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Review

Osteoarthritis Year in Review 2014: rehabilitation and outcomes

M.R. Maly † *, S.M. Robbins ‡

† *School of Rehabilitation Science, McMaster University, Canada*
‡ *Centre for Interdisciplinary Research in Rehabilitation, Constance Lethbridge Rehabilitation Centre, School of Physical and Occupational Therapy, McGill University, Canada*

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SUMMARY

Objective: To highlight research studies examining rehabilitation for hip and knee osteoarthritis (OA), as well as the outcome measures used to assess treatment efficacy, published in 2013.
Design: A systematic search was performed in Medline, CIHAHL and Embase databases from January to December 2013. The search was limited to 2013, human studies, and English. Rehabilitation intervention studies included were prospective controlled designs. The Grading of Recommendations Assessment, Development and Evaluation (GRADE) system was used to evaluate the quality of evidence. First, individual articles were rated for quality. Second, articles were grouped based on outcome: OA disease markers, pain, physical function (self-reported, performance), and health.
Results: Of 503 titles reviewed, 36 studies were included. The outcome measures related to OA disease markers were organized into subthemes of anthropometrics, biomechanics and physiology. The quality of evidence was of moderate, high, and low quality for anthropometric, biomechanical and physiological measures respectively. These studies supported the use of diet for weight loss combined with exercise. Bodies of evidence that showed the efficacy of exercise and passive strategies (thermal/electrical modalities, traction, manual therapy) for reducing pain were of low and moderate quality respectively. The evidence supporting diet and exercise, physiotherapy, and passive strategies to improve physical function was of moderate quality. Evidence supporting exercise to improve psychological factors was of moderate quality.
Conclusions: Exercise combined with diet for weight loss should be the mainstays of rehabilitation for people with knee and hip OA to provide benefit to OA disease markers, pain, physical function, and health.

Introduction

There is no cure for knee or hip osteoarthritis (OA). The current gold standard treatment is joint replacement. However a tremendous need exists for non-surgical interventions to improve physical functioning and quality of life. Canadians with OA wait, on average, 4.4 years from diagnosis to joint replacement[1]. Unfortunately groups with the greatest need, specifically women and those of low socioeconomic status, experience even longer waits[1]. Most concerning, the demand for hip and knee replacements continues to rise in Canada as a result of our ageing and increasingly obese population[2]. This escalating demand for hip and knee arthroplasty is mirrored in other Westernized countries, including Australia, the United Kingdom, and the United States[3–5]. Given that finite surgical resources are available, advancing conservative management is critical. Further, it is important to track the efficacy of conservative interventions using reliable and valid outcome measures. To this end, *Osteoarthritis and Cartilage* publishes a "Year in Review" focused on rehabilitation outcomes[6,7,8,9]. The purpose of this current year in review was to highlight research studies examining rehabilitation for hip and knee OA, as well as the outcome measures used to assess treatment efficacy, published in 2013. For the purpose of this review, rehabilitation techniques included all conservative strategies that aimed to enhance and restore physical ability and quality of life, therefore advancing OA treatment.

Method

A systematic literature search was performed in Medline, CIHAHL and Embase databases from January, 2013 to December, 2013 inclusive. A single year was selected to enable quality ratings

* Address correspondence and reprint requests to: M.R. Maly, School of Rehabilitation Science, McMaster University, Room 435, Institutes of Applied Health Sciences, 1400 Main Street West, Hamilton, Ontario L8S 1C7, Canada. Tel: 1-905-525-9140x27823; Fax: 1-905-524-0069.
E-mail addresses: mmaly@mcmaster.ca (M.R. Maly), shawn.robbins@mcgill.ca (S.M. Robbins).

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of articles by both authors. Some overlap exists with a previous "year in review"[6]. Key words included osteoarthritis, knee; osteoarthritis, hip; rehabilitation; physical therapy modalities; physical therapy; physiotherapy; and exercise. The search was limited to 2013, human studies, and English. Rehabilitation intervention studies included were prospective controlled designs, including both randomized and non-randomized designs, and studies that enrolled participants with a diagnosis of knee or hip OA. Uncontrolled, qualitative, and retrospective studies, protocols, as well as reviews, meta-analyses, and case studies were excluded. Abstracts without a full article and papers that replicated data from another article were excluded. Studies of outcomes after surgery (e.g., examining rehabilitation protocol following joint replacement), oral or injectable medications, and neutraceuticals were excluded. Publication titles and abstracts were reviewed for inclusion by both authors. Discrepancies for inclusion were discussed and full papers reviewed to reach agreement on inclusion.

Grading of Recommendations Assessment, Development and Evaluation (GRADE) was used to rate the quality of evidence[10]. This system separates decisions about quality of evidence from strength of recommendations. In GRADE, strength of recommendations reflects the extent to which desirable treatment effects, such as improvements in pain, mobility and quality of life, outweigh undesirable effects, such as muscle soreness after exercise[11]. Because this review focused on 1 year of published work, strength of recommendations was not pursued. Instead, emphasis was placed on rating the quality of evidence.

GRADE rates the quality of a body of evidence as high, moderate, low, and very low. First, a quality rating for each research article was assigned. Preliminary ratings were based on study design. Evidence gleaned from randomized controlled trials (RCT) was initially rated as high; other designs as low. Next, GRADE relies on explicit criteria for downgrading or upgrading quality ratings[10]. Ratings were downgraded based on the following criteria: study limitations (e.g., lack of blinding, large loss to follow-up), inconsistency of results (e.g., inadequate explanation for heterogeneity), indirectness (e.g., indirect comparison), imprecision (e.g., small sample size), and reporting bias (e.g., failure to report outcomes showing no effect)[12]. Ratings were downgraded by one quality category for each criterion identified. On the other hand, a large magnitude of effect or a dose–response relationship upgraded the quality rating. The authors reached consensus on quality of evidence ratings for each article.

Second, articles were grouped by outcomes of interest. This approach enabled quality ratings of a body of evidence for a desired outcome. We determined outcome measure groupings of OA disease markers; pain; physical function; and general health. Considering the consistency of findings between articles, size of the treatment effect, study limitations, precision, and probability of publication bias among all of the studies reporting on an outcome measure of interest, a quality level was reached through consensus.

Results and discussion

Of 503 titles reviewed, 36 studies were included. Articles were excluded when reviewing abstracts due to the following criteria: design ($n = 234$), intervention ($n = 116$), diagnosis other than knee or hip OA ($n = 95$), humans ($n = 4$), abstract only ($n = 3$), duplicate study ($n = 1$), and data replicated from another study ($n = 1$). When reviewing full article text, additional articles were excluded due to the following criteria: design ($n = 3$), intervention ($n = 1$), abstract only ($n = 8$), and data replicated from another study ($n = 1$).

Of these 36 papers included in this review, only two papers were dedicated to hip OA. Five studies included participants with both knee and hip OA and 29 studies included only knee OA. Individual articles were of high ($n = 2$), moderate ($n = 14$), low ($n = 10$) and very low ($n = 10$) quality (Table I). Descriptions of studies in the following sections emphasize articles of high and moderate quality.

Papers were grouped based on outcome measures: OA disease markers, pain, physical function (self-reported, mobility performance), and other aspects of health (Table II). Interventions included exercise (strengthening, walking, yoga, gaming), physical agents and electrotherapy (ultrasound, phonophoresis, short wave diathermy, transcutaneous electrical nerve stimulation, neuromuscular electrical stimulation), manual therapy (mobilizations, traction), Chinese medicine (acupuncture, meridians) and other (pain coping, counselling, whole body vibration).

In this review, we utilize the same terms presented in the articles to describe interventions. In general, "exercise" reflected planned, structured physical activities aimed at improving health and well-being, such as aerobic, strengthening, balance, or other exercise modalities. Strengthening, strength training, and resistance exercise were considered synonyms. "Physical activity" reflected less structured activities intended to be integrated into daily life. "Physiotherapy" and "physical therapy" referred to any intervention or intervention series prescribed by a physiotherapist. Therefore, physiotherapy could include a number of interventions including exercise, physical agents and electrotherapy, manual therapy, and where permitted by jurisdiction, Chinese medicine. It is important to note that within each type of intervention, the specific parameters utilized by researchers varied substantially. In some cases, the descriptions of interventions are very scant. We contend that outcomes vary based on the type of intervention, and parameters utilized within each intervention. Thus, readers are encouraged to consult the original articles to enhance understanding of the actual interventions provided to study participants.

Disease markers of OA

Outcome measures that captured disease markers of OA were grouped into subthemes of anthropometrics, biomechanics, and physiology.

Anthropometrics

Because of the impact of obesity on the pathology and incidence of knee and hip OA through pathways of inflammation, joint loads, and movement strategies, anthropometric measures such as body size are one of the most important disease markers to target in rehabilitation for OA[13]. Three studies reported on anthropometrics in 855 participants with knee OA. Measures included body mass, body mass index, and waist circumference using traditional methods. Fat mass and lean mass were measured using dual X-ray absorptiometry. As a body of evidence, the papers provided moderate quality, consistent evidence that diet for weight loss and exercise were effective in reducing abnormal anthropometrics, such as body mass and fat mass, in people with knee OA.

Interventions for anthropometric outcome measures: diet and exercise. While diet for weight loss, exercise, and the combination of diet and exercise all improved body composition, dieting for weight loss was more effective than exercise alone in reducing body mass, waist circumference, and fat mass[14,15]. For example, a RCT ($n = 192$, knee OA) compared diet, exercise, and no intervention during a 12 month maintenance period subsequent to an intensive 4 month diet[14]. In the diet group, maintenance of weight loss was achieved through weekly meetings with a dietician and the provision of formula with the necessary macronutrients, vitamins and minerals. In the exercise group, circuit training, with a warm-up and cool-down period, lasted 1 h. The frequency of exercise each week was not reported. Adherence to these maintenance interventions was

Table I
GRADE was used to rate the quality of evidence. Quality ratings were categorized as high, moderate, low or very low for each study of rehabilitation strategies for knee or hip OA published in 2013. Randomized controlled trials were initially provided a quality rating of high. Elements of study design, directness of evidence, explanation of heterogeneity, imprecision, and probability of publication bias resulted in a downgraded quality rating. Evidence of dose–response gradients resulted in an upgraded quality rating

Primary author	Joint	n	Design	Downgrade quality					Upgrade quality	Quality rating
				Design limitation(s)	Indirectness	Explanation of heterogeneity	Imprecision	Probability of publication bias		
Abbott[37]	Hip & Knee	206	RCT	Participants not blinded	No	No	No	Low	None	MODERATE
Alpayci[29]	Knee	98	RCT	Participants not blinded	No	No	No	Low	None	MODERATE
Ay[40]	Knee	60	RCT	Participants not blinded Assessor not blinded	No head to head comparison	No	No	Low	None	LOW
Barrios[17]	Knee	38	RCT	Assessor not blinded	No	No	No	Low	None	MODERATE
Bossen[39]	Hip & Knee	199	RCT	Participants not blinded Assessor not blinded	No	No	No	Low	None	MODERATE
Boyaci[32]	Knee	101	RCT	Participants not blinded Assessor not blinded	No	No	Two week follow up	Low	None	LOW
Chen, L[36]	Knee	214	RCT	None	Acupuncturists with extensive training	No	Large loss to follow up	Unlikely	None	MODERATE
Chen, W[30]	Knee	50	RCT	Participants not blinded Assessor not blinded	No	No	No	Low	None	MODERATE
Christensen[14]	Knee	192	RCT	Adherence poor	Intense diet intervention	No	No	Low	None	MODERATE
Daskapan[23]	Knee	40	RCT	Adherence unclear	No head to head comparison	No	Several comparisons	Low	None	LOW
Elboim-Gabyzon[26]	Knee	63	RCT	Participants not blinded Assessor not blinded	No	No	Large loss to follow up	Low	None	VERY LOW
French[38]	Hip	131	RCT (modified cross-over)	Participants not blinded	No	No	Unlikely	Low	None	MODERATE
Ghasemi[22]	Knee	30	Controlled trial	No randomization Participants not blinded Assessor not blinded	No head to head comparison	No	Large loss to follow up	Low	None	VERY LOW
Horng[44]	Knee	28	RCT	Participants not blinded Assessor not blinded	No head to head comparison	No	Three week follow up Large loss to follow up	Low	None	VERY LOW
Hunt[16]	Knee	17	RCT (pilot)	Participants not blinded	No	No	Few participants	Unlikely	None	LOW
Hunt[27]	Knee	20	RCT (pilot)	None	No	No	Few participants	Low	None	MODERATE
Imoto[24]	Knee	100	RCT	Participants not blinded	No	No	No	Low	None	MODERATE
Imoto[25]	Knee	100	RCT	Participants not blinded	No	No	No	Low	None	MODERATE
Katz[35]	Knee	351	RCT	Participants not blinded Assessor not blinded Large cross-over	No	No	No	Low	None	MODERATE
Knoop[20]	Knee	159	RCT	Participants not blinded	No	No	No	Low	None	MODERATE
Kudo[45]	Knee	209	RCT	Participants not blinded Assessor not blinded Adherence unclear	No head to head comparison	No	No	Low	None	VERY LOW
Kumar[21]	Knee	44	RCT	Participants not blinded	Proprioceptive program unclear	No	No	Low	None	LOW
Larose[41]	Knee	115	RCT	Participants not blinded Subgroup analysis of larger study	No	No	Large loss to follow up; Few participants in each category	Low	None	LOW
Luksurapan[31]	Knee	46	RCT	None	No	No	Two week follow up	Low	None	HIGH
Malas[18]	Knee	61	RCT	Participants not blinded	No head to head comparison	No	Three week follow up	Low	None	LOW
Mattiello-Sverzut[19]	Knee	18 26 21	RCT	Different groups explored for each measure	No	No	Few participants in each category	Low	None	LOW
Messier[15]	Knee	454	RCT	Participants not blinded	No	No	No	Low	Dose–response	HIGH
Nambi[46]	Knee	30	Controlled trial	No randomization Participants not blinded Assessor not blinded	No	No	No	Low	None	VERY LOW
O'Brien[42]	Hip & Knee	27	RCT (Pilot)	Participants not blinded	No	No	Few participants Large loss to follow up	Low	None	VERY LOW

Park[28]	Knee	36	RCT	Participants not blinded Assessor not blinded	No	No	Large loss to follow up	Low	None	VERY LOW
Parsons[47]	Hip & Knee	336	RCT	Participants not blinded Assessor not blinded	No	No	Large loss to follow up	Low	None	LOW
Poulsen[33]	Hip	118	RCT (proof of principle)	Participants not blinded	No	No	No	Low	None	MODERATE
Saleki[48]	Knee	40	RCT	Participants not blinded Assessor not blinded	No head to head comparison	Yes	No	Low	None	VERY LOW
Schencking[49]	Hip & Knee	30	RCT (Pilot)	Participants not blinded Assessor not blinded	No head to head comparison	No	No	Low	None	VERY LOW
Wi[43]	Knee	40	RCT	Participants not blinded Assessor not blinded	Benefits of exercise program unclear	No	No	Low	None	LOW
Zhang[50]	Knee	100	Controlled trial	No randomization Participants not blinded Assessor not blinded	No head to head comparison	No	No	Low	None	VERY LOW

A sample smaller than 30 participants was identified as a limitation.
Retention rates below 85% were noted as a limitation.
Follow up periods shorter than 4 weeks were identified as a limitation.
Statistical approaches that do not compare the study arms directly were noted as a limitation.

low: 59.1% in diet and 22% in exercise. Reductions in body mass, waist circumference, and fat mass assessed with dual energy X-ray absorptiometry were greater in the diet groups than exercise group ($P < 0.01$). A similar high quality study comparing diet for weight loss, exercise, and a combination of diet and exercise (Intensive Diet and Exercise for Arthritis (IDEA) trial) showed that the diet and diet combined with exercise groups lost more body mass and fat mass than the group engaged in exercise alone[15]. However, the total energy deficit induced by diet and exercise may not have been equivalent between groups. Further, interventions designed to reduce body mass may also cause a loss of lean mass[14,15]. During the 52 week maintenance period after an intense diet intervention, loss of lean mass was equivalent between diet, exercise and control groups[14]. In the larger RCT, the diet and exercise group combined with diet alone groups lost more lean mass than the exercise group ($P < 0.01$); but the percentage of lean mass at 18 months was no different between the three groups[15].

Biomechanics

Three studies reported on biomechanical outcomes in 509 participants with knee OA. Investigators evaluated the efficacy of interventions to reduce joint compressive forces and the knee adduction moment. This moment is a surrogate for the distribution of loads across the medial and lateral knee. Together these studies provided high quality evidence that diet for weight loss combined with exercise is effective in reducing compressive knee loads.

Interventions for biomechanics outcome measures: diet and exercise. A high quality study, IDEA trial, investigated the impact of 18 months of dieting for weight loss, dieting and exercise, or exercise alone on joint compressive forces in men and women with radiographic knee OA[15]. The diet intervention provided an initial energy-intake deficit of 800–1000 kcal/day to promote weight loss. Each exercise session involved aerobic walking (15 min), strengthening training (20 min), aerobic activity (15 min) and a cool-down, 3 days per week. Of the 454 that enrolled, 399 (88%) completed follow-up assessments at 18 months. Compared to groups that received just exercise, those who engaged in the diet program demonstrated reductions in joint compressive forces (95% CI, 55–345 N; $P = 0.007$). Participants with large (−32.5–10.0%), medium (−9.8–5.0%) and small (−4.9–9.9%) changes in body mass had knee compressive forces of 2402 N (95% CI 2397, 2568 N), 2708 N (2616, 2799 N) and 2842 N (2772, 2911 N) respectively. This dose–response relationship ($P < 0.001$) elevated the quality rating of this paper[15].

The knee adduction moment does not appear to be easily modified by exercise. In a pilot RCT, 17 participants with radiographic medial knee OA were randomly allocated to receive a home program of strengthening exercise for the quadriceps, hamstrings and hip abductors, for 10 weeks, or no intervention[16]. The knee adduction moment peak and impulse were no different after strengthening[16].

Intervention for biomechanical outcome measures: shoe orthoses. From 2013 data, the role of shoe orthoses in modifying the knee adduction moment was unclear. Thirty-eight participants with radiographic, symptomatic knee OA were randomly allocated to receive a lateral shoe orthoses, or a neutral (control) orthosis, for wear over 12 months[17]. In the treatment group, the magnitude of lateral wedging was individualized to achieve maximum pain relief. A nearly significant group by time interaction ($P = 0.052$) showed a reduction in the knee adduction moment with lateral shoe orthoses over 12 months[17]. However the small sample and lack of data on compliance are important limitations to consider.

Table II
Findings of 36 studies investigating rehabilitation interventions for knee and hip OA published in 2013, organized by outcome measure. Broad categories of outcome measures included OA disease markers, pain, physical function, and health. *P*-values are included in *italics*. N/A indicates a *P*-value was not available in the source article

Outcome	Sub-outcome	First author Design Sample Quality rating	Sample size (retention)	Number of study arms: interventions for each arm	Follow-up period (weeks)	Results		Primary or secondary outcome measure
						Study arm(s) resulting in improvement after intervention	Differences between study arms in treatment effects	
OA disease markers								
Anthropometrics								
Tissue composition								
	Fat mass							
		Christensen[14] RCT Knee OA MODERATE	$n = 192$ (91%)	3: Diet/exercise/control	16, 68	Diet/exercise/control (all groups *P = 0.001*)	Loss of fat mass greater in diet group than exercise group (*P < 0.001*) or control group (*P = 0.009*)	Primary
		Messier[15] RCT Knee OA HIGH	$n = 454$ (88%)	3: Diet + exercise/diet/ exercise	26, 78	Diet + Exercise/Diet (*P-values N/A*)	Diet and diet + exercise groups lost more fat mass than exercise group (*P < 0.001*)	Secondary
	Lean mass							
		Christensen[14] RCT Knee OA MODERATE	$n = 192$ (91%)	3: Diet/exercise/control	16, 68	Diet/exercise/control (*P-values N/A*)	Change in lean mass not different between groups (*P = 0.660*)	Primary
		Messier[15] RCT Knee OA HIGH	$n = 454$ (88%)	3: Diet + exercise/diet/ exercise	26, 78	Diet + exercise/diet (*P-values N/A*)	Diet and diet + exercise groups lost more lean mass than exercise group (*P < 0.001*), but percentage of lean mass at 18 months did not differ among groups (*P-value N/A*)	Secondary
	Bone marrow lesion							
		Kudo[45] RCT Knee OA (women) VERY LOW	$n = 209$ (97%)	2: Group exercise/home exercise	12	Not reported	No head to head comparison of treatment effect of group vs home exercise presented (*P-value N/A*)	Secondary
Basic measurements								
	Waist circumference							
		Christensen[14] RCT Knee OA MODERATE	$n = 192$ (91%)	3: Diet/exercise/control	16, 68	Diet/exercise/control (*all groups P = 0.007*)	Reduction in waist circumference greater in diet group than exercise group (*P = 0.002*). No difference between the diet group and the control group (*P = 0.220*).	Primary
	Body mass							
		Christensen[14] RCT Knee OA MODERATE	$n = 192$ (91%)	3: Diet/exercise/control	16, 68	Diet/exercise/control (*all groups P = 0.002*)	Loss of body mass greater in diet group than exercise group (*P < 0.001*) and the control group (*P = 0.039*)	Primary

	Messier[15] RCT Knee OA HIGH	$n = 454$ (88%)	3: Diet + exercise/diet/exercise	26, 78	Diet + exercise/diet/exercise (*P-values N/A*)	Diet and diet + exercise groups lost more body mass than exercise group ($P < 0.001$)	Secondary
Alignment							
	Kudo[45] RCTv Knee OA (women) VERY LOW	$n = 209$ (97%)	2: Group exercise/home exercise	12	Not reported	No head to head comparison of treatment effect of group vs home exercise presented (*P-value N/A*)	Secondary
Biomechanics							
Internal forces							
Joint compression							
	Messier[15] RCT Knee OA HIGH	$n = 454$ (88%)	3: Diet + exercise/diet/exercise	26, 78	Diet + exercise/diet/exercise (*P-values N/A*)	Reduction in compressive forces greater in diet group compared to exercise group ($P = 0.007$); other head-to-head comparisons not significant ($P > 0.05$)	Primary
Kinematics							
Knee adduction angle excursion							
	Barrios[17] RCT Knee OA MODERATE	$n = 38$ (100%)	2: Lateral wedge orthosis/neutral orthosis	52	No improvement (*P-value N/A*)	Knee adduction angle excursion group × time interaction ($P = 0.003$); increased angle excursion in control group ($P = 0.001$)	Secondary
Kinetics							
Knee adduction moment peak							
	Barrios[17] RCT Knee OA MODERATE	$n = 38$ (100%)	2: Lateral wedge orthosis/neutral orthosis	52	Lateral wedge orthosis ($P < 0.001$)	Knee adduction moment peak group × time interaction ($P = 0.052$); decreased knee adduction moment peak in treatment group ($P = 0.039$)	Primary
	Hunt[16] RCT (pilot) Knee OA LOW	$n = 17$ (88%)	2: Strengthening/control	10	Strengthening/control (*P-values N/A*)	Knee adduction moment peak not different between groups after intervention ($P = 0.910$)	Secondary
Knee adduction angular impulse							
	Barrios[17] RCT Knee OA MODERATE	$n = 38$ (100%)	2: Lateral wedge orthosis/neutral orthosis	52	Lateral wedge orthosis ($P = 0.009$)	Knee adduction angular impulse group × time interaction not significant (*P-value N/A*)	Primary

(*continued on next page*)

Table II (*continued*)

Outcome	Sub-outcome	First author Design Sample Quality rating	Sample size (retention)	Number of study arms: interventions for each arm	Follow-up period (weeks)	Results		Primary or secondary outcome measure
						Study arm(s) resulting in improvement after intervention	Differences between study arms in treatment effects	
		Hunt[16] RCT (pilot) Knee OA LOW	$n = 17$ (88%)	2: Strengthening/control	10	Strengthening/control (*P-values N/A*)	Knee adduction angular impulse not different between groups after intervention ($P = 0.720$)	Secondary
Physiology								
Cartilage turnover								
	sCPII	Hunt[16] RCT (pilot) Knee OA LOW	$n = 17$ (88%)	2: Strengthening/control	10	Strengthening (*P-values N/A*)	sCPII changes not different between exercise and control groups ($P = 270$)	Primary
	sHA	Hunt[16] RCT (pilot) Knee OA LOW	$n = 17$ (88%)	2: Strengthening/control	10	Strengthening (*P-values N/A*)	sHA changes not different between exercise and control groups ($P = 0.100$)	Primary
	sCOMP	Hunt[16] RCT (pilot) Knee OA LOW	$n = 17$ (88%)	2: Strengthening/control	10	Strengthening (*P-values N/A*)	sCOMP reduction greater in exercise group compared to control group ($P = 0.04$)	Primary
	uCTXII	Hunt[16] RCT (pilot) Knee OA LOW	$n = 17$ (88%)	2: Strengthening/control	10	Strengthening (*P-values N/A*)	uCTXII changes not different between exercise and control groups ($P = 0.110$)	Primary
	uC2C	Hunt[16] RCT (pilot) Knee OA LOW	$n = 17$ (88%)	2: Strengthening/control	10	Strengthening (*P-values N/A*)	uC2C changes not different between exercise and control groups ($P = 0.730$)	Primary
	MMP3	Zhang[50] Controlled study Knee OA VERY LOW	$n = 100$ (100%)	2: Exercise + diclofenacsodium/ diclofenac sodium	4	Exercise + diclofenac sodium/diclofenac Sodium (*P-values N/A*)	MMP3 lower in exercise group than control group at follow up ($P < 0.05$)	Primary
Inflammation								
	IL-6	Messier[15] RCT Knee OA HIGH	$n = 454$ (88%)	3: Diet + exercise/diet/ exercise	26, 78	Diet + exercise ($P = 0.008$)/exercise (*P-values N/A*)	IL6 demonstrated greater improvement in diet group ($P = 0.006$) and diet + exercise group ($P = 0.007$) compared to exercise group	Primary
	TNF-α	Zhang[50] Controlled study Knee OA VERY LOW	$n = 100$ (100%)	2: Exercise + diclofenac sodium/Diclofenac sodium	4	Exercise + diclofenac sodium/diclofenac sodium (*P-values N/A*)	TNF-α lower in exercise group than control group at follow up ($P < 0.05$)	Primary
	hsCRP	Zhang[50] Controlled study Knee OA VERY LOW	$n = 100$ (100%)	2: Exercise + diclofenac sodium/diclofenac sodium	4	Exercise + diclofenac sodium/diclofenac sodium (*P-values N/A*)	hsCRP lower in exercise group than control group at follow up ($P < 0.05$)	Primary
	RAGE	Mattiello-Sverzut[19] RCT Knee OA LOW	$n = 21$ (unclear)	3: Resistance training/ resistance training + ibuprofen/ resistance training + glucosamine	12	Resistance training ($P < 0.05$); other improvements insignificant (*P-values N/A*)	RAGE marker number reduced in glucosamine group compared to placebo and ibuprofen groups ($P < 0.05$)	Primary

Other							
	Capillaries expression	Mattiello-Sverzut[19] RCT Knee OA LOW	$n = 26$ (unclear)	3: Resistance training/ resistance training + ibuprofen/ resistance training + glucosamine	12	No improvement (*P-value N/A*)	Not different between groups (*P-value N/A*)	Primary
	Collagen	Mattiello-Sverzut[19] RCT Knee OA LOW	$n = 26$ (unclear)	3: Resistance training/ resistance training + ibuprofen/ resistance training + glucosamine	12	Not reported	Increased immunoreactivity to collage type IV after training not different between groups (*P-value N/A*)	Primary
	Muscle Architecture	Malas[18] RCT Knee OA LOW	$n = 61$ (92%)	6: Isometric right/isometric left/isotonic right/isotonic left/isokinetic right/ isokinetic left	3	Isometric (muscle thickness and fascicle length $P < 0.01$)/ Isotonic (muscle thickness $P < 0.05$)/ Isokinetic (muscle thickness $P < 0.05$) all in the strengthened leg	No head to head comparison of treatment effect of isometric, isotonic, isokinetic exercise presented (*P-value N/A*)	Secondary
Pain								
WOMAC								
	Pain only							
		Horng[44] RCT Knee OA VERY LOW	$n = 28$ (89%)	2: Collateral meridian therapy with electrical stimulation (manipulate a non-painful meridian)/ placebo	1, 2, 3, 12	CMT/placebo (*P-values N/A*)	CMT group had significantly lower WOMAC scores than the placebo group at 2 weeks ($P = 0.04$) and 3 weeks ($P = 0.03$) follow-up, but not at baseline ($P = 0.660$), 1 week ($P = 0.260$), or 12 weeks ($P = 0.500$).	Primary
		Luksurapan[31] RCT Knee OA HIGH	$n = 46$ (100%)	2: Phonophoresis of piroxicam/ultrasound	2	Phonophoresis of piroxicam/ultrasound (*both groups* $P < 0.001$)	Improvement in WOMAC pain scores greater in phonophoresis group compared to ultrasound group ($P = 0.006$)	Primary
Numeric rating scale								
		Bossen[39] RCT Hip or knee OA MODERATE	$n = 199$ (85% 3 months; 75% 12 months)	2: Web-based physical activity intervention/ waiting list control	12, 52	Web-based Physical activity intervention/ waiting list control (*P-values N/A*)	Pain NRS improved in the intervention group compared to control group at 12 weeks ($P = 0.002$) but not at 52 weeks ($P = 0.330$)	Secondary
		Hunt[27] RCT Knee OA MODERATE	$n = 20$ (95%)	2: Exercise + pain coping skills training/exercise	10	Exercise + pain coping skills training/ exercise + non-directive counselling (*both groups* $P < 0.05$)	Improvement in pain NRS not different between groups at follow up ($P = 0.910$)	Primary

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Table II (*continued*)

Outcome	Sub-outcome	First author Design Sample Quality rating	Sample size (retention)	Number of study arms: interventions for each arm	Follow-up period (weeks)	Results		Primary or secondary outcome measure
						Study arm(s) resulting in improvement after intervention	Differences between study arms in treatment effects	
		Imoto[24] RCT Knee OA MODERATE	$n = 100$ (100%)	2: Neuromuscular electrical stimulation/education	8	NMES ($P < 0.001$)/ Education (*non-significant*)	Pain NRS improved to a greater extent in the NMES group compared to control group ($P = 0.01$)	Primary
		Knoop[20] RCT Knee OA MODERATE	$n = 159$ (97%)	2: Stabilization training + exercise/ exercise	6, 12, 38	Stabilization training + exercise/ exercise (*P-values N/A*)	Improvement in pain NRS not different between groups at follow up ($P = 0.300$)	Secondary
		Kumar[21] RCT Knee OA LOW	$n = 44$ (100%)	2:Physiotherapy + proprioceptive training/physiotherapy	4	Physiotherapy + proprioceptive training/physiotherapy (*both groups* $P < 0.001$)	Improvement in pain NRS greater in proprioceptive group compared to physiotherapy only group ($P = 0.001$)	Primary
		Imoto[25] RCT Knee OA MODERATE	$n = 100$ (87%)	2: NMES + exercise/ exercise	8	NMES + exercise/ exercise (both groups $P < 0.001$)	Improvement in pain NRS not different between groups at follow up ($P = 0.520$)	Primary
		Park[28] RCT Knee OA VERY LOW	$n = 44$ (50%)	2: Whole body vibration + exercise/ exercise	4, 8	Whole body vibration + exercise/ exercise (*non-significant* $P < 0.07$)	Improvement in pain NRS greater in the whole body vibration group than exercise only group at follow up ($P = 0.04$)	Primary
		Poulsen[33] RCT (proof of principle) Hip OA MODERATE	$n = 118$ (94%)	3: Manual therapy + education/ education/minimal control intervention (written advice)	6, 52	Not reported	Pain NRS not different between groups at follow up ($P = 0.058$)	Primary
	Pain threshold							
		W. Chen[30] RCT Knee OA MODERATE	$n = 54$ (93%)	2: TENS/hyaluronic acid injections	2, 8, 12	No improvement (both groups $P \geq 0.520$)	Pain threshold not different between groups at all follow up times ($P \geq 0.07$)	Secondary
	Brief pain inventory							
		L. Chen[36] RCT Knee OA MODERATE	$n = 214$ (85% 12 weeks; 71% 26 weeks)	2: Acupuncture/non-penetrating acupuncture	12, 26	Acupuncture/non-penetrating acupuncture (*P-values N/A*)	Pain score change not different between groups at 12 weeks ($P = 0.703$) and 26 weeks ($P = 0.780$) follow up	Secondary
	Visual analogue scale							
		W. Chen[30] RCT Knee OA MODERATE	$n = 54$ (93%)	2: TENS/hyaluronic acid injections	2, 8, 12	TENS/hyaluronic acid (*both groups* $P < 0.001$)	Pain VAS improved to a greater extent in TENS group than HA group at 2 weeks follow up ($P = 0.03$), but not at 8 weeks ($P = 0.380$) or 12 weeks ($P = 0.06$)	Primary
		Alpayci[29] RCT Knee OA MODERATE	$n = 98$ (92%)	3: Control (hot pack, short wave diathermy)/ intermittent traction + hot pack, short wave diathermy/constant traction + hot pack, short wave diathermy	3, 7	Control/intermittent traction/constant traction (*all groups* $P < 0.001$ *across both follow up times*)	No improvements in pain VAS between groups at week 3 ($P = 0.461$); improvements greater in the intermittent ($P = 0.034$) and	Secondary

				Phonophoresis/ ultrasonography/short-wave diathermy (*all groups P < 0.001*)	constant traction ($P = 0.018$) groups compared to control at week 7	Primary
Boyaci[32] RCT Knee OA LOW	$n = 101$ (100%)	3: Phonophoresis/ ultrasonography/short-wave diathermy	2		Improvement in pain VAS not different between groups after treatment period ($P = 0.362$)	
Daskapan[23] RCT Knee OA LOW	$n = 40$ (100%)	2: Mini squat/straight leg raises	2, 6	Mini squat/ straight Leg raises (*both groups P < 0.001*)	No difference between mini squat and straight leg raise groups following the intervention on pain VAS scores ($P = 0.149$); Mini squat group significantly lower VAS pain scores at 6 week follow-up ($P = 0.03$)	Primary
Elboim-Gabyzon[26] RCT Knee OA VERY LOW	$n = 63$ (79%)	2: Exercise/ NMES + exercise	12	Exercise/NMES+ exercise (*both groups P < 0.001*)	VAS pain group × time interaction ($P = 0.01$); greater decrease in VAS pain in the NMES group	Primary
Ghasemi[22] Controlled study Knee OA VERY LOW	$n = 30$ (83%)	2: Yoga exercise/control	8	Yoga exercise ($P < 0.05$)	No head to head comparison of yoga exercise vs control presented (*P-value N/A*)	Primary
Horng[44] RCT Knee OA VERY LOW	$n = 28$ (89%)	2: Collateral meridian therapy with electrical stimulation (manipulate a nonpainful meridian)/ placebo	1, 2, 3, 12	CMT/placebo (*P-values N/A*)	CMT group had significantly lower VAS pain scores than the placebo group at 2 weeks ($P = 0.02$) and 3 weeks ($P = 0.01$) follow-up, but not at baseline ($P = 0.780$), 1 week ($P = 0.06$), or 12 weeks ($P = 0.650$).	Primary
Luksurapan[31] RCT Knee OA HIGH	$n = 46$ (100%)	2: Phonophoresis of piroxicam/ultrasound	2	Phonophoresis of piroxicam/ultrasound (*both groups P < 0.001*)	Improvement in pain VAS greater in phonophoresis group than ultrasound group ($P = 0.009$)	Primary
Nambi[46] Controlled study Knee OA VERY LOW	$n = 30$ (100%)	2: Iyengar yoga + biofeedback + strengthening + TENS/biofeedback + strengthening + TENS	8	Iyengar yoga + biofeedback + strengthening + TENS/biofeedback + strengthening + TENS (*P-values N/A*)	Improvement in pain VAS greater in yoga group compared to control ($P < 0.05$)	Primary

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Table II (*continued*)

Outcome	Sub-outcome	First author Design Sample Quality rating	Sample size (retention)	Number of study arms: interventions for each arm	Follow-up period (weeks)	Results		Primary or secondary outcome measure
						Study arm(s) resulting in improvement after intervention	Differences between study arms in treatment effects	
		Saleki[48] RCT Knee OA VERY LOW	$n = 40$ (unclear)	2: Acupuncture/isometric exercise	4	Isometric exercise ($P < 0.01$)	No head to head comparison treatment effect of acupuncture and isometric exercise presented (*P-value N/A*)	Primary
		Schencking[49] RCT Hip or knee OA VERY LOW	$n = 30$ (100%)	3: Kneipp hydrotherapy/ physiotherapy/kneipp hydrotherapy + physiotherapy	10	Kneipp hydrotherapy/ physiotherapy/kneipp hydrotherapy + physiotherapy (*P-values N/A*)	No head to head comparison of treatment effect of hydrotherapy, hydrotherapy plus physiotherapy, physiotherapy alone (*P-value N/A*)	Primary
Physical function ***Self-reported*** *WOMAC* Full scale		Abbott[37] RCT Hip or knee OA MODERATE	$n = 206$ (93%)	4: Manual physiotherapy/ exercise therapy/ manual + exercise therapy/ usual care	52	Manual physiotherapy/ exercise therapy/ manual + exercise therapy (*P-values N/A*)	WOMAC scores demonstrated greater improvement in manual therapy group compared to usual care ($P = 0.03$)	Primary
		Alpayci[29] RCT Knee OA MODERATE	$n = 98$ (92%)	3: Control (hot pack, short wave diathermy)/ intermittent traction + hot pack, short wave diathermy)/constant traction + hot pack, short wave diathermy	3, 7	Control/intermittent traction/constant traction (*all groups $P \leq 0.001$ across both follow up times*)	WOMAC pain ($P = 0.009$) and total ($P = 0.021$) score improvements greater in the constant traction group compared to control at week 3; WOMAC physical function ($P < 0.001$) and total ($P < 0.001$) score improvements greater in intermittent and constant traction groups compared to control at 7 weeks; WOMAC stiffness ($P = 0.014$) improvements greater in constant traction group compared to control at 7 weeks	Primary
		Boyaci[32] RCT Knee OA LOW	$n = 101$ (100%)	3: Phonophoresis/ ultrasonography/short-wave diathermy	2	Phonophoresis/ ultrasonography/short-wave diathermy (*all groups $P < 0.001$*)	Improvement in WOMAC not different between groups after treatment period ($P = 0.515$)	Primary
		L. Chen[36] RCT Knee OA MODERATE	$n = 214$ (85% 12 weeks; 71% 26 weeks)	2: Acupuncture/non-penetrating acupuncture	12, 26	Acupuncture/non-penetrating acupuncture (*P-values N/A*)	WOMAC total score change not different between groups at 12 weeks ($P = 0.193$) and 26 weeks ($P = 0.148$) follow up	Primary
		Elboim-Gabyzon[26] RCT Knee OA VERY LOW	$n = 63$ (79%)	2: Exercise/ NMES + exercise	12	Exercise/ NMES + exercise (*both groups $P < 0.001$*)	WOMAC change not different between groups after treatment period ($P = 0.260$)	Primary

Hunt[27] RCT Knee OA MODERATE	$n = 20$ (95%)	2: Exercise + pain coping skills training/exercise	10	Exercise + pain coping skills training/ exercise + non-directive counselling (*both groups $P < 0.001$*)	WOMAC change not different between groups at follow up ($P \geq 0.120$)	Secondary
Kudo45 RCT Knee OA (women) VERY LOW	$n = 209$ (97%)	2: Group exercise/home exercise	12	Group exercise ($P < 0.05$)	WOMAC scores demonstrated greater improvement in group exercise compared to home exercise ($P < 0.05$)	Primary
Kumar[21] RCT Knee OA LOW	$n = 44$ (100%)	2:Physiotherapy + proprioceptive training/physiotherapy	4	Physiotherapy + proprioceptive training/ physiotherapy (*both groups $P < 0.05$*)	Improvement in WOMAC greater in proprioceptive group compared to physiotherapy group ($P = 0.001$)	Secondary
Luksurapan[31] RCT Knee OA HIGH	$n = 46$ (100%)	2: Phonophoresis of piroxicam/ultrasound	2	Phonophoresis of piroxicam/ultrasound (*both groups $p < 0.001$*)	No difference between groups at follow up ($p = 0.143$)	Primary
Malas[18] RCT Knee OA LOW	$n = 61$ (92%)	6: Isometric right/isometric left/isotonic right/isotonic left/isokinetic right/ isokinetic left	3	Isometric ($P < 0.01$)/ isotonic ($P < 0.01$)/ isokinetic (pain and function scales only; $P < 0.01$)	No head to head comparison of treatment effect of isometric, isotonic, isokinetic exercise presented (*P-value N/A*)	Primary
Nambi[46] Controlled study Knee OA VERY LOW	$n = 30$ (100%)	2: Iyengar yoga + biofeedback + strengthening + TENS/ biofeedback + strengthening + TENS	8	Iyengar yoga + biofeedback + strengthening + TENS/biofeedback + strengthening + TENS (*P-values N/A*)	Improvement in WOMAC greater in yoga group compared to control ($P < 0.05$)	Secondary
Parsons[47] RCT Hip or knee OA LOW	$n = 336$ (74%)	2: Usual care (pre-operative assessment)/usual care + health maintenance clinic (education, individualized care)	Control − 16.5; Exper. − 18	Not reported	WOMAC not different between groups at follow up ($P = 0.690$)	Primary
Ay[40] RCT Knee OA LOW	$n = 60$ (100%)	3: Home exercise demonstration, supervision and written material/home exercise Supervision and written material/home exercise written material	4, 12	Home exercise demonstration, Supervision and written material/home exercise supervision and written material (*both groups $P < 0.001$*)	WOMAC Pain scores not different between groups at 4 weeks follow up ($P = 0.930$), but differences between groups at 12 weeks ($P = 0.001$) with home- exercise supervision group showing the greatest improvement; no head-to-head group comparisons given	Secondary

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Table II (*continued*)

Outcome	Sub-outcome	First author Design Sample Quality rating	Sample size (retention)	Number of study arms: interventions for each arm	Follow-up period (weeks)	Results		Primary or secondary outcome measure
						Study arm(s) resulting in improvement after intervention	Differences between study arms in treatment effects	
	Function and pain							
		Messier[15] RCT Knee OA HIGH	$n = 454$ (88%)	3: Diet + exercise/diet/ exercise	26, 78	Diet + exercise ($P < 0.002$)/diet/ exercise (*P-values N/A*)	Greater reductions in pain demonstrated in the diet + exercise group compared to diet group ($P = 0.001$) and exercise group ($P = 0.004$). Greater reductions in function for the diet + exercise group compared to diet group ($P = 0.003$) and exercise group ($P < 0.001$).	Secondary
	Function only							
		French[38] RCT (modified cross over design) Hip OA MODERATE	$n = 131$ (86%)	3: Exercise/ exercise + manual therapy/ control	9, 18	Exercise/ exercise + manual therapy (*P-values N/A*)	WOMAC physical function improvement greater in exercise and exercise + manual therapy compared to control at follow up ($P = 0.002$)	Primary
		Katz[35] RCT Knee OA MODERATE	$n = 351$ (94% 6 months; 91% at 12 months; 30% crossed over from PT to surgery)	2: Surgery/physiotherapy	26, 52	Surgery/physiotherapy (*P-values N/A*)	WOMAC physical function scores not different between surgery and physiotherapy groups at both follow up times (*P-value N/A*)	Primary
		Knoop[20] RCT Knee OA MODERATE	$n = 159$ (97%)	2: Stabilization training + exercise/exercise	6, 12, 38	Stabilization training + exercise/ exercise (*P-values N/A*)	Improvement in WOMAC physical function subscale change not different between groups at follow up ($P = 0.990$)	Primary
		Park[28] RCT Knee OA VERY LOW	$n = 44$ (50%)	2: Whole body vibration + exercise/ exercise	4, 8	Whole body vibration + exercise/ exercise (*both groups* $P < 0.012$)	Improvement in WOMAC not different between groups at follow up ($P = 0.967$)	Primary
	Function, pain, and stiffness							
		Imoto[25] RCT Knee OA MODERATE	$n = 100$ (87%)	2: NMES + exercise/exercise	8	NMES + exercise/ exercise (*both groups* $P < 0.001$)	Improvement in WOMAC function, pain and stiffness subscales not different between groups at follow up ($P \geq 0.230$)	Secondary
KOOS/HOOS								
	Full scale − KOOS							
		Ghasemi[22] Controlled Study Knee OA VERY LOW	$n = 30$ (83%)	2: Yoga exercise/control	8	Yoga exercise ($P < 0.05$)	No head to head comparison of yoga exercise vs control presented (*P-value N/A*)	Primary
		Saleki[48] RCT Knee OA VERY LOW	$n = 40$ (unclear)	2: Acupuncture/isometric exercise	4	Acupuncture (*change in Pain, ADL, and QoL scores*, $P \leq 0.02$)/ isometric exercise (*change in Symptoms*	KOOS Pain score improved in the acupuncture group compared to the isometric exercise	Primary

					and QoL scores, $P \leq 0.04$)	group following intervention ($P = 0.03$) improved in over isometric group	
	KOOS – pain scale only						
		Katz[35] RCT Knee OA MODERATE	$n = 351$ (94% 6 months; 91% at 12 months; 30% crossed over from PT to surgery)	2: Surgery/physiotherapy	52	Surgery/physiotherapy (*P-values N/A*)	KOOS pain scores not different between surgery and physiotherapy groups at follow up (*P-value N/A*)	Secondary
	Full scale - HOOS						
		Poulsen[33] RCT (proof of principle) Hip OA MODERATE	$n = 118$ (94%)	3: Manual therapy + education/ education/minimal control intervention (written advice)	6, 52	Manual therapy + education/ education/minimal control intervention (*HOOS Pain, Sport/Rec, and QoL subscale scores for all groups* $P \leq 0.04$)	All HOOS subscales demonstrate greater improvement in the manual therapy group compared to control group ($P < 0.05$)	Primary
	Function – KOOS/HOOS						
		Bossen[39] RCT Hip or Knee OA MODERATE	$n = 199$ (85% 3 months; 75% 12 months)	2: Web-based physical activity intervention/ waiting list control	12, 52	Web-based physical activity intervention/ waiting list control (*P-values N/A*)	Physical function improved in the intervention group compared to the control group at 3 months ($P = 0.006$) but not at 12 months ($P = 0.100$)	Primary
		Daskapan[23] RCT Knee OA LOW	$n = 40$ (100%)	2: Mini squat/straight Leg Raises	2, 6	Mini squat (*at follow up*, $P = 0.004$)	No difference between mini squat and straight leg raise groups following intervention ($P = 0.398$) and at follow up ($P = 0.201$)	Primary
SF36								
	Full scale						
		L. Chen[36] RCT Knee OA MODERATE	$n = 214$ (85% 12 weeks; 71% 26 weeks)	2: Acupuncture/non-penetrating acupuncture	12	Acupuncture/non-penetrating acupuncture (*P-values N/A*)	SF-36 physical and mental change scores not different between groups at 12 weeks follow up ($P \geq 0.169$)	Secondary
		French[38] RCT (modified cross over design) Hip OA MODERATE	$n = 131$ (86%)	3: Exercise/ exercise + manual therapy/ control	9, 18	Exercise/ exercise + manual therapy/control (*mental only, P-values N/A*)	SF-36 not different between groups at follow up [though physical component summary nearly better in exercise group compared to control at 9 weeks ($P = 0.06$)]	Secondary
		Messier[15] RCT	$n = 454$ (88%)	3: Diet + exercise/diet/ exercise	26, 78	Diet + exercise (*physical subscale*,	SF36 physical subscale demonstrated greater improvement in the	Secondary

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Table II (*continued*)

Outcome	Sub-outcome	First author Design Sample Quality rating	Sample size (retention)	Number of study arms: interventions for each arm	Follow-up period (weeks)	Results		Primary or secondary outcome measure
						Study arm(s) resulting in improvement after intervention	Differences between study arms in treatment effects	
		Knee OA HIGH				*P = 0.01*)/Diet/Exercise (*P-values N/A*)	diet + exercise group compared to exercise group alone (*P = 0.005*)	
		Schencking[49] RCT Hip or knee OA VERY LOW	*n* = 30 (100%)	3: Kneipp hydrotherapy/ physiotherapy/kneipp hydrotherapy + physiotherapy	10	Kneipp hydrotherapy (*PS only*)/ physiotherapy/Kneipp hydrotherapy + physiotherapy (*P-values N/A*)	No head to head comparison of treatment effect of hydrotherapy, hydrotherapy plus physiotherapy, physiotherapy alone (*P-value N/A*)	Secondary
	Physical activity scale							
		Katz[35] RCT Knee OA MODERATE	*n* = 351 (94% 6 months; 91% at 12 months; 30% crossed over from PT to surgery)	2: Surgery/physiotherapy	52	Surgery/physiotherapy (*P-values N/A*)	SF-36 Activity scores not different between surgery and physiotherapy groups at follow up (*P-value N/A*)	Secondary
	SF-8							
		Wi[43] RCT Knee OA LOW	*n* = 40 (unclear)	2: Virtual gaming/control	4	No improvement (*P > 0.05*)	SF-8 change scores not different between groups at follow up (*P > 0.05*)	Secondary
Lesquesne index								
		W. Chen[30] RCT Knee OA MODERATE	*n* = 54 (93%)	2: tens/Hyaluronic acid injections	2,8,12	TENS/hyaluronic acid (both groups *P < 0.001*)	Lequesne index improved to a greater extent in TENS group than HA group at 2 weeks follow up (*P = 0.01*) and 12 weeks follow up (*P = 0.03*), but not 8 weeks (*P = 0.160*)	Primary
		Imoto[24] RCT Knee OA MODERATE	*n* = 100 (100%)	2: NMES/education	8	NMES (*P < 0.001*)/ education (*non-significant*)	Lequesne index improved to a greater extent in the NMES group compared to control group (*P = 0.03*)	Secondary
		Schencking[49] RCT Hip or knee OA VERY LOW	*n* = 30 (100%)	3: Kneipp hydrotherapy/ physiotherapy/kneipp hydrotherapy + physiotherapy	10	Kneipp hydrotherapy (*hip only*)/ physiotherapy (*knee only*)/kneipp hydrotherapy + physiotherapy (*hip only*, *P-values N/A*)	No head to head comparison of treatment effects of hydrotherapy, hydrotherapy plus physiotherapy, physiotherapy alone	Secondary
Lysholm scoring scale								
		Park[28] RCT Knee OA VERY LOW	*n* = 44 (50%)	2: Whole body vibration + exercise/ exercise	4, 8	Whole body vibration + exercise/ exercise (*non-significant P = 0.054*)	Improvement in LSS not different between groups at follow up (*P = 0.994*)	Secondary

Self-reported knee stability							
	Knoop[20] RCT Knee OA MODERATE	$n = 159$ (97%)	2: Stabilization training + exercise/exercise	6, 12, 38	Stabilization training + exercise/ exercise (*P-values N/A*)	Self-reported knee stability scores not different between groups at follow up ($P = 0.790$)	Primary
Self-made 'function scale'							
	Zhang[50] Controlled study Knee OA VERY LOW	$n = 100$ (100%)	2: Exercise + diclofenac sodium/diclofenac sodium	4	Exercise + diclofenac sodium ($P < 0.05$)/ diclofenac sodium ($P < 0.05$)	Function was higher in the intervention group vs the control group at follow up ($P = 0.033$).	Secondary
Performance							
Balance							
Standing balance							
	Daskapan[23] RCT Knee OA LOW	$n = 40$ (100%)	2: Mini squat/straight leg Raises	2, 6	No improvement ($P \geq 0.117$)	No difference between mini squat and straight leg raise groups after intervention ($P = 0.659$) and at follow up ($P = 0.327$)	Primary
	Malas[18] RCT Knee OA LOW	$n = 61$ (92%)	6: Isometric right/isometric left/isotonic right/isotonic left/isokinetic right/ isokinetic left	3	Isometric ($P < 0.01$)/ isokinetic ($P < 0.05$)	No head to head comparison of treatment effect isometric, isotonic, isokinetic exercise presented (*P-value N/A*)	Primary
	Park[28] RCT Knee OA VERY LOW	$n = 44$ (50%)	2: Whole body vibration + exercise/ exercise	4, 8	Whole body vibration + exercise/ exercise (*both groups* $P < 0.004$)	Improvement in standing balance not different between groups at follow up ($P \leq 0.484$)	Primary
Range of motion							
Knee							
	Alpayci[29] RCT Knee OA MODERATE	$n = 98$ (92%)	3: Control (hot pack, short wave diathermy)/ intermittent traction + hot pack, short wave diathermy)/constant traction + hot pack, short wave diathermy	7	Intermittent traction ($P = 0.002$ *and* $P = 0.021$ *at 3 and 7 weeks respectively*)/constant traction ($P < 0.001$ *and* $P = 0.001$ *at 3 and 7 weeks respectively*)	Knee ROM improvements greater in constant traction group compared to intermittent traction ($P = 0.006$) and control groups at week 3 ($P = 0.001$); no differences among groups in ROM from baseline to week 7 ($P = 0.300$)	Secondary
	W. Chen[30] RCT Knee OA MODERATE	$n = 54$ (93%)	2: TENS/hyaluronic acid injections	2, 8, 12	TENS ($P < 0.001$)	Passive knee range of motion not different between groups at all follow up times ($P \geq 0.160$)	Secondary
	Kudo[45] RCT Knee OA (women) VERY LOW	$n = 209$ (97%)	2: Group exercise/home exercise	12	Not reported	No head to head comparison of group vs home exercise presented (*P-value N/A*)	Secondary
	Schencking[49] RCT Hip or knee OA VERY LOW	$n = 30$ (100%)	3: Kneipp hydrotherapy/ physiotherapy/kneipp hydrotherapy + physiotherapy	10	Kneipp hydrotherapy/ physiotherapy/kneipp hydrotherapy + physiotherapy (*flexion for all groups, P-values N/A*)	No head to head comparison of hydrotherapy group, hydrotherapy plus physiotherapy group, physiotherapy alone groups (*P-value N/A*)	Secondary

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Table II (*continued*)

Outcome	Sub-outcome	First author Design Sample Quality rating	Sample size (retention)	Number of study arms: interventions for each arm	Follow-up period (weeks)	Results		Primary or secondary outcome measure
						Study arm(s) resulting in improvement after intervention	Differences between study arms in treatment effects	
	Hip							
		French[38] RCT (modified cross over design) Hip OA MODERATE	$n = 131$ (86%)	3: Exercise/ exercise + manual therapy/ control	9, 18	Exercise/ exercise + manual therapy (*P-values N/A*)	Active hip range of motion greater in exercise and exercise + manual therapy groups compared to control ($P = 0.001$) at 9 weeks follow up	Secondary
		Poulsen[33] RCT (proof of principle) Hip OA MODERATE	$n = 118$ (94%)	3: Manual therapy + education/ education/minimal control intervention (written advice)	6, 52	No improvement (*P-value N/A*)	Hip range of motion was not different between groups at follow up (*P-value N/A*)	Primary
		Schencking[49] RCT Hip or knee OA VERY LOW	$n = 30$ (100%)	3: Kneipp hydrotherapy/ physiotherapy/kneipp hydrotherapy + physiotherapy	10	Kneipp hydrotherapy/ physiotherapy/ kneipp hydrotherapy + physiotherapy (*flexion for all groups, P-values N/A*)	No head to head comparison of hydrotherapy group, hydrotherapy plus physiotherapy group, physiotherapy alone groups (*P-value N/A*)	Secondary
	Joint position sense							
		Kumar[21] RCT Knee OA LOW	$n = 44$ (100%)	2: physiotherapy + proprioceptive training/ physiotherapy	4	Physiotherapy + proprioceptive training/physiotherapy (*both groups $P < 0.001$*)	Improvement in joint position sense greater in proprioceptive group compared to physiotherapy group ($P < 0.05$)	Secondary
	Strength							
	Isometric quadriceps/hamstrings strength							
		Elboim-Gabyzon[26] RCT Knee OA VERY LOW	$n = 63$ (79%)	2: Exercise/ NMES + exercise	12	Exercise/ NMES + exercise (*both groups $P < 0.001$*)	Isometric quadriceps strength not different between groups at follow up ($P = 0.730$)	Primary
		Hunt[27] RCT Knee OA MODERATE	$n = 20$ (95%)	2: Exercise + pain coping skills training/exercise	10	Exercise + pain coping skills training/exercise (both improvements non-significant)	Isometric quadriceps and hamstrings strength not different between groups at follow up ($P \geq 0.200$)	Secondary
		Hunt[16] RCT (pilot) Knee OA LOW	$n = 17$ (88%)	2: Strengthening/control	10	Strengthening (*P-value N/A*)	Knee strength not different between groups after intervention ($P \geq 0.120$)	Secondary
		Kudo[45] RCT Knee OA (women) VERY LOW	$n = 209$ (97%)	2: Group exercise/home exercise	12	Not reported	No head to head comparison of treatment effect of group vs home exercise presented (*P-value N/A*)	Secondary
		Malas[18] RCT Knee OA LOW	$n = 61$ (92%)	6: Isometric right/isometric left/isotonic right/isotonic left/isokinetic right/ isokinetic left	3	Isometric (*knee extension, $P < 0.01$*)	No head to head comparison of treatment effect of isometric, isotonic, isokinetic exercise presented (*P-value N/A*)	Primary

	Park[28] RCT Knee OA VERY LOW	$n = 44$ (50%)	2: Whole body vibration + exercise/ exercise	4, 8	Whole body vibration + exercise/ exercise (*both groups $P < 0.01$ at 1 and 2 months follow up*)	Improvement in isometric knee extensor strength for both knees not different between groups at follow up ($P \geq 0.377$)	Primary
Isokinetic quadriceps/hamstrings strength							
	Daskapan[23] RCT Knee OA LOW	$n = 40$ (100%)	2: Mini squat/straight leg Raises	2, 6	Mini squat [*Right knee extensor torque at 60°/sec, 90°/sec, 120°/sec, and 180°/sec ($P \leq 0.029$); Left knee extensor torque at 90°/sec, 120°/sec, and 180°/sec ($P \leq 0.03$); Left knee flexor torque at 120°/sec ($P = 0.029$)*]/straight leg raises [*Right knee flexor torque at 90°/sec ($P < 0.001$); Left knee flexor torque at 90°/sec and 120°/sec ($P \leq 0.042$)*]	No differences between groups at follow up ($P = 0.091$)	Primary
	Knoop[20] RCT Knee OA MODERATE	$n = 159$ (97%)	2: Stabilization training + exercise/exercise	6, 12, 38	Stabilization training + exercise/ exercise (*P-values N/A*)	Isokinetic quadriceps and hamstrings strength not different between groups at follow up ($P = 0.790$)	Secondary
	Park[28] RCT Knee OA VERY LOW	$n = 44$ (50%)	2: Whole body vibration + exercise/ exercise	4, 8	Whole body vibration + exercise/ exercise (*both groups $P < 0.001$ for the right limb only*)	Improvement in right and left isokinetic knee extensor strength not different between groups at follow up ($P = 0.377$)	Primary
Stair test							
	Ay[40] RCT Knee OA LOW	$n = 60$ (100%)	3: Home exercise demonstration, supervision and written material/home exercise supervision and written material/home exercise written material	4, 12	Home exercise demonstration, supervision and written material/home exercise supervision and written material/ home exercise written material (*all groups at 12 weeks follow up $P < 0.043$*)	Difference between groups at 4 ($P = 0.029$) and 12 ($P = 0.004$) weeks with the home-exercise supervision group having decreased stair climbing times; no head-to- head group comparisons given	Secondary
	Elboim-Gabyzon[26] RCT Knee OA VERY LOW	$n = 63$ (79%)	2: Exercise/ NMES + exercise	12	Exercise/ NMES + exercise (*both groups $P < 0.001$*)	Stair ascent and descent time not different between groups at follow up ($P = 0.630$)	Primary
	Hunt[27] RCT Knee OA MODERATE	$n = 20$ (95%)	2: Exercise + pain coping skills training/exercise	10	Exercise + pain coping skills training ($P = 0.008$)/exercise ($P = 0.01$)	Improvement in step test performance not different between groups at follow up ($P = 0.900$)	Secondary

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Table II (*continued*)

Outcome	Sub-outcome	First author Design Sample Quality rating	Sample size (retention)	Number of study arms: interventions for each arm	Follow-up period (weeks)	Results		Primary or secondary outcome measure
						Study arm(s) resulting in improvement after intervention	Differences between study arms in treatment effects	
		O'Brien[42] RCT (feasibility) Hip or knee OA VERY LOW	$n = 27$ (56%)	2: Exercise + action and coping plans/exercise	12	Exercise + action and coping plans/exercise (*both groups $P < 0.001$*)	Step test was not different between groups at follow up ($P = 0.420$)	Primary
	Stair climbing questionnaire							
		Knoop[20] RCT Knee OA MODERATE	$n = 159$ (97%)	2: Stabilization training + exercise/exercise	6, 12, 38	Stabilization training + exercise/ exercise (*6 and 12 weeks, P-values N/A*)	Self-reported stair climbing not different between groups at follow up ($P = 0.930$)	Secondary
Sit to stand								
		Ay[40] RCT Knee OA LOW	$n = 60$ (100%)	3: Home exercise demonstration, supervision and written material/home exercise supervision and written material/home exercise written material	4, 12	Home exercise demonstration, supervision and written material/home Exercise supervision and written material/ home exercise written material (*all groups $P \leq 0.038$ by 12 weeks follow up*)	Differences in sit-to-stand time was significant between groups at 4 weeks ($P = 0.001$) and 12 weeks ($P < 0.001$) with the home-exercise supervision group having the quickest time; no head- to- head group comparisons presented	Secondary
		French[38] RCT (modified cross over design) Hip OA MODERATE	$n = 131$ (86%)	3: Exercise/ exercise + manual therapy/ control	9, 18	Exercise/ exercise + manual therapy/control (*P-values N/A*)	Sit-to-stand time not different between groups at follow up ($P = 0.950$)	Secondary
TUG								
		Abbott[37] RCT Hip or knee OA MODERATE	$n = 206$ (93%)	4: Manual physiotherapy/ exercise therapy/ manual + exercise therapy/ usual care	52	Manual physiotherapy/ exercise therapy/ manual + exercise therapy (*P-values N/A*)	TUG demonstrated greater improvement in exercise therapy group compared to usual care (*P-value N/A*)	Secondary
		Daskapan[23] RCT Knee OA LOW	$n = 40$ (100%)	2: Mini squat/straight leg raises	2, 6	Mini squat ($P < 0.001$)/ Straight Leg Raises ($P = 0.001$)	TUG scores improved in the mini squat group following intervention ($P = 0.015$) but no difference between groups at follow up ($P = 0.327$)	Primary
		Elboim-Gabyzon[26] RCT Knee OA VERY LOW	$n = 63$ (79%)	2: Exercise/ NMES + exercise	12	Exercise/ NMES + exercise (*both groups $P < 0.001$*)	TUG was not different between groups at follow up ($P = 0.660$)	Primary
		Imoto[24] RCT Knee OA MODERATE	$n = 100$ (100%)	2: NMES/education	8	NMES ($P < 0.001$)/ education (*non-significant*)	TUG improved to a greater extent in the NMES group compared to control group ($P = 0.05$)	Primary
		Knoop[20] RCT Knee OA MODERATE	$n = 159$ (97%)	2: Stabilization training + exercise/exercise	6, 12, 38	Stabilization training + exercise/ exercise (*P-values N/A*)	Improvement in Get Up and Go no different between groups at follow up ($P = 0.08$)	Secondary

	Imoto[25] RCT Knee OA MODERATE	$n = 100$ (87%)	2: NMES + exercise/exercise	8	NMES + exercise/ exercise (both groups *P < 0.001*)	Improvement in TUG not different between groups at follow up (*P = 0.120*)	Primary
	O'Brien[42] RCT (feasibility) Hip or knee OA VERY LOW	$n = 27$ (56%)	2: Exercise + action and coping plans/exercise	12	Exercise + pain coping skills training/exercise (*both groups P = 0.02*)	TUG not different between groups at follow up (*P = 0.260*)	Primary
	Schencking[49] RCT Hip or knee OA VERY LOW	$n = 30$ (100%)	3: Kneipp hydrotherapy/ physiotherapy/kneipp hydrotherapy + physiotherapy	10	Kneipp hydrotherapy/ physiotherapy/kneipp hydrotherapy + physiotherapy (*P-values N/A*)	No head to head comparison of hydrotherapy group, hydrotherapy plus physiotherapy group, physiotherapy alone groups	Primary
TUG questionnaire							
	Knoop[20] RCT Knee OA MODERATE	$n = 159$ (97%)	2: Stabilization training + exercise/ exercise	6, 12, 38	Stabilization training + exercise (*6 and 12 weeks only*)/ exercise (*all time points, P-values N/A*)	Self-reported rising from sitting not different between groups at follow up (*P = 0.320*)	Secondary
Walking tests							
10-m							
	O'Brien[42] RCT (feasibility) Hip or knee OA VERY LOW	$n = 27$ (56%)	2: Exercise + action and coping plans/exercise	12	Exercise + pain coping skills training/exercise (*both groups P = 0.01*)	10 m walk time was not different between groups at follow up (*P = 0.360*)	Primary
15-m							
	Boyaci[32] RCT Knee OA LOW	$n = 101$ (100%)	3: Phonophoresis/ ultrasonography/short-wave diathermy	2	Phonophoresis/ ultrasonography/short-wave diathermy (*all groups P < 0.001*)	Improvement in 15 m walk time no different between groups after treatment period (*P = 0.505*)	Primary
30-m							
	W. Chen[30] RCT Knee OA MODERATE	$n = 54$ (93%)	2: TENS/hyaluronic acid injections	2, 8, 12	TENS/hyaluronic acid (*both group P ≤ 0.01*)	Walking time improvement greater in TENS vs HA group at 8 weeks (*P = 0.03*), but not at 2 weeks (*P = 0.06*) or 12 weeks (*P = 0.07*) follow up	Secondary
40-m							
	Abbott[37] RCT Hip or knee OA MODERATE	$n = 206$ (93%)	4: Manual physiotherapy/ exercise therapy/ manual + exercise therapy/ usual care	52	Manual physiotherapy/ exercise therapy/ manual + exercise therapy (*P-values N/A*)	Walking demonstrated greater improvement in exercise therapy group compared to usual care (*P-value N/A*)	Secondary
100-m							
	Ay[40] RCT Knee OA LOW	$n = 60$ (100%)	3: Home exercise demonstration, supervision and written material/home exercise supervision and written material/home exercise written material	4, 12	Home exercise demonstration, supervision and written material/Home exercise supervision and written material/ Home exercise written material (*all groups P ≤ 0.025*)	Differences in walking between groups at 4 weeks (*P = 0.003*) and 12 weeks (*P < 0.001*) with home-exercise supervision group having the quickest completion time; no head- to- head comparison of groups presented	Secondary

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Table II (*continued*)

Outcome	Sub-outcome	First author Design Sample Quality rating	Sample size (retention)	Number of study arms: interventions for each arm	Follow-up period (weeks)	Results		Primary or secondary outcome measure
						Study arm(s) resulting in improvement after intervention	Differences between study arms in treatment effects	
	50-foot							
		French[38] RCT (modified cross over design) Hip OA MODERATE	$n = 131$ (86%)	3: Exercise/ exercise + manual therapy/ control	9, 18	Exercise + manual therapy (*P-value N/A*)	50 foot walk not different between groups at follow up ($P = 0.720$)	Secondary
		Malas[18] RCT Knee OA LOW	$n = 61$ (92%)	6: Isometric right/isometric left/isotonic right/isotonic left/isokinetic right/ isokinetic left	3	Isometric ($P < 0.01$)/ isotonic ($P < 0.05$)/ isokinetic ($P < 0.05$)	No head to head comparison of treatment effect of isometric, isotonic, isokinetic exercise presented	Primary
	Six minute walk test (SMWT)							
		L. Chen[36] RCT Knee OA MODERATE	$n = 214$ (85% 12 weeks; 71% 26 weeks)	2: Acupuncture/non-penetrating acupuncture	12	Acupuncture/non-penetrating acupuncture (*P-values N/A*)	SMW not different between groups at 12 weeks follow up ($P = 0.562$)	Secondary
		Messier[15] RCT Knee OA HIGH	$n = 454$ (88%)	3: Diet + exercise/diet/ exercise	26, 78	Diet + exercise ($P < 0.001$)/diet/ exercise (*P-values N/A*)	Changes in SMW greater in diet + exercise group compared to exercise group ($P = 0.005$) and the diet group ($P < 0.001$)	Secondary
		O'Brien[42] RCT (feasibility) Hip or knee OA VERY LOW	$n = 27$ (56%)	2: Exercise + action and coping plans/exercise	12	No improvement ($P = 0.730$)	SMW was not different between groups at follow up ($P = 0.480$)	Primary
	Accelerometry							
		Bossen[39] RCT Hip or knee OA MODERATE	$n = 199$ (85% 3 months; 75% 12 months)	2: Web-based physical activity intervention/ Waiting list control	12, 52	No improvement; control group digressed (*P-values N/A*)	Accelerometry showed that the intervention group had higher objective PA than the control group at 12 months ($P = 0.045$)	Secondary
	Walking questionnaire							
		Knoop[20] RCT Knee OA MODERATE	$n = 159$ (97%)	2: Stabilization training + exercise/exercise	6, 12, 38	Stabilization training + exercise (*6 and 12 weeks only*)/ exercise (*6 and 12 weeks only, P-value N/A*)	Self-reported walking not different between groups at follow up ($P = 0.600$)	Secondary
Health								
Aerobic fitness								
Systolic blood pressure								
		Christensen[14] RCT Knee OA MODERATE	$n = 192$ (91%)	3: Diet/exercise/control	16, 68	Diet/exercise/control (*P-values N/A*)	Reduction in systolic blood pressure not different between diet and exercise groups ($P = 0.600$)	Secondary

Maximal oxygen uptake (VO_2 peak)							
	Larose[41] RCT Knee OA LOW	$n = 222$ (52%)	3: Supervised walking + behavioural intervention/supervised walking/unsupervised walking	26	Supervised walking + behavioural intervention/ supervised walking/(*all groups $P < 0.01$*)	Increase in peak oxygen consumption no different between groups after walking + behavioural or walking interventions ($P \leq 0.110$). Men in unsupervised and behavioural groups had greater increment in maximal oxygen consumption than supervised group ($P = 0.01$)	Primary
Workload							
	Larose[41] RCT Knee OA LOW	$n = 222$ (52%)	3: Supervised walking + behavioural intervention/supervised walking/unsupervised walking	26	No improvement ($P \geq 0.05$)	Workload at maximal aerobic effort not different between groups after walking + behavioural or walking interventions ($P \geq 0.180$)	Primary
Heart rate maximum							
	Larose[41] RCT Knee OA LOW	$n = 222$ (52%)	3: Supervised walking + behavioural intervention/supervised walking/unsupervised walking	26	No improvement ($P \geq 0.110$)	Maximal heart rate not different between groups after walking + behavioural or walking interventions ($P \geq 0.160$)	Primary
Ventilation							
	Larose[41] RCT Knee OA LOW	$n = 222$ (52%)	3: Supervised walking + behavioural intervention/supervised walking/unsupervised walking	26	Women only: supervised walking + behavioural intervention/ supervised walking/(*all groups $P < 0.01$*)	Increase in ventilation at maximum aerobic effort not different between groups after walking + behavioural or walking interventions ($P \geq 0.770$)	Primary
Test duration							
	Larose[41] RCT Knee OA LOW	$n = 222$ (52%)	3: Supervised walking + behavioural intervention/supervised walking/unsupervised walking	26	No improvement ($P \geq 0.520$)	Men in unsupervised group had greater increment in test duration than supervised group ($P = 0.04$)	Primary
Physical activity questionnaire (MET score)							
	Christensen[14] RCT Knee OA MODERATE	$n = 192$ (91%)	3: Diet/exercise/control	16, 68	Not reported	Physical activity changes not different between groups at follow up ($P = 0.340$)	Secondary
Exercise adherence							
	O'Brien[42] RCT (feasibility) Hip or knee OA VERY LOW	$n = 27$ (56%)	2: Exercise + action and coping plans/exercise	12	N/A (cross-sectional measure)	Adherence was not different between groups at follow up ($P \geq 0.210$)	Primary

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Table II (*continued*)

Outcome	Sub-outcome	First author Design Sample Quality rating	Sample size (retention)	Number of study arms: interventions for each arm	Follow-up period (weeks)	Results		Primary or secondary outcome measure
						Study arm(s) resulting in improvement after intervention	Differences between study arms in treatment effects	
Global measures								
	Patient and physician comment							
		Boyaci[32] RCT Knee OA LOW	$n = 101$ (100%)	3: Phonophoresis/ ultrasonography/short-wave diathermy	2	N/A (cross-sectional measure)	Patient ($P = 0.667$) or physician ($P = 0.315$) evaluation of treatment efficacy not different between groups after treatment period	Secondary
	Patient global assessment							
		W. Chen[30] RCT Knee OA MODERATE	$n = 54$ (93%)	2: TENS/hyaluronic acid injections	12	TENS/hyaluronic acid (*both groups* $P < 0.001$)	Global assessment (reflecting satisfaction with treatment) greater in TENS than HA group at 2 weeks ($P = 0.01$) and 12 weeks ($P = 0.03$), but not 8 weeks ($P = 0.160$)	Secondary
	Overall perceived change							
		Hunt[27] RCT Knee OA MODERATE	$n = 20$ (95%)	2: Exercise + pain coping skills training/exercise	10	N/A (cross-sectional measure)	Overall perceived change (ordinal scale 1 −5) not different between groups at follow up (*P-value N/A*)	Secondary
	Perceived effect of intervention							
		Bossen[39] RCT Hip or knee OA MODERATE	$n = 199$ (85% 3 months; 75% 12 months)	2: Web-based physical activity intervention/ waiting list control	12, 52	Web-based physical activity intervention (*P-value N/A*)	Perceived effect of intervention demonstrated significant differences at 12 weeks ($P < 0.001$) with an improvement in the intervention group compared to the control group	Primary
		L. Chen[36] RCT Knee OA MODERATE	$n = 214$ (85% 12 weeks; 71% 26 weeks)	2: Acupuncture/non-penetrating acupuncture	12, 26	N/A (no baseline score for true comparison)	Patient global assessment not different between groups at both follow up times ($P \geq 0.278$)	Secondary
		Knoop[20] RCT Knee OA MODERATE	$n = 159$ (97%)	2: Stabilization training + exercise/exercise	6, 12, 38	N/A (cross-sectional measure)	Global perceived effect was greater in experimental group at 12 weeks follow up compared to the control group ($P = 0.04$)	Secondary
		Poulsen[33] RCT (proof of principle) Hip OA MODERATE	$n = 118$ (94%)	3: Manual therapy + education/ education/minimal control intervention (written advice)	6, 52	Not reported	Greater proportion of manual therapy group reported effectiveness compared to education and control groups ($P < 0.001$)	Secondary
Disability								
	Disability							
		W. Chen[30] RCT Knee OA MODERATE	$n = 54$ (93%)	2: TENS/hyaluronic acid injections	12	TENS/hyaluronic acid (*both groups* $P \leq 0.02$)	Disability (single item, scored on 5 point scale) not different between TENS and HA groups at all follow up times ($P \geq 0.09$)	Secondary

ADL scale	Imoto[24] RCT Knee OA MODERATE	$n = 100$ (100%)	2: NMES/education	8	NMES ($P < 0.001$)/ education (*non-significant*)	ADL improved to a greater extent in the NMES group compared to control group ($P = 0.01$)	Secondary
LLTQ ADL scale	O'Brien[42] RCT (feasibility) Hip or knee OA VERY LOW	$n = 27$ (56%)	2: Exercise + action and coping plans/exercise	12	No improvement ($P = 0.940$)	LLTQ-ADL change was no different between groups at follow up ($P = 0.590$)	Primary
Psychological							
Coping strategies questionnaire	Hunt[27] RCT Knee OA MODERATE	$n = 20$ (95%)	2: Exercise + pain coping skills training/exercise	10	Exercise + pain coping skills training ($P = 0.04$)	CSQ changes not different between groups at follow up ($P = 0.07$)	Primary
AIMS2	Hunt[27] RCT Knee OA MODERATE	$n = 20$ (95%)	2: Exercise + pain coping skills training/exercise	10	Exercise + pain coping skills training/ exercise + non-directive counselling (*both groups* $P = 0.03$)	AIMS2 changes not different between groups at follow up ($P \geq 0.120$)	Secondary
ASES	Hunt[27] RCT Knee OA MODERATE	$n = 20$ (95%)	2: Exercise + pain coping skills training/exercise	10	Exercise + pain coping skills training/ exercise + non-directive counselling (*P-values N/A*)	ASES changes not different between groups at follow up ($P \geq 0.530$)	Secondary
Patient satisfaction	Parsons[47] RCT Hip or knee OA LOW	$n = 336$ (74%)	2: Usual care (pre-operative assessment)/usual care + health maintenance clinic (education, individualized care)	Control − 16.5; Exper. − 18	Not reported	Patient satisfaction was greater in the experimental group compared to control group ($P < 0.001$)	Primary
Medications	Poulsen[33] RCT (proof of principle) Hip OA MODERATE	$n = 118$ (94%)	3: Manual therapy + education/ education/minimal control Intervention (written advice)	6, 52	Not reported	Medication use not different between groups at follow up (*P-values N/A*)	Secondary
Self-efficacy	Bossen[39] RCT Hip or knee OA MODERATE	$n = 199$ (85% 3 months; 75% 12 months)	2: Web-based physical activity intervention/ waiting list control	12, 52	Web-based PHYSICAL activity intervention/ waiting list control (*at 3 months*); Web-based physical activity intervention (*at 12 months*; *P-values N/A*)	Self-efficacy (other symptoms subscale of arthritis self-efficacy scale) improved in the intervention group compared to control group at 3 months ($P = 0.008$), but not at 12 months ($P = 0.350$)	Secondary
	O'Brien[42] RCT (feasibility) Hip or knee OA VERY LOW	$n = 27$ (56%)	2: Exercise + action and coping plans/exercise	12	Exercise + pain coping skills training/exercise (*Maintenance self-efficacy only*, $P = 0.03$)	Recovery self-efficacy improved to a greater extent in the exercise alone group compared to the exercise + action and coping skills group ($P = 0.02$)	Primary

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Table II (*continued*)

Outcome	Sub-outcome	First author Design Sample Quality rating	Sample size (retention)	Number of study arms: interventions for each arm	Follow-up period (weeks)	Results		Primary or secondary outcome measure
						Study arm(s) resulting in improvement after intervention	Differences between study arms in treatment effects	
	Tiredness	Bossen[39] RCT Hip or knee OA MODERATE	$n = 199$ (85% 3 months; 75% 12 months)	2: Web-based physical activity intervention/ waiting list control	12, 52	Web-based physical activity intervention/ waiting List control (*P-values N/A*)	Tiredness NRS improved in the intervention group compared to control group at 3 months ($P = 0.04$) and 12 months ($P = 0.008$)	Secondary
	Anxiety	Bossen[39] RCT Hip or knee OA MODERATE	$n = 199$ (85% 3 months; 75% 12 months)	2: Web-based physical activity intervention/ waiting list control	12, 52	Web-based physical activity intervention/ waiting list control (*P-values N/A*)	Anxiety improved in the intervention group compared to control group at 12 months ($P = 0.007$)	Secondary
	Depression	Bossen[39] RCT Hip or knee OA MODERATE	$n = 199$ (85% 3 months; 75% 12 months)	2: Web-based physical activity intervention/ waiting list control	12, 52	Web-based physical activity intervention/ waiting list control (*P-values N/A*)	Depressive symptoms not different between groups at 3 months ($P = 0.09$) and 12 months ($P = 0.09$) follow up	Secondary
	Quality of life	Bossen[39] RCT Hip or knee OA MODERATE	$n = 199$ (85% 3 months; 75% 12 months)	2: Web-based physical activity intervention/ waiting list control	12, 52	Web-based physical activity intervention/ waiting list control (*P-values N/A*)	Quality of life not different between groups at 3 months ($P = 0.280$) and 12 months ($P = 0.680$) follow up	Secondary
	Pain coping	Bossen[39] RCT Hip or knee OA MODERATE	$n = 199$ (85% 3 months; 75% 12 months)	2: Web-based physical activity intervention/ waiting list control	12, 52	Web-based physical activity intervention (*P-values N/A*)	Pain coping improved in the intervention group compared to control group only at 12 months ($P = 0.008$)	Secondary
	Locus of control	Bossen[39] RCT Hip or knee OA MODERATE	$n = 199$ (85% 3 months; 75% 12 months)	2: Web-based physical activity intervention/ waiting list control	12, 52	Web-based physical activity intervention/ waiting list control (*P-values N/A*)	Locus of control changes not different between groups at 3 months ($P = 0.410$) and 12 months ($P = 0.610$) follow up	Secondary
	Hospital anxiety & depression scale	French[38] RCT (modified cross over design) Hip OA MODERATE	$n = 131$ (86%)	3: Exercise/ exercise + manual therapy/ control	9, 18	Exercise + manual therapy (*anxiety only, P-value N/A*)	Anxiety ($P = 0.920$) and depression ($P = 0.260$) not different between groups at follow up	Secondary
	Depression	Wi[43] RCT Knee OA LOW	$n = 40$ (unclear)	2: Virtual gaming/control	4	Virtual gaming ($P < 0.05$)	Depressive symptoms lower in the experimental group than the control group ($P < 0.05$)	Primary

LLTQ ADL = Lower Limb Tasks Questionnaire-Activities of daily living subscale.
AIMS2 = Arthritis Impact Measurement Scale 2.
ASES = Arthritis Self Efficacy Scale.

Physiology

Five investigations, involving 697 participants with knee OA, reported physiological outcome measures. These markers included biomarkers derived from serum and urine that reflect the synthesis and degradation of articular cartilage, biomarkers of systemic inflammation from blood, and the morphological presence of collagen, capillaries, and muscle architecture using muscle biopsy and ultrasound techniques. A mix of high and low quality studies provided inconsistent findings regarding the impact of diet and exercise on OA pathophysiology, owing in large part to the variety of measures used. Thus, this body of work supporting exercise to manage OA pathophysiology was rated as low quality evidence.

Interventions for physiological outcome measures: diet and exercise. Exercise alone altered muscle characteristics. Ultrasound measurements of knee extensors after 15 sessions of strengthening exercise increased muscle thickness in knee OA[18]. Exercise combined with diet for weight loss was effective in addressing cartilage turnover and inflammation in knee OA in some studies. In a high quality study, diet and diet combined with exercise resulted in greater improvements in plasma interleukin 6 (IL-6), an inflammatory cytokine implicated in OA pathology, compared to exercise alone[15]. Strengthening was associated with reductions in serum cartilage oligomeric matrix protein (COMP) in a feasibility trial of 17 people with knee OA[16]. COMP is involved in cell proliferation and apoptosis and therefore, COMP is a marker of cartilage turnover. This work adds some confidence that joint loads associated with exercise are not necessarily associated with increased cartilage turnover in people with radiographic evidence of knee OA, though more work is required.

On the other hand, a study that examined muscle tissue from biopsy presented low level evidence that exercise may yield a negative effect on OA pathophysiology. Chronic inflammation is associated with age-related accumulations of advanced glycation end products. These end products are thought to promote stiffness and reduce muscle function. The receptor of advanced glycation end product (RAGE) has been implicated in prolonging inflammation. A double-blind RCT examined the impact of resistance training, resistance training with ibuprofen, and resistance training with glucosamine sulphate on the presence of RAGE in 21 people with knee OA[19]. Twelve weeks of resistance training increased the presence of RAGE in vastus lateralis in the group receiving only exercise ($P < 0.05$). In comparison, glucosamine combined with resistance training lowered the labelling of intra- and extra-cellular RAGE ($P < 0.05$), suggesting a protective effect of glucosamine[19].

These discrepancies between studies published in 2013 may reflect the differences in duration of the follow up period, intervention, and type of inflammatory marker. Further research is necessary to clarify the impact of exercise on inflammation.

Pain

Twenty studies, including 1558 participants with hip and knee OA, reported on pain. The pain subscale of the Western Ontario McMaster Universities Osteoarthritis Index (WOMAC), numeric pain rating, and visual analogue scales were the most common tools. One study examined pain threshold.

Eleven studies reported on the impact of exercise on pain intensity, ranging from very low to moderate quality. This body of evidence suggested a consistent positive response of pain to exercise; however many had limitations in design, particularly around blinding, sample size, and a lack of head-to-head comparison of study arms. Together, these studies provide low quality evidence that exercise reduces pain as a result of hip and/or knee OA.

Also, consistent evidence from seven studies showed the benefits of passive interventions, such as phonophoresis, ultrasound, acupuncture, manual therapy, traction, and transcutaneous electrical stimulation (TENS), on pain intensity in people with hip and knee OA. The majority of these studies were of moderate quality.

Intervention for pain outcome measures: exercise

While the articles were not all of the highest quality, exercise was consistently effective for pain management. A RCT examined the efficacy of exercises targeting the knee laxity that results from the ligamentous, muscular, and proprioceptive deficits caused by OA[20]. Participants with clinical knee OA ($n = 159$) were randomized into two arms. The control group completed a 12-week supervised program of strengthening and functional activities. The experimental group received the same program with the addition of joint stabilization training (low load proprioception, neuromuscular control activities). Both groups completed two supervised sessions each week, and completed a home program on the remaining 5 days each week. Both groups reported substantial reductions in pain on the numeric pain rating scale[20]. Another study randomized 44 participants to receive 4 weeks of proprioceptive training, or 4 weeks of traditional physiotherapy (ultrasound, cycling, stretching, resistance exercise). Proprioceptive training resulted in greater reductions in pain than traditional physiotherapy ($P = 0.001$)[21]. However details of the proprioceptive training were limited[21]. Other forms of exercise useful in reducing pain included yoga in a sample with knee OA[22] and mini squats and straight leg raises in women with bilateral knee OA[23].

Interventions for pain outcome measures: exercise combined with neuromuscular electrical stimulation

Evidence of the usefulness of neuromuscular electrical stimulation (NMES) in reducing pain was inconsistent. NMES applies an electrical current to the muscle fibres and neuromuscular junction to produce contraction. NMES stimulated exercises were superior to education alone in 100 participants with radiographic knee OA ($P < 0.01$)[24]. However, in two studies where NMES was compared head-to-head with exercise, findings were conflicting. One hundred people with radiographic knee OA were randomized to receive either exercise, or exercise with NMES[25]. The control group received exercise including stationary cycling, stretching, and isometric quadriceps strengthening in sitting. In the experimental group, NMES placed on rectus femoris and vastus medialis facilitated isometric quadriceps strengthening. After treatment two times each week for 8 weeks, both groups improved in pain ($P < 0.05$). No difference was noted between groups ($P = 0.52$)[25]. In contrast, greater improvement in pain was noted in a group receiving NMES with exercise compared to exercise alone ($P = 0.01$)[26]. This study randomized 50 people with symptomatic and radiographic knee OA to receive 12 treatments, over 6 weeks, of either (1) group exercise of range of motion, strengthening, functional activities and balance training, or (2) group exercise with additional NMES stimulation of rectus femoris and vastus medialis in sitting. This study experienced a loss to follow-up (81% retention) and lacked blinding of the participants and assessors at the follow up time point[26].

Interventions for pain outcome measures: exercise combined with other strategies

Exercise was combined with other rehabilitation strategies, including pain coping skills training[27] or whole body vibration[28]. Pain coping skills training is an element of cognitive behavioural therapy that includes three components: education about pain and the role of pain coping skills, training in cognitive and behavioural coping skills, and applying coping skills to real-life situations. In a

feasibility RCT, 20 participants with knee OA were randomized to a group receiving exercise and pain coping skills training, or exercise and non-directive counselling over 10 weeks[27]. Both reported improvement in pain ($P < 0.05$) and no differences were noted between groups at follow up ($P = 0.91$). Specialized training of physiotherapists was required to deliver these interventions[27].

Interventions for pain outcome measures: passive rehabilitation strategies

Other rehabilitation strategies producing statistically significant improvements in pain included traction[29], TENS[30], thermal agents (ultrasound, phonophoresis and shortwave diathermy)[31,32] and manual therapy[33]. In a randomized, double-blind, controlled trial of 46 people with symptomatic knee OA, phonophoresis was superior to traditional ultrasound in reducing pain over 2 weeks of therapy[31]. Phonophoresis is a technique that uses ultrasonic waves to enhance percutaneous absorption of drugs, in this case, piroxicam. Phonophoresis was delivered with the ultrasound delivering continuous, 1.0 W/cm^2, 1 MHz wave over 0.5% piroxicam gel. The ultrasound group received the same ultrasound dosage, with an unmedicated coupling gel (i.e., no piroxicam). Advantages of phonophoresis include avoiding the adverse side effects of system administration of non-steroidal anti-inflammatories and the combined effect of ultrasound[31].

A three-arm RCT compared manual therapy combined with education, education alone, and controls in 118 participants with radiographic hip OA[33]. Manual therapy is a hands-on technique that addresses abnormal arthrokinematics and pain by stimulating joint mechanoreceptors. The education group received two one-on-one sessions and three group sessions on hip anatomy, hip OA, mobility and pain management. The manual therapy group received this education in addition to manual therapy (trigger point release, muscle stretching using segmental inhibition/excitation, manipulation) twice a week for 6 weeks. The control group received a pamphlet. Compared to the control group, the manual therapy group experienced reduced pain intensity immediately after 6 weeks of treatment. Though treatment ceased, this effect that was maintained 12 months later. Education alone was not superior to the control group[33].

Physical function

The majority of studies reported at least one outcome measure of physical function. The outcomes were subdivided into self-report or performance-based measures.

Self-reported physical function

Self-reported physical function is a critically important outcome from the perspective of the patient, though sometimes these measures are subject to recall error and may not be appropriate for those with impaired cognition[34]. Twenty-nine studies showed self-reported outcomes on 3466 participants with hip and knee OA. The most common measurements used included the WOMAC, the Knee or Hip injury and Osteoarthritis Outcome Scores (KOOS/HOOS) and the Short Form-36 (SF36).

Physical function outcome measures reported by people with hip and/or knee OA improved as a result of physiotherapy. Physiotherapy programs included exercise for flexibility and strength, manual therapy, and diet combined with exercise. These studies ranged in quality from very low to high. Several were limited by challenges blinding participants and/or outcome assessors from the treatment arm, a lack of direct head-to-head comparisons of study arms, and small samples. Nonetheless, this body of work presented moderate quality evidence that physiotherapy improved self-reported physical function in people with hip and knee OA.

Intervention for self-reported function outcome measures: physiotherapy. Physiotherapy was equally effective to arthroscopic surgery for a majority of people with knee OA. A large, multi-center, RCT compared surgery to physiotherapy for 351 people with a meniscal tear and knee OA detected on radiographs or magnetic resonance imaging[35]. The arthroscopy group received partial meniscectomy and removal of loose fragments of cartilage and bone. Post-surgically, participants received physiotherapy equivalent to the physiotherapy only group. This physiotherapy protocol was approximately 6 weeks involving an individualized program of one or two one-on-one visits with a physiotherapist and a home program each week. Goals were to address inflammation, range of motion, strength, flexibility, aerobic fitness, proprioception, and balance. At 6 months, of the 330 active participants, no difference was found between the surgical and physiotherapy groups in the WOMAC physical function subscale. However several participants in the physiotherapy group crossed over to the surgical group by 6 months (30.2%) and 12 months (5.6%). These cross-over participants experienced little improvement in functional status from the point of randomization to the time of cross-over. Their WOMAC physical function scores were equivalent to those assigned to the surgical group at 12 months follow up[35]. While the cross-over of patients from physiotherapy to surgery was a limitation, one important strength of the study was its design to assess effectiveness in a real-world application.

Other physiotherapy techniques included acupuncture, manual therapy, and exercise combined with diet. In a randomized, double-blind, controlled trial of 214 people with radiographic knee OA, the integration of acupuncture into an exercise-based physiotherapy program was compared with a control group receiving exercise and non-penetrating acupuncture[36]. After 12 sessions, both groups reported improvements on the WOMAC; however no difference existed between groups at follow up. Thus acupuncture did not add to the effects of exercise[36]. In a sample ($n = 206$) with clinical hip or knee OA, a RCT compared manual therapy, exercise, manual therapy and exercise, or usual care provided by their existing healthcare team[37]. The manual therapy group demonstrated greater improvement in WOMAC scores than the usual care group at 1-year follow up ($P = 0.03$). Similar findings were noted in a sample of 131 people with clinical and radiographic hip OA[38]. Relative to a wait-list control group, improvement in WOMAC scores after a 9 week intervention period were the same for a group receiving exercise (strength, flexibility) and another group receiving exercise and manual therapy[38]. Further, dieting for weight loss and exercise together proved more effective in improving WOMAC physical function compared to dieting alone ($P = 0.003$) or exercise alone ($P = 0.001$) in the IDEA trial[15].

Intervention for self-reported function outcome measures: electronic coaching. Electronic coaching facilitated OA self-management. A web-based intervention, entitled "Join2move," was evaluated in comparison to a wait list control group in 199 people with self-reported knee and/or hip OA[39]. In this RCT, the 9-week behavioural graded activity aimed to gradually increase physical activity. This intervention included a baseline test, goal setting, time-contingent physical activity objectives, and text messaging to promote physical activity. Physical function captured on either the KOOS or HOOS showed a 15% improvement in the intervention group relative to the control group at 3 months ($P = 0.006$). The treatment effect was lost at 12 months follow up[39].

Performance

Performance measures were further divided into impairments (e.g., balance, range of motion, and strength) and mobility limitations (e.g., sit-to-stand, stairs, walking). Twelve papers that

included 827 participants reported on performance measures related to impairments in hip and knee OA. The majority of these investigations examined the impact of exercise on impairments. Together these investigations provide low quality evidence that exercise alone improves balance, range of motion, and strength tasks. Also, moderate quality evidence from two studies demonstrated the benefits of passive strategies including traction and TENS on impairments.

Sixteen research articles, including 1856 participants, used mobility performance measures to assess the efficacy of rehabilitation in knee and/or hip OA. Measurements included a variety of walking, transferring from sit-to-stand and stair climbing performance tasks. This body of work provided moderate quality, consistent evidence of the efficacy of exercise and diet for weight loss in improving mobility performance in knee and hip OA. Passive strategies included TENS and thermal agents such as phonophoresis, ultrasound, and short-wave diathermy. The evidence supporting the efficacy of passive rehabilitation techniques in improving mobility performance was consistent and of moderate quality.

Intervention for performance outcome measures: exercise. Balance and strength were improved after resistance training. Sixty-six people with knee OA were randomized to receive one of six different resistance-training protocols. These protocols involved 20 min of one of isometric, isokinetic, or isotonic contractions, on either their left or right leg, 5 days a week for 3 weeks. All six groups demonstrated the ability to spend a longer time period in single-leg stance at follow up[18]. More sophisticated measurements of balance could be incorporated in future research; however it is important to note that 3 weeks was likely inadequate to produce appreciable improvements in muscle strength. Increased isometric quadriceps strength resulted from protocols of mini-squats[23], and isometric exercise[18]. However, supplementing exercise with whole body vibration[28] or NMES[26] resulted in no further benefit over exercise alone.

Exercise improved performance of stair-climbing, transferring tasks such as the Timed Up and Go, and walking performance in samples with knee and/or hip OA[20,23,26,27,37,40]. An 8 week program combining strengthening exercise with NMES improved Time Up and Go (TUG) scores in a sample with radiographic knee OA[24]. After a warm-up on an exercise bike, participants performed a seated strengthening exercise against the resistance provided by an ankle weight. NMES was applied to the rectus femoris and vastus medialis (time on: 10 s, time off: 30 s, pulse duration 250 μs, 50 Hz) for 20 min. Time to complete the TUG, which requires a participant to stand up from a standard chair, walk 3 m, turn, return to the chair and sit, was reduced by over 1 s ($P < 0.001$), an improvement greater than that observed in the control group ($P = 0.05$)[24]. The control group received only education; thus it is unclear whether the treatment effect is attributed to the combination of strengthening and NMES, or either treatment alone. Similarly, exercise was more effective in improving performance of the 40 m walk test amongst 206 people with hip or knee OA than usual care; that is, care administered by their general practitioner and other health care providers ($P = 0.03$)[37].

Electronic coaching improved quantity of physical activity[39]. Exercise in combination with other therapies such as NMES[26], pain coping skills[27], and stability training[20] improved mobility performance. However, these additional interventions provided no greater benefit to mobility performance over exercise alone[20,26,27]. One addition to exercise that was successful in boosting improvements to mobility performance over exercise alone was dieting for weight loss. Data from the IDEA trial showed that diet combined with exercise improved Six Minute Walk scores to a greater extent than exercise alone or diet alone in people with knee OA at 18 month follow up[15].

Interventions for performance outcome measures: passive strategies. TENS is a technique that applies an electrical current to stimulate analgesia through activation of a spinal segment, and/or supraspinal centres[30]. A RCT of 54 participants with clinical knee OA were randomized to a group receiving intra-articular hyaluronic acid injections or TENS. The injections were 2.5 mL of 1% sodium hyaluronate solution, administered via a lateral parapatellar approach once per week for five consecutive weeks. The TENS was applied with silver spike point electrodes, positioned on acupuncture points for knee problems, to best replicate an acupuncture-like effect without the use of needles. The TENS parameters were a mixed frequency of 3 Hz and 20 Hz with a pulse width of 200 μs and this treatment was applied three times each week for 20 min, over a 4 week period. Data from 50 people who completed the trial showed that walking time improved in the TENS group to a greater extent than the hyaluronic acid group ($P = 0.03$)[30]. While the TENS group received more attention than the hyaluronic acid group, this paper provides moderate level evidence that TENS is effective in improving walking performance.

A RCT compared phonophoresis of ketoprofen with ultrasound and short-wave diathermy in 101 people with bilateral radiographic knee OA[32]. Each group received intervention from the same physiotherapist 5 days a week for 2 weeks. Each treatment session started with a hot pack. In the experimental group, phonophoresis of ketoprofen, an anti-inflammatory, was administered at a frequency of 1 MHz, with a power of 1.5 W/cm^2 for 8 min to both knees. The ultrasound group received ultrasound with the same parameters without any drug. The group receiving short-wave diathermy received the intervention via electrodes placed on the knees in parallel, at 27.12 MHz, for 20 min. Walking time for a 15 m span was improved in all three groups. No differences between groups were noted[32]. It would be interesting to note whether this improvement in mobility performance was maintained beyond the 2-week intervention period.

Health

The theme of health included subthemes of aerobic fitness, disability, psychological measures and other global health outcome measures. Global health outcome measures were varied and as a result, summarized only in Table II.

Aerobic fitness

Three studies documented aerobic fitness in 441 participants with knee or hip OA. These studies formed a body of evidence showing consistent but low quality evidence of efficacy of exercise for fitness in OA. A RCT of 222 adults with knee OA compared three programs: (1) structured, supervised walking program with a behavioural intervention, (2) structured, supervised walking program, or (3) unsupervised, self-directed walking program[41]. All interventions were 12 months in duration. Both groups receiving structured walking met three times per week with a physical activity specialist who led increases in intensity and duration. The behavioural intervention involved 20 sessions of 2 h each to discuss short-term goals, barriers to walking, and strategies to address barriers, as well as education. The participants in the behavioural intervention also received monthly face-to-face counselling. The self-directed group was instructed to avoid walking with the supervised groups. The study had a 52% retention rate. Measures of cardiorespiratory fitness were derived from a graded treadmill stress test: maximal oxygen consumption, workload, maximum heart rate, ventilation, and duration. Women that received

structured walking (with or without the behavioural intervention) experienced an improvement in maximal ventilation at follow up ($P < 0.01$). Men and women in all groups experienced an increase in peak oxygen consumption ($P < 0.01$). No group differences were noted in the outcome measures. Participants did not tolerate the maximal stress test on the treadmill[41]; therefore future work may consider submaximal stress tests on a cycle ergometer to avoid weight-bearing related pain from interfering with performance on a fitness test.

Disability

Only three studies, reporting on 181 participants included a measure of disability. In one of these studies, the measurement was a single item. Thus no quality rating was determined for this small body of evidence. TENS produced improvements in a single item measure of disability in activities of daily living (ADL)[30]. ADL improved to a greater extent in people with knee OA after NMES with strengthening exercise compared to control[24].

Psychological

Seven investigations involving 871 participants with hip and knee OA measured a variety of psychological outcomes, including anxiety, self-efficacy and depression. Exercise studies in people with hip and knee OA produced consistent, moderate quality evidence of its efficacy in improving psychological outcomes.

In a study involving 199 participants with hip or knee OA, a 9 week behavioural graded activity aimed to gradually increase physical activity improved several psychological outcomes[39]. Tiredness rated on a numerical scale was reduced relative to a wait-list control group at 3 months ($P = 0.04$) and 12 months ($P = 0.007$). The anxiety dimension of the Hospital Anxiety and Depression Scale showed the intervention group, compared to the control group, experienced less anxiety at 3 month ($P = 0.05$) and 12 month ($P = 0.008$) follow ups. Scores on the pain coping inventory improved in the intervention group compared to the control group at 12 months ($P = 0.008$)[39].

Self-efficacy is the belief that one has the capacity to execute the necessary actions to satisfy the demands of a given situation. Self-efficacy for exercise maintenance was improved after a 12 week gym and home exercise program combined with individual counselling to develop plans for action and coping with challenges associated with their hip or knee OA ($P = 0.03$)[42]. This RCT was a small feasibility study and therefore further work is necessary to understand the impact of exercise and goal-setting for coping skills in knee OA.

Finally, 40 older women with knee OA were randomized to an experimental group who participated in an exercise game using an Xbox 360 for 30 min per session, three times per week for 4 weeks[43]. The control group received no intervention. The experimental group demonstrated a reduction in scores on the Short Geriatric Depression Scale from baseline to follow up ($P < 0.05$). This treatment effect was greater compared to the control group ($P < 0.05$)[43].

Key messages

In 2013, papers investigating the efficacy and effectiveness of rehabilitation strategies used outcome measures spanning from markers of OA disease to overall health. The largest bodies of evidence focused on physical function and pain intensity. Exercise combined with dieting to manage body mass should be the mainstays of rehabilitation for people with hip and knee OA. Evidence published in 2013 showed that these strategies provided benefit to OA disease markers, pain, physical function and health. More research is necessary regarding the impact of reduced lean mass associated with dieting.

Moderate quality evidence supported physiotherapy to improve self-reported physical function. Physiotherapy was as useful as surgery for OA-related meniscal tears. No repercussions were noted in cases where physiotherapy failed and the patient moved on to arthroscopic surgery. To improve performance of balance, strength, and joint range of motion, low and moderate quality evidence supported the use of exercise and passive strategies such as TENS. Similarly, moderate quality evidence showed that mobility performance was improved by exercise combined with diet, and passive strategies including TENS, phonophoresis, ultrasound, and short-wave diathermy. To reduce pain intensity, moderate level evidence supported the use of thermal and/or electrical modalities, traction, and manual therapy in people with hip and knee OA.

A large body of evidence evaluated markers of OA disease. Moderate and high quality evidence supported the use of dieting for weight loss combined with exercise in reducing body mass and fat mass, along with compressive knee forces, in people with knee OA. However, the role of exercise in addressing OA pathophysiology was less clear. The majority of studies showed that exercise imparted a positive effect on cartilage turnover and inflammation; however findings from one investigation suggested that exercise increased inflammation within muscle. Given the variety of measurements used to understand the mechanisms involved in OA, it is not surprising that findings regarding OA markers were inconsistent. This inconsistency resulted in a low quality rating for the body of evidence supporting exercise for OA pathophysiology.

Though a variety of psychological measures were included in rehabilitation intervention studies published in 2013, the body of evidence supporting the use of exercise to improve psychological factors such as anxiety and depression was of moderate quality.

Examining the 2013 rehabilitation literature by outcome measure highlighted areas for future research. Few studies focus on hip OA. Most measurements of pain focused on pain intensity. Further, few studies measured the impact of rehabilitation on disability as a result of OA. The majority of exercise intervention studies were limited by challenges in blinding. By comparison, studies of physical agents generally had higher quality ratings because of relative ease in blinding both participants and research staff. Other common study limitations were losses to follow up greater than 15% of the baseline sample, and, in some cases, indirect statistical comparisons of study arms. Further, future work must address inconsistencies present in rehabilitation intervention protocols, which present challenges in grouping outcome data. Many of these findings are consistent with previous annual reviews of rehabilitation strategies for OA[6–9].

In summary, conservative intervention is a critical component of care for people with OA. The evidence from 2013 shows that diet for weight loss and exercise should be the mainstays of rehabilitation for people with hip and knee OA. These interventions improve OA disease markers, pain, physical function and general health.

Contributions

Maly: literature review, data abstraction, interpretation, drafting and finalizing manuscript.
Robbins: literature review, data abstraction, interpretation, reviewing and finalizing manuscript.

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None.

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