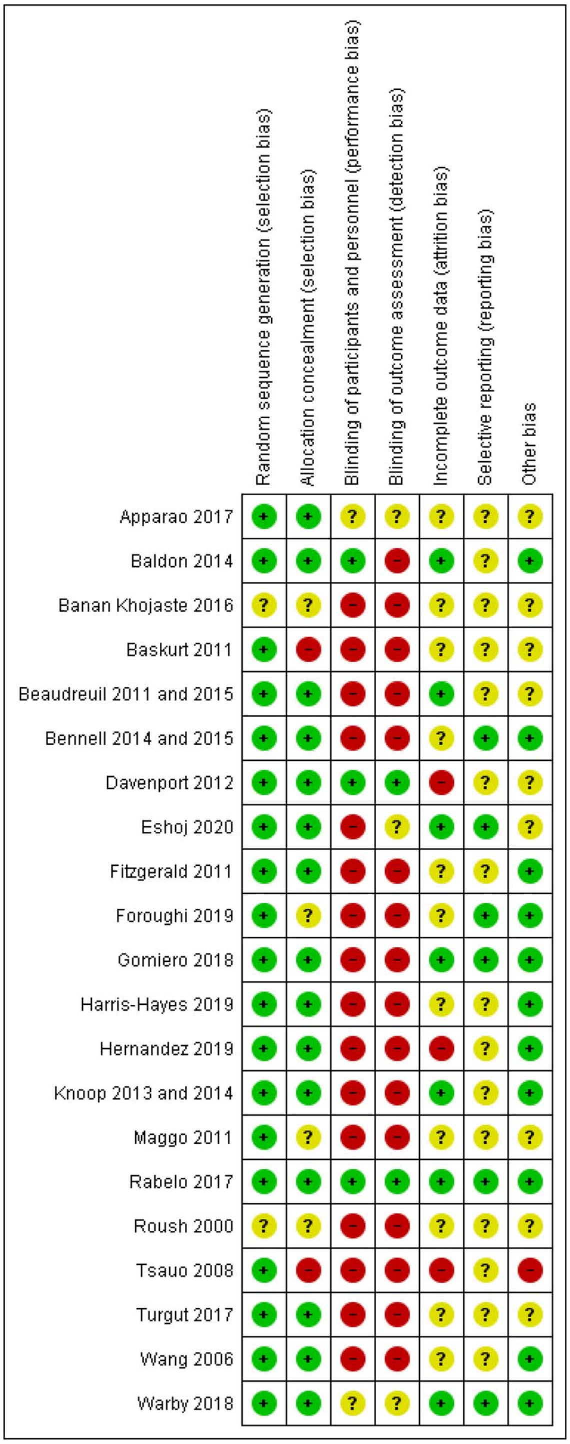

Figure 2. Detailed Methodological Assessment of Included Studies Using the Cochrane Risk-of-Bias Tool. Green = low risk of bias; red = high risk of bias; yellow = unclear or unknown risk of bias.

Disability Outcomes

Fifteen RCTs assessed the efficacy of MCEs compared to strengthening exercises on self-reported disability. One RCT reported only graphical results,[38] and this RCT was not pooled into the meta-analysis. Fourteen RCTs were pooled together.[31–33,35–37,41–43,47–53] MCEs resulted in greater disability reduction when compared to strengthening exercises in the short term (SMD = −0.28; 95% CI = −0.43 to −0.13; n = 713; P < .001; Fig. 4). In the mid-term, no significant difference was observed (SMD = −0.05; 95% CI = −0.27 to 0.17; n = 309; P = .66; see Fig. 4).

A subgroup analysis excluding OA trials was also performed (RC-related shoulder pain, shoulder instability, hip-related groin pain, and PFPS). A greater mean disability reduction in favor of MCEs was reported in the short term (SMD = −0.40; 95% CI = −0.61 to −0.19; n = 354; P < .001; Suppl. Fig. 7A), and a subgroup analysis including only knee OA trials reported no significant difference in disability reduction between the 2 groups in the short term (SMD = −0.15; 95% CI = −0.41 to 0.11; n = 359; P = .27; Suppl. Fig. 7B).

Health-Related Quality of Life Outcomes

Six RCTs assessed the efficacy of MCEs compared to strengthening exercises on health-related quality of life. Five RCTs reported results in the short term.[31–33,42,51,52] However, significant heterogeneity was present in this meta-analysis (χ^2 P < .001 and I^2 = 79%; Suppl. Fig. 8). Taken separately, the study by Apparao et al[31] reported a significant effect in favor of MCEs, whereas the 4 other RCTs reported no statistically significant differences between the 2 types of interventions.[32,33,42,51,52] In the mid-term, Gomiero et al[35] reported no significant difference between groups in their trial.

Effect of the Addition of Motor Control Exercises to a Strengthening Exercise Program

Five RCTs assessed the addition of MCEs to a strengthening exercise program.[30,34,39,40,45] In terms of pain, the addition of MCEs to a strengthening exercises program resulted in a statistically significant greater pain reduction in the short term (MD = −0.71; 95% CI = −1.26 to −0.17; n = 246; P = .01; Suppl. Fig. 9) but not in the mid-term (MD = −0.60; 95% CI = −1.35 to 0.15; n = 198; P = .12; see Suppl. Fig. 9). For disability, the addition of MCEs to a strengthening program was associated with a significant greater disability reduction in the short-term (SMD = −0.44; 95% CI = −0.74 to −0.15; n = 275; P = .003; Suppl. Fig. 10) but not in the mid-term (SMD = −0.66; 95% CI = −1.51 to 0.19; n = 229; P = .13; see Suppl. Fig. 10).

Grading of Recommendations, Assessment, Development, and Evaluations: Quality of the Evidence

Based on the GRADE approach, pain and disability-related results were found to be of moderate quality evidence in the short term and of low-quality evidence in the mid-term for primary analyses. Secondary analyses excluding OA conditions on pain and disability-related results were found to be of moderate-quality evidence while results including only OA conditions were of low quality. Health-related quality of life results were based on very low-quality evidence. Pain and disability outcomes for the addition of MCEs to strengthening exercises were found to be of very low- to moderate-quality evidence. The quality of the evidence presented was downgraded because of risk of bias in the included trials and the imprecision or inconsistency of the results (Table).

Discussion

This systematic review assessed the efficacy of MCEs compared to strengthening exercises for adults with upper- and lower-extremity MSKDs. Twenty-one RCTs were included in

Table. Summary of Findings[a]

Outcomes	Population	Main Results (95% CI) Motor Control Exercises Compared to Strengthening Exercises	No. of Participants (No. of RCTs)	Risk of Bias Score Mean, % (SD)	Certainty (GRADE)[b]	Statements
Pain VAS or NRS Short-term	MSKDs (upper and lower extremity)	Mean improvement in pain in motor control group was **0.41 points higher** (0.10 to 0.72)	626 (11 RCTs)	68% (17%)	Moderate (1)	MCEs led to greater pain reduction but treatment effect is small and not clinically important
	Excluding OA conditions[c]	Mean improvement in pain in motor control group was **0.74 points higher** (0.26 to 1.22)	293 (8 RCTs)	69% (21%)	Moderate (1)	MCEs led to greater pain reduction but treatment effect is small. Difference might be clinically important
	OA conditions (knee OA)	Mean improvement in pain in motor control group was 0.23 points higher (−0.09 to 0.56)	333 (3 RCTs)	64% (0%)	Moderate (1)	No difference between both types of exercises
Pain VAS or NRS Mid-term	MSKDs (upper and lower extremity)	Mean improvement in pain in motor control group was 0.48 points higher (−1.28 to 2.23)	139 (3 RCTs)	86% (14%)	Very low (3, 4)	Evidence suggests no difference between both types of exercises, but treatment effect is very uncertain
Disability Short-term	MSKDs (upper and lower extremity)	Mean improvement in pain in motor control group was **0.28 SMD higher** (0.13 to 0.43)	713 (13 RCTs)	67% (16%)	Moderate (1)	MCEs led to greater disability reduction but treatment effect is small and likely not clinically important
	Excluding OA conditions[c]	Mean improvement in pain in motor control group was **0.40 SMD higher** (0.19 to 0.61)	354 (9 RCTs)	67% (20%)	Moderate (1)	MCEs led to greater disability reduction and treatment effect is small to moderate. Difference might be clinically important
	OA conditions (knee and thumb OA)	Mean improvement in pain in motor control group was 0.15 SMD higher (−0.11 to 0.41)	359 (4 RCTs)	66% (4%)	Moderate (1)	No difference between both types of exercises
Disability Mid-term	MSKDs (upper and lower extremity)	Mean improvement in pain in motor control group was 0.05 SMD higher (−0.17 to 0.27)	309 (5 RCTs)	79% (14%)	Moderate (1)	No difference between both types of exercises
Health-related quality of life Short-term	MSKDs (upper and lower extremity)	Mean improvement in pain in motor control group was 0.21 SMD higher (−0.31 to 0.73)	303 (5 RCTs)	59% (14%)	Very low (1, 2, 3)	Evidence suggests no difference between both types of exercises, but treatment effect is very uncertain
		Addition of motor control to strengthening exercises				
Pain VAS or NRS Short-term	MSKDs (upper and lower extremity)	Mean improvement in pain in motor control group was **0.71 points higher** (0.17 to 1.26)	246 (3 RCTs)	48% (11%)	Moderate (1)	Addition of MCEs led to greater pain reduction. Difference might be clinically important
Pain VAS or NRS Mid-term	MSKDs (upper and lower extremity)	Mean improvement in pain in motor control group was 0.60 points higher (−0.15 to 1.35)	198 (2 RCTs)	54% (5%)	Low (1, 2)	Evidence suggests no difference with addition of MCEs
Disability Short-term	MSKDs (upper and lower extremity)	Mean improvement in pain in motor control group was **0.44 SMD higher** (0.15 to 0.74)	275 (4 RCTs)	41% (16%)	Low (1, 2)	Addition of MCEs leads to greater disability reduction and treatment effect is small to moderate. Difference might be clinically important
Disability Midterm	MSKDs (upper and lower extremity)	Mean improvement in pain in motor control group was 0.66 SMD higher (−0.19 to 1.51)	229 (3 RCTs)	55% (4%)	Very low (1, 2, 3)	Evidence suggests no difference with addition of MCEs, but treatment effect is very uncertain

[a]Statistically significant ($P < .05$) results appear in bold. Secondary analyses are in gray. MCEs = motor control exercises; MD = mean differences; MSKD = musculoskeletal disorder; NRS = numerical rating scale; OA = osteoarthritis; RCT = randomized controlled trial; VAS = visual analog scale. [b]GRADE Working Group grades of evidence are as follows. High quality: We are very confident that the true effect lies close to that of the estimate of the effect. Moderate quality: We are moderately confident in the effect estimate: The true effect is likely to be close to the estimate of the effect, but there is a possibility that it is substantially different. Low quality: Our confidence in the effect estimate is limited: The true effect may be substantially different from the estimate of the effect. Very low quality: We have very little confidence in the effect estimate: The true effect is likely to be substantially different from the estimate of effect. Explanation of parenthetical values: 1. Downgraded because of risk of bias (≥ 50% of the information is from studies at moderate or high risk of bias). 2. Downgraded because of imprecision of results. 3. Downgraded because of inconsistency of results. 4. Downgraded 2 points because of very serious imprecision. [c]Rotator cuff–related shoulder pain, shoulder instability, hip-related groin pain, and patellofemoral pain syndrome.

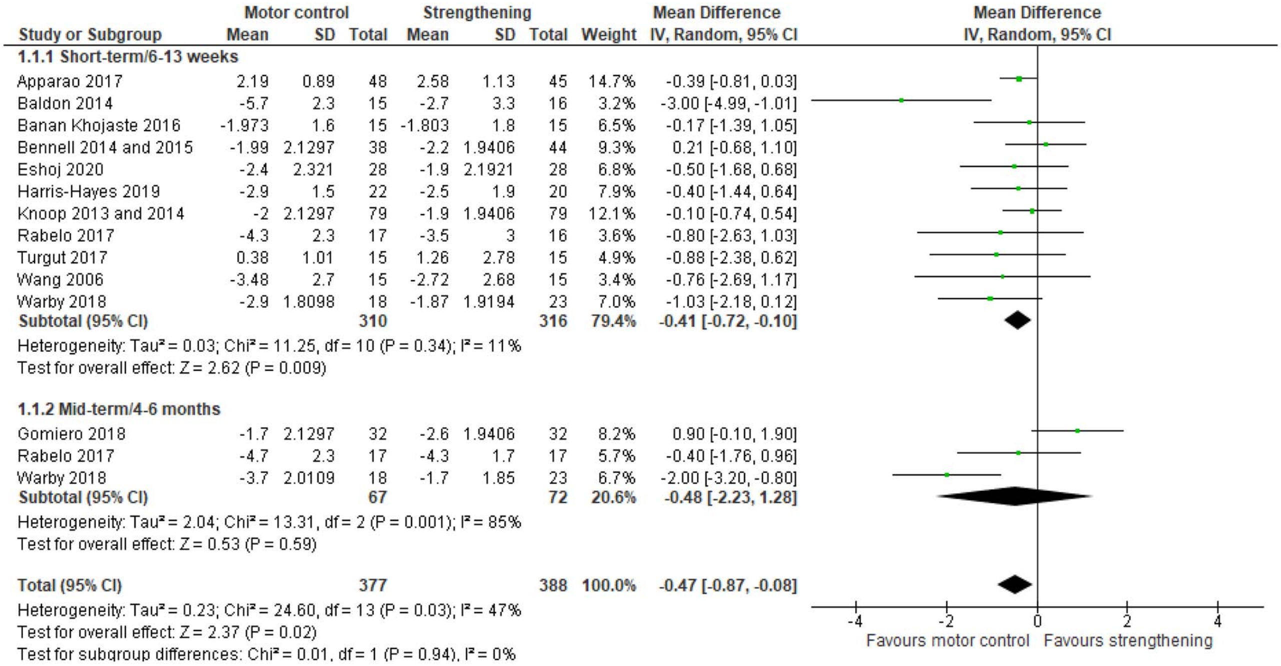

Figure 3. Efficacy of motor control exercises compared to strengthening exercises for change in pain (VAS or NRS, 0–10) in adults with upper- or lower-extremity musculoskeletal disorders. IV = inverse variance method; NRS = numerical rating scale; VAS = visual analog scale.

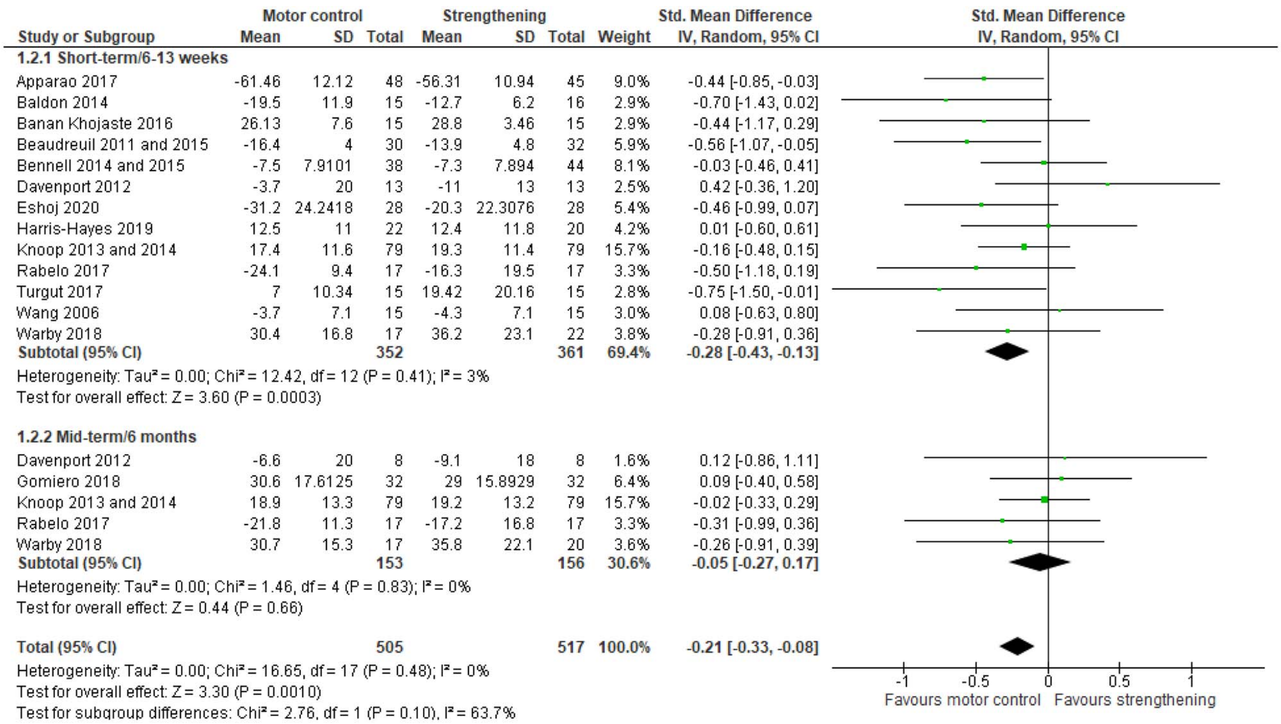

Figure 4. Efficacy of motor control exercises compared to strengthening exercises for change in self-reported disability in adults with upper- or lower-extremity musculoskeletal disorders. IV = inverse variance method; Std = standardized.

this review while 19 were pooled in different meta-analyses. Four of the included trials were considered to be at low risk of bias.

Regarding our results, there is moderate-quality evidence that MCEs led to greater disability reduction than strengthening exercises in the short-term. However, the treatment effect is small (SMD = −0.28; 95% CI = −0.43 to −0.13) and likely not clinically important.[59] Interestingly, a subgroup analysis, based on moderate-quality evidence, excluding OA trials, reported that MCEs led to greater disability reduction in the short term (SMD = −0.40; 95% CI = −0.61 to −0.19); treatment effect can be considered small to moderate and might be clinically important.[59] Subgroup analyses including only OA trials did not show any significant difference between the 2 types of intervention. In the mid-term, there is no difference between both types of exercises. Regarding pain-related outcomes, there is moderate-quality evidence that MCEs led to greater pain reduction when compared to strengthening exercises in the short term. However, treatment effect is small (MD = −0.41 out of 10 points; 95% CI = −0.72 to −0.10) and not clinically important.[55–58] Based on moderate-quality evidence, a subgroup analysis excluding OA trials reported that MCEs led to greater pain reduction (MD = −0.74 out of 10 points; 95% CI = −1.22 to −0.26). This effect might be considered clinically important because the CI of the estimate crosses the reported MCIDs (1.1–1.4) for RC disorders and PFPS.[55,57,58] Subgroup analyses including only OA trials did not show any significant difference between the 2 types of intervention. In the mid-term, very low-quality evidence suggests that there is no significant difference between the 2 interventions, but treatment effect is very uncertain. Owing to the very low quality of the evidence, the effect of MCEs compared to strengthening exercises in terms of health-related quality of life in the short term is unclear, but no significant differences were observed between the 2 types of exercises. Based on moderate-quality evidence, the addition of MCEs to a strengthening program leads to greater pain reduction in the short term and treatment effect might be clinically important.[55,57,58] Regarding disability reduction, low-quality evidence suggests that the addition of MCEs to a strengthening program leads to greater disability reduction in the short-term, and treatment effect might also be clinically important.[59]

An important point to consider in our interpretation of these results is that we mostly used published MCIDs to classify treatment effects as clinically important or not. However, some authors have criticized distribution-based and anchor-based methods to estimate clinically important between-group-differences.[60,61] Smallest worthwhile effects estimated using the benefit-harm trade-off method have been suggested to be a better indicator to compare 2 different interventions already established as effective.[60,62,63] Smallest worthwhile effects should be elicited from the patient's perspective and should take into consideration the effect, costs, risk, and associated inconvenience of the intervention.[60,62–65] The estimated smallest worthwhile effects of MCEs compared to strengthening exercises is unknown, but since the costs, risks, and inconvenience of both interventions are comparable, it may be argued that the smallest worthwhile effects specific to our results could be even smaller than previously published MCIDs.

Clinical Implications

Our results suggest differential effects of MCEs depending on the types of MSKDs. Larger pain and disability reductions were observed for non-OA conditions such as RC-related shoulder pain, shoulder instability, and PFPS when compared to OA conditions such as knee OA. A potential explanation is that OA is mainly an articular disorder affecting joint metabolic activity[66] and that specific muscular activation and movement control may play a smaller role or do not provide greater benefit than more general strengthening exercise. A recent Cochrane review on exercise for knee OA reported that exercises are efficient to reduce pain and disability, but meta-analyses could not demonstrate significant differences between different types of exercises.[67] Older age and longer symptom duration associated with OA conditions may also partly explain the lower treatment effect of MCEs on OA conditions. One other explanation for the potential superiority of MCEs over strengthening exercises is that MCE programs may involve a more progressive approach with initial lower loads exercises when compared to strengthening focused programs and could therefore partly explain the small observed effect in the short term. Based on our results, MCEs probably confer a small beneficial effect of uncertain clinical relevance in the short term when compared to strengthening exercises for conditions such as RC-related shoulder pain, shoulder instability, hip-related groin pain, or PFPS. Therefore, our results suggest that MCE might be prioritized over strengthening exercises for adults with these MSKDs. However, it is still unclear which interventions should be prioritized for OA conditions. Commonalities among MCEs and strengthening exercises could also explain the overall, small observed differences; however, mechanisms behind these effects remain unclear and may involve complex peripheral and central nervous as well as immune system changes.[68,69] Additionally, it is possible that the timing within the rehabilitation process influence the effect of exercises. For example, MCEs might be more beneficial in the short term as observed in our review, while more emphasis on strengthening may or may not be more beneficial in the later stages of rehabilitation. The clinical presentation and specific findings when functionally evaluating patients, the patient's preferences, and likely compliance with the different approaches may also have be taken into consideration and could also influence outcomes, and these factors were not systematically taken into account in the included trials.

Globally, our results have commonality with previously published meta-analyses on MCEs compared to strengthening exercises for MSKDs.[19,22] It is important to highlight that the meta-analysis published by Shire et al[19] focused only on RC-related shoulder pain and therefore did not include RCTs on instability,[50,51] and a more recent publication by Turgut et al[48] was included in our meta-analyses. Even if they did not report statistically significant differences, trends in favor of MCEs both for pain reduction (SMD = −0.19; 95% CI = −0.61 to 0.22; n = 132) and disability reduction (SMD = −0.30; 95% CI = −0.76 to 0.16; n = 193) were observed in their meta-analyses. Likewise, the Cochrane review on chronic LBP reported statistically significant differences in favor of MCEs for pain and disability reduction in the short and mid-term.[22] However, none of these differences reached their respective MCIDs. The other Cochrane review on acute LBP was based on low-quality evidence and did not report any statistically significant differences between these 2 exercise approaches.[23]

Strengths and Limitations

Strengths of this review include the use of 4 important bibliographical databases, a comprehensive search strategy, the use of the validated Cochrane risk-of-bias tool, and the use of the GRADE approach to rate the strength and certainty of the evidence. Several limitations, however, need to be highlighted in the interpretation of our results. Because our review includes only 3 RCTs comparing MCEs to strengthening with a low risk of bias (none on OA), performing a secondary analysis including only RCTs with a low risk of bias was not pertinent. The lack of standardization in the pain visual analog scale/numerical rating scale questions is also a limitation of the included literature and may have led to a lack of responsiveness of these outcomes. It is also important to state that our review includes trials with participants diagnosed with RC-related shoulder pain, shoulder instability, hip-related groin pain, PFPS, knee OA, and thumb OA. Therefore, conclusions of our review may not be applicable to other upper- and lower-limb MSKDs. Another important aspect of our present results is that all MCE approaches were analyzed together, although different MCE approaches might differ in overall effectiveness. This also applies to strengthening-exercise approaches that were analyzed together. Owing to the nature of the interventions, treatment providers could not be blinded and only a few trials achieved blinding or had naive participants. This could have affected the observed results. The absence of other objective outcomes such as performance-based outcomes may also be a limitation in our review and results for these outcomes could have been different; still, the included visual analog scale/numerical rating scale pain and disability questionnaires are considered valid outcome measures to assess the efficacy of rehabilitation interventions for MSKDs. The lack of long-term follow-up from the included trials limits our conclusions with respect to short and mid-term follow-up only.

Conclusions

Based on moderate-quality evidence, MCEs lead to statistically greater pain and disability reductions when compared to strengthening exercises among adults with upper- or lower-extremity MSKDs in the short term, but these differences are small and likely not clinically important. Our results suggest a differential effect of MCE depending on the types of MSKDs. More precisely, moderate-quality evidence reports that MCEs provide greater reduction in pain and disability in non-OA conditions (RC-related shoulder pain, shoulder instability, and PFPS) but not for OA conditions such as knee OA in the short term. For non-OA conditions, treatment effect of MCEs on pain and disability reductions might be clinically important. In the mid-term, our results suggest that treatment effect of MCE and strengthening exercises on pain and disability reduction are not significantly different. The addition of new trials to these analyses could change our present conclusion.

Author Contributions

Concept/idea/research design: S. Lafrance, P. Ouellet, J.S. Roy, J. Lewis, D. Høyrup Christiansen, B. Dubois, P. Langevin, F. Desmeules
Writing: S. Lafrance, F. Desmeules
Data collection: S. Lafrance, P. Ouellet, R. Alaoui
Data analysis: S. Lafrance, P. Ouellet, R. Alaoui, F. Desmeules
Project management: S. Lafrance, F. Desmeules
Fund procurement: F. Desmeules
Providing facilities/equipment: F. Desmeules
Providing institution liaisons: F. Desmeules
Clerical/secretarial support: S. Lafrance
Consultation (including review of manuscript before submitting): J.S. Roy, J. Lewis, D. Høyrup Christansen, B. Dubois, P. Langevin

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Systematic Review Registration

This review protocol is registered in PROSPERO at https://www.crd.york.ac.uk/prospero/ (CRD42019144967).

Disclosures

The authors completed the ICMJE Form for Disclosure of Potential Conflicts of Interest and reported no conflicts of interest.

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