Effect of Land-Based Generic Physical Activity Interventions on Pain, Physical Function, and Physical Performance in Hip and Knee Osteoarthritis

A Systematic Review and Meta-Analysis

Shanelle Fernandopulle, BPhty, Meredith Perry, PhD, Donald Manlapaz, MSPT, and Prasath Jayakaran, PhD

Objective: The aim of this study was to evaluate the effects of land-based generic physical activity interventions on pain, physical function, and physical performance in individuals with hip/knee osteoarthritis, when compared with a control group that received no intervention, minimal intervention, or usual care.

Methods: A systematic search for randomized controlled trials on 11 electronic databases (from their inception up until April 30, 2016) identified 27 relevant articles. According to the compendium of physical activities, interventions were categorized into: recreational activities (tai chi/Baduajin—6 articles), walking (9 articles), and conditioning exercise (12 articles).

Results: Meta-analysis for recreational activity ($n = 3$) demonstrated significant mean difference (MD) of −9.56 (95% confidence interval [CI], −13.95 to −5.17) for physical function (Western Ontario and McMaster Universities Arthritis Index) at 3 mos from randomization. Pooled estimate for walking intervention was not significant for pain intensity and physical performance but was significant for physical function ($n = 2$) with a MD of −10.38 (95% CI, −12.27 to −8.48) at 6 mos. Meta-analysis for conditioning exercise was significant for physical function ($n = 3$) with a MD of −3.74 (95% CI, −5.70 to −1.78) and physical performance (6-minute walk test) with a MD of 42.72 m (95% CI, 27.78, 57.66) at 6 mos. The timed stair-climbing test ($n = 2$) demonstrated a significant effect at 18 mos with a MD of −0.49 secs (95% CI, −0.75 to −0.23).

Conclusion: Very limited evidence to support recreational activity and walking intervention was found for knee osteoarthritis, in the short-term on pain and physical function, respectively.

Key Words: Osteoarthritis, Physical Activity, Exercise, Health, Function, Walking, Aerobics, Systematic Review, Meta-Analysis

(*Am J Phys Med Rehabil* 2017;96:773–792)

Osteoarthritis (OA) of the hip and knee is a chronic progressive condition which affects physical function and quality of life.[1] Generally, non-pharmacological and non-surgical strategies are considered important in managing people with OA symptoms such as pain, decreased mobility, and muscle strength.[2]

A number of reviews have investigated the evidence for effectiveness of interventions such as physiotherapy, manual therapy, and non-pharmacological management for hip and knee OA.[2,3] Physiotherapy interventions have typically included a combination of targeted muscle strengthening exercises and aerobic activities. The effectiveness of these interventions have regularly been reviewed or updated and generally suggest a positive evidence for pain and physical function.[4,5] However, a number of international societies advocate for exercise and physical activity (PA) as core interventions in all stages of the disease,[6–9] in order to maintain general fitness and thereby prevent further degeneration and progression to surgery.

PA is also an integral part of management and prevention of lifestyle-related comorbidities such as cardiovascular diseases, diabetes, and obesity.[10] The World Health Organization defines PA as "any bodily movement produced by skeletal muscles that requires energy expenditure."[11] Accordingly, PA can include a spectrum of activities such as simple walking activity, aerobic activity with ergometers, aquatic activity, and highly active recreational activity. Furthermore, the type of activity (specific exercises, sport and PA) has been distinguished to be different and may have different health benefits and/or risk of injury.[12]

Recent Cochrane reviews on aquatic activity and therapeutic exercises suggested moderate evidence for short-term benefits, as measured by pain and physical function.[5,13] A number of other reviews highlighted the importance of other forms of PA in the rehabilitation of hip and knee OA[14–16]; yet, there has not been any recent reviews to evaluate the

From the Centre for Health, Activity and, Rehabilitation Research, School of Physiotherapy, University of Otago, Dunedin (SF, DM, PJ); Wellington Hospital, Capital and Coast District Health Board, Wellington (SF); and Centre for Health, Activity and, Rehabilitation Research, School of Physiotherapy, University of Otago, Wellington (MP), New Zealand.

All correspondence and requests for reprints should be addressed to: Prasath Jayakaran, PhD, Centre for Health, Activity and, Rehabilitation Research, School of Physiotherapy, University of Otago, 325 Great King St, Dunedin 9016, New Zealand.

The School of Physiotherapy Research Support Fund, University of Otago, funded the stipend for summer studentship (first author) and remuneration for the research assistant (third author) work.

Financial disclosure statements have been obtained, and no conflicts of interest have been reported by the authors or by any individuals in control of the content of this article.

Supplemental digital content is available for this article. Direct URL citations appear in the printed text and are provided in the HTML and PDF versions of this article on the journal's Web site (www.ajpmr.com).

ISSN: 0894-9115

DOI: 10.1097/PHM.0000000000000736

evidence for its effectiveness on pain and physical function. Therefore, the aim of this systematic review was to evaluate the short-term and long-term effects of PA interventions on pain and physical performance measures in people with hip or knee OA, when compared with a control group that received no intervention, minimal intervention, or usual care.

METHODS

Search Strategy Used for Identification of Studies

A systematic literature search was performed, with reference to the Cochrane review guidelines, in the following 11 databases from their inception: Academic Search Complete, The Allied and Contemporary Medicine Database, Cumulative Index to Nursing and Allied Health Literature, EMBASE, MEDLINE, PsychInfo, PubMed, Science Direct, Scopus, SPORTDiscuss, and Web of Science. Initial search was conducted on November 28, 2014, by one of the reviewers (S. Fernandopulle) and was further updated and checked by a second reviewer (D. Manlapaz) on August 3, 2015. The search was further monitored for any new/relevant publications until April 30, 2016. Search terms were analogous to osteoarthritis, hip joint or knee joint, physical activity, and randomized controlled trial using key words or subject terms as appropriate to the database. The search strategy adapted for each database has been detailed in Appendix A (http://links.lww.com/PHM/A410). The reference list of the included articles was searched for further relevant publications.

The search was executed by one of the reviewers (S. Fernandopulle) and exported to Endnote X7 program for step-by-step screening. The removal of duplicates and screening of title and abstract were completed by one reviewer (S. Fernandopulle). The full-text screening was done independently by two reviewers (S. Fernandopulle and P. Jayakaran) to determine the eligibility to be included in the review. Any difference in opinion was discussed with the third reviewer (M. Perry) to reach a consensus. This review conforms to the Preferred Reporting Items for Systematic Reviews and Meta-Analyses guidelines[17] and the required information has been reported accordingly (please refer Appendix B for the checklist, http://links.lww.com/PHM/A411). Although the review protocol was determined a priori, because of a limited timeframe for execution of search and data extraction, the protocol was not able to be registered prospectively. However, the modifications made after extracting the data have been included in the results section.

Criteria for Considering Studies for This Review

Types of Studies

Randomized or quasi-randomized controlled trials investigating the effectiveness or efficacy of PA were included. The definitions as described by Cochrane Collaboration were used as a reference guide for the types of studies.[18] Studies were excluded if they were cohort, case-controlled, or observational studies. In addition, commentaries, conference proceedings, editorials, reviews, thesis, and studies with a sample size fewer than 10 in each group were excluded.

Types of Participants

Studies with adult participants (≥18 yrs old) with hip or knee OA confirmed by a physician/specialist using clinical or radiological criteria were considered for inclusion in the review. Studies that investigated post-operative interventions such as hip or knee replacements were excluded from the review.

Types of Intervention

Studies that included PA as an intervention were eligible to be included in the review. Studies that investigated aquatic activity and therapeutic exercise were not a focus of this review and were therefore excluded. Studies on therapeutic exercises such as muscle strengthening and stretching exercises tailored to the impairment/joint condition reportedly have better effects on the outcomes of interest in this study.[4,5]

Types of Controls/Comparator

Studies that compared the effects of PA intervention with those of a control group, which may have received usual care, minimal intervention, or no intervention, were eligible to be included in the review. For the purposes of the review, usual care was defined as regular care supplied in everyday practice (as defined by the authors) and any intervention that were one-off advice, education, and/or periodic contact with no active intervention were defined as minimal intervention.

Types of Outcomes

Studies that reported measures of pain (such as visual analog scale [VAS] and numerical pain rating scale), physical function (measured by subjective and objective scales), and physical performance (such as timed walking tests) as either the primary or secondary outcome measures were considered for inclusion in the review. Outcome measures considered in this review were in line with previous recommendations and guidelines.[19,20] Measures obtained/reported up to 3 mos (or 12 wks) from randomization were considered as short-term and measures obtained 6 mos or after were defined as long-term.

If more than one publication/output was located from a trial, all publications were crosschecked for author names, outcome variables, and number of study participants to avoid duplication bias. This was discussed among the reviewers (P. Jayakaran, S. Fernandopulle, D. Manlapaz, and M. Perry) after their independent review of the publications to arrive at a conclusion. If duplication of data were observed, only the data from the latest publication were considered for further analysis.

Assessment of Risk of Bias

All included articles were screened for internal validity with risk of bias items adopted from the Cochrane Back and Neck review group's checklist.[21] Articles were marked as "yes" or "no" for each item and "unclear" was used if adequate details were not available to make a clear decision. Citations such as trial registration, protocol, or a publication if cited by the included article were referred for further details. Authors were not contacted to clarify these details. One of the reviewers (S. Fernandopulle) completed the risk of bias assessment for all included articles. Two other reviewers (P. Jayakaran and M. Perry) independently completed the assessment for 14 and 13 articles, respectively. Any discrepancy in the assessment was discussed among the reviewers to reach a consensus.

Data Extraction and Synthesis

The data were extracted using a predetermined data extraction template that was developed for this purpose by one of the reviewers and cross-checked by a second reviewer. The data extraction included bibliographic information such as title, authors, journal; aims/objective of the study; study sample details such as, hip/knee OA, number of participants, mean (SD) age of the participants; randomization process; blinding; details of primary and secondary outcome measures; details of intervention for experimental and control groups; mean/mean difference (MD) of the outcome measures; and details of statistical tests/intention-to-treat analysis. Adverse events as reported by the included studies that may or may not have been a result of participating in the intervention program were also extracted.

Deviations from a Priori Decision

A wide range of interventions was observed in the included studies. Therefore, to assist with the pooling of studies for descriptive and meta-analysis, the interventions were categorized based on the compendium of physical activities[22,23] into walking intervention, recreational activity, and conditioning exercise protocol that primarily included an aerobic component. This classification was determined to present homogenous mixture of studies, after extraction of the data with regard to the intervention and before proceeding to any descriptive or meta-analysis.

Meta-Analysis

Data pooling and meta-analysis were performed if two or more studies were homogeneous. The homogeneity was assessed independently by two reviewers (P. Jayakaran and M. Perry) and the inclusion/exclusion of an article from meta-analysis was discussed between the two reviewers. The clinical diversity (participant characteristics) and methodological diversity (intervention, duration of the intervention, follow-up) of the included trials were evaluated in determining the homogeneity between studies.[18]

Meta-analysis was performed to determine the effect of walking intervention on pain (at 3 and 6 mos) and physical function (at 6 and 12 mos), the effect of recreational activity on physical function at 3 mos, and the effect of conditioning exercise on function at 6 mos. The heterogeneity of the pooled estimates (variability in effect estimates) was determined using I^2 values and was interpreted using the Cochrane's general guidelines of interpretation.[18]

RESULTS

Figure 1 illustrates the step-by-step article selection process for the review. The electronic search identified 3391 titles. After removal of duplicates, 2192 articles went through the title, abstract, and full-text screening process. Twenty-seven articles that satisfied the criteria were identified and included in this review. Hand search of reference lists of the included studies identified another 16 potentially relevant articles. However, on full-text screening, these references were excluded for the following reasons: non-randomized studies (n = 7); protocols of the included studies (n = 2); interventions such as muscle strengthening and diet, which were not of interest to the review (n = 4); conference abstract (n = 1); and not on OA or sample size fewer than 10 (n = 2).

The mean age of the participants of the included articles ranged between 54 and 73 yrs, and most them included more female than male participants. Two articles[24,25] included participants with either hip or knee OA, whereas the remaining investigated participants with knee OA.

The number of participants in each study varied between 21 and 435 participants per study. The maximum follow-up time was 18 mos postintervention, and 13 studies reported a follow-up of at least 6 mos. The measures of physical function of the included studies were the Western Ontario and McMaster Universities Arthritis Index (WOMAC) in 15 articles, Arthritis Impact and Measurement Scale (AIMS) in 5 articles, and Knee Injury and Osteoarthritis Outcome Score (KOOS) in 3 articles. Two studies also used other conventional measures such as the Japanese Knee OA measurement and a customized measure of disability. Physical performance was measured by the 6-minute walk test (6MWT) in 12 articles, timed up and go test (TUG) in 3 articles, and timed stair-climbing test in 5 articles. Pain intensity was measured by 9 of the included articles.

PA interventions of the included studies were recreational activity in the form of martial arts (namely, tai chi and Baduajin), customized and/or individualized walking interventions, and conditioning exercise interventions with combinations of aerobic exercise, strength training, and flexibility. A number of studies also included an educational component as a cointervention. Table 1 shows the descriptive data of the included articles and a summary of the reported effect on outcome measures.

Recreational Activity as an Intervention

All six articles studying the effect of recreational activity interventions in the form of martial arts found a significant improvement inn pain scales in the short-term (8 wks to 3 mos) compared with the control group that received no intervention or minimal intervention.[25–30] Most of these studies also showed that there was a significant improvement in the WOMAC physical function subscale for the intervention group.[26–29] However, the effect on the WOMAC stiffness subscale was inconsistent. Of the two articles that followed up participants for longer than 3 mos,[27,30] neither found a significant difference for any of the WOMAC subscales. Both articles studying pain found a significant improvement in VAS scores. The article studying physical performance using TUG[25] found no significant improvement and the two articles studying physical performance with 6MWT had differing results.[26,30] The meta-analysis of three studies[25,27,29] for physical function (Fig. 2.1.1) at 3 mos from randomization indicated a significant effect (MD, −9.56; 95% confidence interval [CI], −13.95 to −5.17) for tai chi and Baduajin. No heterogeneity was observed in the statistical analysis (I^2 = 0%).

Walking as an Intervention

Nine articles studied the effect of walking interventions in people with OA, three studies were home based[31–33] and six were class based or supervised.[34–39] According to the individual study results, the walking intervention was effective on

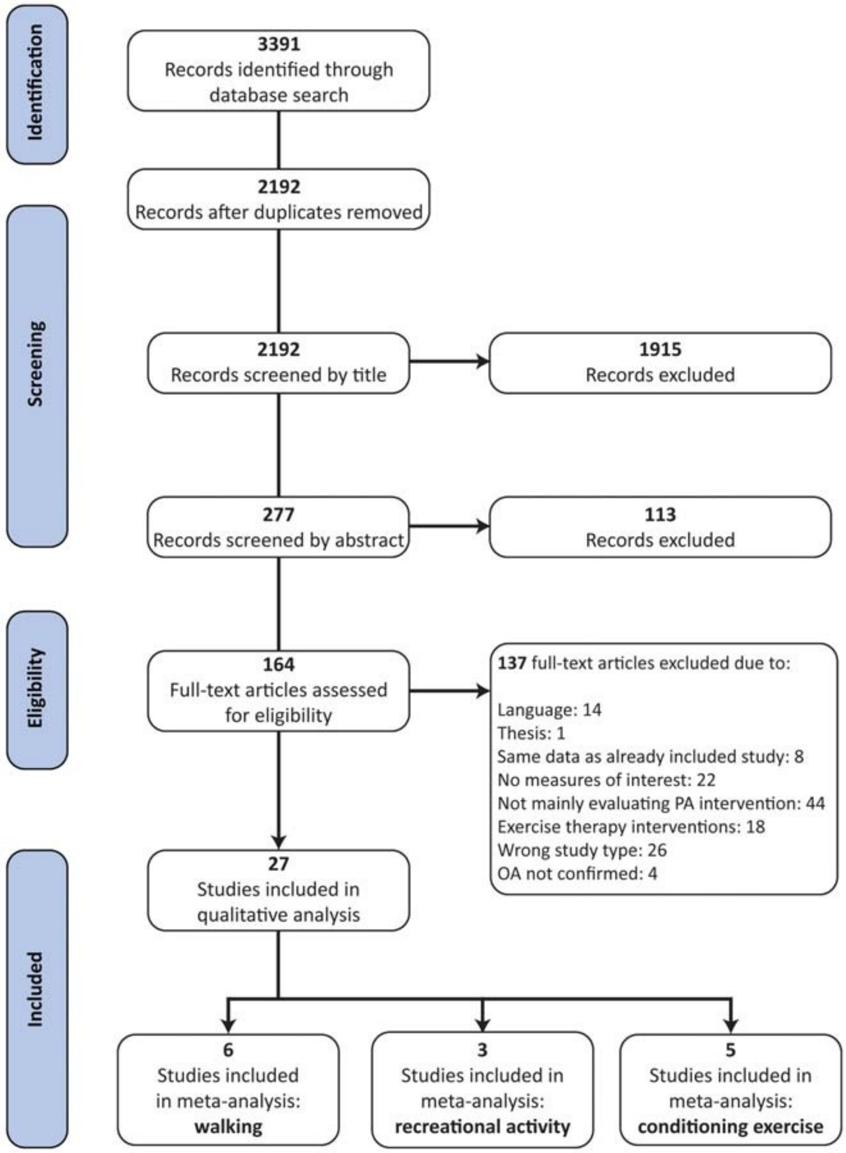


FIGURE 1. Flowchart of the article selection process.

physical performance measures (6MWT) in the short-term (8 wks[37] and 3mos[36]) and in the longer-term (9, 12, and 18 mos)[36,38] when compared with the control group that received minimal intervention or usual care. Of the two studies that used TUG for physical performance, only one study reported significant improvement when compared with the control group (active control) at 4 wks,[32] whereas the other reported no difference in the short- or at longer-term.[35] No significant effect was observed in physical function as measured by WOMAC subscales[31,35,38] or the AIMS[34,39] when compared with the control group, which constituted minimal intervention or usual care.

Of five articles that measured pain intensity, three found no statistically significant difference between groups,[33,36,39] whereas the other two reported significant improvement within the experimental group.[31,34] However, only two of the five studies included an active control group (usual care or regular health education), whereas the other studies either did not intervene or had only one-off educational component.

The meta-analysis of two studies for the physical function (WOMAC) measure at 6 mos[31,38] from randomization (Fig. 3.1.1) indicated a significant effect (MD, −10.38; 95% CI, −12.27 to −8.48) for walking interventions, whereas at 12 mos[35,38,39] (Fig. 3.1.2), it was not significant (standardized MD, −0.03; 95% CI, −0.35 to 0.28). There was no heterogeneity in these comparisons (I^2 = 0%).

The meta-analyses for pain at 3 mos[33,34] (standardized MD, 0.19; 95% CI, −0.31 to 0.68) and 6 mos[31,33] (standardized MD, −1.55; 95% CI, −3.62 to 0.52) were not significant (Figs. 3.1.4 and 1.5). A substantial heterogeneity was observed for comparisons at 6 mos (I^2 = 94%) but not at 3 mos (I^2 = 0%). Although the individual studies reported significant difference in physical performance as measured by the 6MWT, the pooled

TABLE 1. Summary of data extracted from the 27 included studies

Study	Participants			Methodology		Outcome Measures and Results	
Author (Year)	Mean Age, Sex, Joint/s	Sample Size	OA Confirmation	Description of Intervention	Follow-up	Primary Outcome Measure	Secondary Outcome Measure
An et al. (2008)	65 yrs old, ♀ only, knee OA	21	ACR	EG: Eight Baduanjin sections in a round, slow and nonstop manner, with each section performed 20 times, 30-min session five times per week for 8 wks CG: No intervention	8 wks	WOMAC: ↑* pain, stiffness and physical function between groups	6 MWT: ↑* between groups
Bautch et al. (1997)	69 yrs old, ♂ and ♀, knee OA	30	ACR	EG: 1-h exercise session (ROM exercises and individualized low intensity walking), three time per week for 12 wks with weekly educational program CG: 1-h weekly educational program for 12 wks	30 wks	VAS: ↑* within EG	AIMS: ↑* within CG; no change in EG
Brismee et al. (2007)	70 yrs old, ♂ (17%) and ♀ (83%), knee OA	31	ACR	EG: Three instructed group tai chi classes per week for 6 wks followed by another 6 wks of home video tai chi three times per week for 5 min of warm-up exercise, 30 min of 24 form simplified Yang style tai chi, and 5 min of cool-down exercise CG: Three 40-min health-related group sessions per week for 6 wks	3, 6, 9, 12, 15, 18 wks	WOMAC—pain: ↑* within EG at week 9; VAS: ↑* within EG at week 9 Overall pain ↑* between EG and CG at weeks 9 and 12	WOMAC stiffness: ↑* within EG at week 9 WOMAC physical function: ↑* within EG at week 9 and ↑* between EG and CG at week 9 and 12
Brosseau et al. (2012)	63.4 yrs old, ♂ (31%) and ♀ (69%), knee OA	222	ACR	EG: 12-mo supervised walking program three times per week (10-min warm-up, 45-min aerobic walking phase, 10-min cool-down). EG is divided by walking group and walking plus behavioral group. CG: Educational pamphlet	3, 6, 9, 12, 18 mos	WOMAC: no difference among group; ↑* between walking and walking plus behavioral group	6 MWT: no change among groups TUG: no change among groups
Evcik et al. (2002)	56.9 yrs old, ♂ (35%) and ♀ (65%), knee OA	81	Radiographic evidence	EG: Regular walking program. Patients started the walking program for 10 mins, three times per week. Gradually increased the walking time up to half an hour for 3 mos CG: No intervention	6 mos	WOMAC physical function: ↑* within EG WOMAC pain: ↑* within EG VAS: ↑* within EG	

(Continued on next page)

TABLE 1. (Continued)

Study	Participants			Methodology		Outcome Measures and Results	
Author (Year)	Mean Age, Sex, Joint/s	Sample Size	OA Confirmation	Description of Intervention	Follow-up	Primary Outcome Measure	Secondary Outcome Measure
Focht et al. (2005)	69 yrs old, knee OA	252	Radiographic evidence	EG: 60-min exercise sessions three times per week. Each session comprised an aerobic phase (15 mins), a resistance training phase (15 mins), a second aerobic phase (15 mins), and a cool down (15 mins). CG: Health education—monthly meeting for 1 hr during the first 3 mos. Phone contact for remainder of the 18 mos	6, 18 mos	6 MWT: ↑* within groups	Timed stair-climbing test: no change between the groups of interest to the review
Fransen et al. (2007)	70 yrs old, ♂ (24%) and ♀ (76%), hip and knee OA	152	ACR	EG: Classes for 1 h, two times per week for 12 wks. Modification of 24 forms from the Sun style of tai chi and includes a preliminary 10-min warm-up session. CG: No intervention	12 wks	WOMAC physical function: ↑* within EG WOMAC pain: ↑* within EG	TUG: no change Timed stair-climbing test: no change between the groups of interest to the review Timed 50-ft walk: no change between the groups of interest to the review
Hiyama et al. (2012)	73 yrs old, ♀, knee OA	40	—	EG: Instructed to increase their daily steps to 3000 more than their number of steps (median) before baseline assessments. Ice therapy, ROM exercises, and strengthening exercises at home every day CG: Ice therapy, ROM, and strengthening exercises at home every day	4 wks	TUG: ↑* within and between groups	Japanese knee OA measure: ↑* pain, stiffness and physical function between groups Tandem gait test: ↑* between groups
Huang et al. (2000)	53.8 yrs old	126	Radiographic evidence	EG: Auricular acupuncture, diet control, and aerobic exercise-cycling three times a week for 8 wks (approximately 300 to 500 Kcal energy consumption each session) CG: Three electrotherapy treatment per week for 12 wks	8, 12 wks	VAS: ↑* within and between groups	Timed 100-m walk: ↑* between groups Lequesne's functional index: ↑* between groups
Hughes et al. (2006)	73 yrs old, ♂ (17%) and ♀ (83%), hip and knee OA	215	ACR	EG: Fitness walking up to 30 mins, resistance training, and group discussion. 90-min session held three times per week for 8 wks CG: One-off education about self-management and exercises	2, 6, and 12 mos	WOMAC pain: ↑* between group at 6 mos WOMAC stiffness: ↑* between group at 2 and 6 mos WOMAC physical function: no change	6 MWT: no change at 2, 6, and 12 mos

Lee et al. (2009)	69 yrs old, ♂ (7%) and ♀ (93%), knee OA	44	Radiographic evidence	EG: Tai Chi Qigong, consisting of 18 movements, was performed for 1 hr and repeated two times per week for 8 wks CG: No Intervention	8 wks		WOMAC: ↑ pain, stiffness and physical function between groups
Mangani et al. (2006)	69 yrs old, ♂ (7%) and ♀ (93%), knee OA	435	Radiographic evidence	EG: Walking three times per week for 1 hr. 3 mos facility-based walking followed by 15 mos of home-based walking CG: Monthly health education program for first 3 mos, follow up by periodic telephone for 15 mos.	3, 9, and 18 mos	6 MWT: ↑ between group at 3, 9, and 18 mos	Knee pain score: no change at 3, 9, and 18 mos Customized measure of disability: ↑* between groups
Messier et al. (2004)	69 yrs old, ♂ (29%) and ♀ (71%), knee OA	252	Radiographic evidence	EG: 60-min exercise sessions three times per week. Each session comprised an aerobic phase (15 mins), a resistance training phase (15 mins), a second aerobic phase (15 mins), and a cool down (15 mins) CG: Monthly meeting for 1 hr during the first 3 mos. Phone contact for remainder of the 18 mos	6, 18 mos	WOMAC physical function: no change between groups	WOMAC pain: ↑* between groups at 18 mos 6MWT: no change between the groups of interest to the review Timed stair-climbing test: no change between the groups of interest to the review
Messier et al. (2013)	66 yrs old, ♂ (28%) and ♀ (72%), knee OA	399	Radiographic evidence	EG: 1-h exercise session three times per week for 18 mos. Aerobic walking (15 mins), strength training (20 mins), a second aerobic phase (15 mins), and cool-down (10 mins). CG: Diet only	6, 18 mos	WOMAC pain: no change between groups WOMAC physical function: no change between groups	6 MWT: ↑* between groups
Miller et al. (2006)	70 yrs old, ♂ (73%) and ♀ (27%), knee OA	79	—	EG: Facility-based, 60 min exercise training program three times per week. The primary mode of aerobic training was walking, with occasional use of cycle ergometers. Participants had a daily energy deficit of 1000 kcal through dietary restriction. CG: Bimonthly group presentations on general health, including OA and exercise. Individuals were encouraged to maintain their weight throughout the 6-mo study.	6 mos	WOMAC: ↑* pain, stiffness, and physical function between groups	6 MWT: ↑* between groups Timed stair-climbing test: not reported

(Continued on next page)

TABLE 1. (Continued)

Study	Participants			Methodology		Outcome Measures and Results	
Author (Year)	Mean Age, Sex, Joint/s	Sample Size	OA Confirmation	Description of Intervention	Follow-up	Primary Outcome Measure	Secondary Outcome Measure
Peloquin et al. (1999)	66 yrs old, ♂ (30%) and ♀ (70%), knee OA	124	Radiographic evidence	EG: Three 1-h exercise sessions per week for 3 mos. Including aerobic exercise, strength training, and stretching CG: 1 h education/information sessions two times per week	3 mo	AIMS: ↑* within and between groups for walking and bending, and arthritis pain ↑* within EG for work, level of tension and support from family and friends No change for mobility, hand and finger function, arm function, self-care tasks, household tasks and social activity	6MWT: ↑*between groups
Peterson et al. (1993)	69.4 yrs old, ♂ and ♀, knee OA	91	Radiographic evidence	EG: 8-wk hospital-based educational and walking program. At first, subjects walked three times per week for 5 mins. Each walking session was increased by 2.5 min per week, if tolerated, until the subject walked four times per week for 30 min each session. CG: Weekly telephone interview	8wk	6 MWT: ↑* within and between groups	
Salacinski et al. (2012)	58 yrs old, ♂ (17%) and ♀ (73%), knee OA	28	Radiographic evidence	EG: 12-wk program consisting of at least two supervised group cycling sessions per week, progressively increased from 40 to 60 mins. The aerobic demand for each participant was individualized. CG: No intervention	12 wks	VAS: no change between groups	WOMAC pain: ↑*between groups WOMAC physical function and stiffness: no change between groups KOOS pain: ↑*between groups KOOS symptoms, sports recreation, function, and knee-related QOL: no change between groups
Schlenk et al. (2011)	63 yrs old, ♂ (4%) and ♀ (96%), knee OA	21	Physician confirmed	EG: 6-mo program consisting of an education program on sedentary living, walking (working up to 150 min per week), and lower limb flexibility and strengthening CG: Usual care	6, 12 mos	6 MWT: ↑* within and between groups	WOMAC physical function: no change

Somers et al. (2012)	58 yrs old, ♂ (29%) and ♀ (71%), knee OA	232	ACR and radiographic evidence	For first 3 mos, there were supervised exercise sessions; second 3 mos, none. aerobic and strengthening for 90 mins three times per week. Participants were randomly allocated in the following programs: (1) pain coping skill training (PCST) and behavioral weight management (BWM), (2) PCST only (3) BWM only, or (4) standard care control	6, 12, 18 mos	WOMAC pain, stiffness, and physical function: ↑* between PCST + BWM AIMS pain and physical: ↑* between PCST + BWM Posttreatment average assessment: ↑*	
Song et al. (2003)	63 yrs old, ♀, knee OA	43	ACR and radiographic evidence	EG: Sun-style tai chi exercise program (12 movements repeated three to five times), three times per week for 12 wks CG: No intervention	12 wks	WOMAC: ↑* pain and stiffness between groups; ↑ physical function between groups	
Sullivan et al. (1998)	73 yrs old, ♂ (15%) and ♀ (85%), knee OA	52	Radiographic evidence	EG: 30 min of indoor walking 3 times per week for 8 wks, then encouraged to keep up walking. Three sessions a week for 8 wks consisting of stretching and strengthening exercises, expert speakers, group discussions, instruction in safe walking techniques, and up to 30 mins of indoor track walking CG: Usual care and weekly interview	8 wks, 1 yr	VAS: no change between groups	AIMS: No change for physical function, arthritis impact, arthritis pain, medication use, general health perception
Talbot et al. (2003)	70 yrs old, ♂ (23%) and ♀ (77%), knee OA	34	Radiographic evidence	EG: Pedometer-driven walking, walking 30% above their baseline step count by the end of 12 wks and 12 hrs of arthritis self-management program CG: 12 h of arthritis self-management program	3, 6 mos	Pain Intensity Scale: no change between groups Pain (MPQ): no change between groups	Timed walk test: no significant change Timed stair climbing test: no significant change Timed chair-rise test: No significant change
Thorstensson et al. (2005)	65 yrs old, ♂ (49%) and ♀ (51%), knee OA	56	Radiographic evidence	EG: 1-hr exercise sessions, twice a week for 6 wks (aerobic exercise, strengthening, and flexibility). Three exercises (most challenging to the individual) were chosen as daily home exercises. Patients were recommended to perform some kind of weight bearing submaximal activity such as walking for 30 min a day. CG: No intervention	6 wks, 6 mos	KOOS: ↑* between groups for QOL; no change for pain, symptoms, ADL, and sport/recreation	

(Continued on next page)

TABLE 1. *(Continued)*

Study	Participants			Methodology		Outcome Measures and Results	
Author (Year)	Mean Age, Sex, Joint/s	Sample Size	OA Confirmation	Description of Intervention	Follow-up	Primary Outcome Measure	Secondary Outcome Measure
Wang et al. (2009)	65 yrs old, ♂ (25%) and ♀ (75%), knee OA	40	ACR and radiographic evidence	EG: 60-min Tai Chi sessions two times per week for 12 wks. Instructed to practice 20 mins per day at home. After 24 treatment sessions, subjects asked to keep practicing tai chi at home CG: Two 60-min class sessions per week for 12 wks. Didactic lessons on OA, diet and nutrition, therapies or physical and mental health education. Stretching upper body, trunk, and lower body. Instructed to practice at least 20 min of stretching exercises per day at home.	12, 24, and 48 wks	WOMAC pain: ↑* between groups at week 12	WOMAC physical function: ↑* between groups at week 12 and 24 VAS: physician and patient ↑* between groups at week 12 6MWT: No significant change Timed chair-rise test: ↑* between groups at week 12, 24 and 48
Wang et al. (2011)	68 yrs old, ♂ (14%) and ♀ (86%), knee OA	78	Radiographic evidence	EG: 60-min flexibility, strengthening (upper and lower body), and aerobic training class, three times per week for 12 wks CG: Usual care	6, 12 wks	KOOS pain: ↑coefficient of modeling 6MWT: ↑ group-by-time	
Yip et al. (2008)	63 yrs old, ♂ (14%) and ♀ (86%) Knee OA	95	ACR	EG: Intervention consisted of six 2-hr classes held once a week: stretching and walking exercises. Tai chi (eight movements—around 15 mins to complete). Given a pedometer three times per week to reinforce walking CG: Usual care	1 wk, 4 mos, 12 mos	VAS: ↑* between groups	

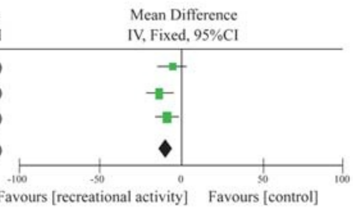
*: significant improvement; ↑: improvement; ♂: male; ♀: female.
ACR indicates American College of Rheumatology classification criteria; CG, control group; EG, experimental group; MPQ, McGill Pain Questionnaire; ROM, range of motion; QOL, quality of life; VAS, visual analog scale.

Recreational activity

1.1 Physical function (WOMAC) at 3 months from randomization

Study or subgroup	Recreational activity Mean	SD	Total	Control Mean	SD	Total	Weight	Mean Difference IV, Fixed, 95%CI
Brismee 2007	31.82	14	20	37.77	11.22	13	25.8%	-5.95 (-14.60, 2.70)
Fransen 2007	36.6	20.9	56	49.9	19	41	30.2%	-13.30 (-21.29, -5.31)
Song 2003	27.5	10	22	36.6	12	21	44.0%	-9.10 (-15.72, -2.48)
Total (95% CI)			98			75	100%	-9.56 (-13.95, -5.17)

Heterogeneity: $Chi^2 = 1.53$, df = 2 ($P = 0.47$); $I^2 = 0\%$
Test for overall effect: $Z = 4.27$ ($P < 0.0001$)

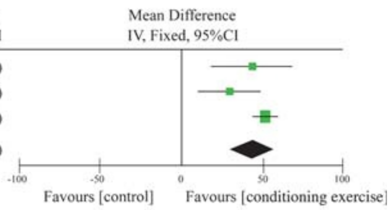


Conditioning exercise

2.1 Physical performance (6MWT) at 6 months from randomization

Study or subgroup	Conditioning exercise Mean	SD	Total	Control Mean	SD	Total	Weight	Mean Difference IV, Fixed, 95%CI
Focht 2005	472.74	90.52	80	430.07	79.55	80	20.7%	42.67 (16.26, 69.08)
Messier 2013	533	86.10	130	505	76.66	123	28.5%	28.00 (7.94, 48.06)
Miller 2006	510	15	39	459	17.4	32	50.8%	51.00 (43.35, 58.65)
Total (95% CI)			249			235	100%	42.72 (27.78, 57.66)

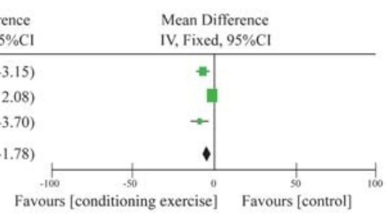
Heterogeneity: $Tau^2 = 99.16$, $Chi^2 = 4.56$, df = 2 ($P = 0.10$); $I^2 = 56\%$
Test for overall effect: $Z = 5.60$ ($P < 0.0001$)



2.2 Physical function (WOMAC) at 6 months from randomization

Study or subgroup	Conditioning exercise Mean	SD	Total	Control Mean	SD	Total	Weight	Mean Difference IV, Fixed, 95%CI
Hughes 2006	17.74	12.9	115	24.46	13.65	100	30.3%	-6.72 (-10.29, -3.15)
Messier 2013	17.7	11.16	130	18.3	10.61	123	53.6%	-0.60 (-3.28, 2.08)
Miller 2006	15.2	9.37	39	23.8	11.83	35	16.1%	-8.60 (-13.50, -3.70)
Total (95% CI)			284			258	100%	-3.74 (-5.70, -1.78)

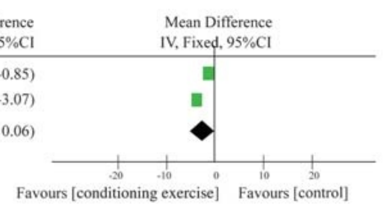
Heterogeneity: $Chi^2 = 11.73$, df = 2 ($P = 0.003$); $I^2 = 83\%$
Test for overall effect: $Z = 3.73$ ($P = 0.0002$)



2.3 Physical performance (timed-stair climbing test) at 6 months

Study or subgroup	Conditioning exercise Mean	SD	Total	Control Mean	SD	Total	Weight	Mean Difference IV, Fixed, 95%CI
Messier 2004	8.87	0.73	70	9.97	0.78	70	50.3%	-1.10 (-1.35, -0.85)
Miller 2006	7.7	0.4	39	11.2	1.2	33	49.7%	-3.50 (-3.93, -3.07)
Total (95% CI)			109			103	100%	-2.29 (-4.65, 0.06)

Heterogeneity: $Tau^2 = 2.85$, $Chi^2 = 90.56$, df = 1 ($P < 0.00001$); $I^2 = 99\%$
Test for overall effect: $Z = 1.91$ ($P = 0.06$)



2.4 Physical performance (timed-stair climbing test) at 18 months

Study or subgroup	Conditioning exercise Mean	SD	Total	Control Mean	SD	Total	Weight	Mean Difference IV, Fixed, 95%CI
Focht 2005	9.15	4.7	80	9.86	5.56	78	2.6%	-0.71 (-2.32, 0.90)
Messier 2004	8.89	0.78	64	9.37	0.76	67	97.4%	-0.48 (-0.74, -0.22)
Total (95% CI)			144			145	100%	-0.49 (-0.75, -0.23)

Heterogeneity: $Chi^2 = 0.08$, df = 1 ($P = 0.78$); $I^2 = 0\%$
Test for overall effect: $Z = 3.66$ ($P = 0.0003$)

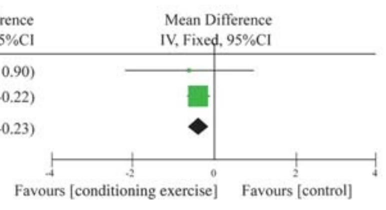


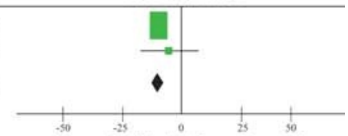
FIGURE 2. Effect of recreational activity and conditioning exercise interventions on physical function and performance.

Walking intervention

1.1 Physical function at 6 months from randomization

Study or subgroup	Walking intervention Mean	SD	Total	Control Mean	SD	Total	Weight	Mean Difference IV, Fixed, 95%CI
Evick 2002	10.2	2.4	28	20.7	4.4	26	97.5%	-10.50 (-12.41, -8.59)
Schlenk 2011	17.3	13.1	11	22.9	14.9	10	2.5%	-5.60 (-17.65, 6.45)
Total (95% CI)			39			36	100%	-10.38 (-12.27, -8.49)

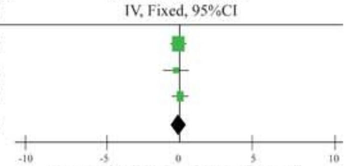
Heterogeneity: $Chi^2 = 0.62$, df = 1 (P = 0.43); $I^2 = 0\%$
Test for overall effect: Z = 10.78 (P < 0.00001)



1.2 Physical function at 12 months from randomization

Study or subgroup	Walking intervention Mean	SD	Total	Control Mean	SD	Total	Weight	Std. Mean Difference IV, Fixed, 95%CI
Brosseau 2012	24.5	13.8	43	25	13.5	40	53.5%	-0.04 (-0.47, 0.39)
Sclenk 2011	18.9	13.2	11	21.6	10.3	10	13.4%	-0.22 (-1.08, 0.64)
Sullivan 1998	4.2	2.6	29	4.1	2.1	23	33.1%	0.04 (-0.51, 0.59)
Total (95% CI)			83			73	100%	-0.03 (-0.35, 0.28)

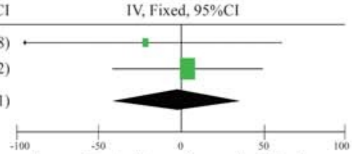
Heterogeneity: $Chi^2 = 0.25$, df = 2 (P = 0.88); $I^2 = 0\%$
Test for overall effect: Z = 0.22 (P = 0.83)



1.3 Physical performance (6MWT) at 12 months from randomization

Study or subgroup	Walking intervention Mean	SD	Total	Control Mean	SD	Total	Weight	Mean Difference IV, Fixed, 95%CI
Schlenk 2011	480	94.9	11	502	104.3	10	23.6%	-22.00 (-107.58, 63.58)
Brosseau 2012	524.86	106.5	44	520.5	115.1	40	76.4%	4.34 (-43.24, 51.92)
Total (95% CI)			55			50	100%	-1.88 (-43.46, 39.71)

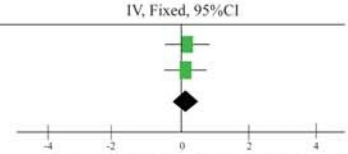
Heterogeneity: $Chi^2 = 0.28$, df = 1 (P = 0.60); $I^2 = 0\%$
Test for overall effect: Z = 0.09 (P = 0.93)



1.4 Pain at 3 months from randomization

Study or subgroup	Walking intervention Mean	SD	Total	Control Mean	SD	Total	Weight	Std. Mean Difference IV, Fixed, 95%CI
Bautch 1997	2.19	0.43	15	2.08	0.54	15	46.8%	0.22 (-0.50, 0.94)
Talbot 2003	1.35	0.93	17	1.2	0.95	17	53.2%	0.16 (-0.52, 0.83)
Total (95% CI)			32			32	100%	0.19 (-0.31, 0.68)

Heterogeneity: $Tau^2 = 0.00$, $Chi^2 = 0.02$, df = 1 (P = 0.90); $I^2 = 0\%$
Test for overall effect: Z = 0.74 (P = 0.46)



1.5 Pain at 6 months from randomization

Study or subgroup	Walking intervention Mean	SD	Total	Control Mean	SD	Total	Weight	Std. Mean Difference IV, Fixed, 95%CI
Evick 2002	3.6	1.3	28	6.8	1.1	26	49.8%	-2.61 (-3.35, -1.87)
Talbot 2003	1.07	0.8	17	1.57	1.12	17	50.2%	-0.50 (-1.19, 0.18)
Total (95% CI)			45			43	100%	-1.55 (-3.62, 0.52)

Heterogeneity: $Tau^2 = 2.09$, $Chi^2 = 16.84$, df = 1 (P < 0.0001); $I^2 = 94\%$
Test for overall effect: Z = 1.47 (P = 0.14)

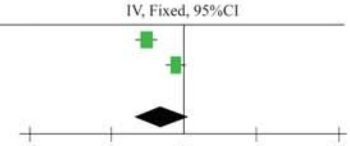


FIGURE 3. Effect of walking intervention on pain, physical function and performance.

estimate (meta-analysis) was not significant at 12 mos for the walking intervention (Fig. 3.1.3) when compared with the control group.[35,38]

Conditioning Exercise (Including Aerobic Component)

Ten articles reported on interventions that were a combination of strength training, flexibility, and aerobic interventions.[24,40–48] Four of 6 articles described significant improvement in physical performance when compared with the control group at 3 mos[40] and at 6 mos[41–43] when compared between or within groups. Three of 4 studies reported a significant improvement in the pain when compared with the control group.[24,43–45] With regard to physical function, Miller et al.[43] and Hughes et al.[24] found significant improvement on the WOMAC stiffness scale, whereas only one out of four reporting on the WOMAC physical function subscale found a significant improvement when compared with the control group.[43] Of the two studies reported on the KOOS for physical function,[40,46] Thorstensson et al.[46] found significant improvement in only the QOL section, while Wang et al.[40] found significant improvement in all sections. Of the studies reporting on AIMS, one study reported significant improvement compared with the control group for walking and bending and arthritis pain.[47] In addition, it reported significant improvement in the exercise group compared with baseline for support from friends and family, arthritis pain, work, and level of tension. Two other studies classified under this category included interventions such as individualized cycling program[49] and acupuncture as a cointervention, along with conditioning exercise.[50] Both these studies reported improved pain and function in the short-term (12 wks).

The meta-analysis for physical performance (Fig. 2.2.1) was significant in 6MWT, with a MD of 42.72 m (95% CI, 27.78–57.66) for conditioning exercise.[41–43] A moderate level of heterogeneity was observed, with an I^2 of 56%. The timed stair-climbing test was not significant at 6 mos[43,44] (Fig. 2.2.3) but was significant at 18 mos[41,44] (Fig. 2.2.4) from randomization (MD, −0.49 s; 95% CI, −0.75 to −0.23), with no heterogeneity (I^2 = 0%). The meta-analysis for physical function (WOMAC) at 6 mos (Fig. 2.2.2) was significant,[24,42,43] with a MD of −3.74 (95% CI, −5.70 to −1.78). A substantial level of heterogeneity was observed, with an I^2 of 83%.

Dropouts and Adverse Events

With the exception of three studies,[32,36,50] all included studies provided some or all details of dropouts. Only one out of six studies on recreational activity reported exacerbation of symptoms due to the intervention and which did not result in withdrawal from study participation. One other study reported 11 adverse events, which were not related to the intervention, whereas three other studies did not provide any details. Of the studies that had walking as an intervention, Peterson et al.[37] reported exacerbation of symptoms in a participant and Hughes et al.[24] reported no adverse events. Other studies provided details with regard to the adverse events. In the conditioning exercise category, exacerbation of symptoms was reported by three studies,[40,47,49] and three other studies reported injuries sustained because of trips/fall while participating in the intervention program.[42,44,48] Table 2 shows details of data extracted with regard to dropouts, adverse events, and adherence to the intervention. Adherence to intervention was measured and reported by 17 of the included studies.

Risk of Bias Assessment

The individual scoring of the risk of bias for each item is as shown in Table 3, and Figure 4 illustrates the overall summary of the included articles for each item. At least 50% of the included articles had a low risk of bias in most items, except for the blinding (participant and care provider), compliance, and intention-to-treat analysis.

DISCUSSION

The primary aim of this systematic review was to review and summarize the evidence for generic PA interventions, such as group classes or walking, in improving pain and physical function outcomes in people with OA. Three categories of PA interventions were identified by the review, namely, recreational activity, walking intervention, and conditioning exercise (a combination of aerobic and strengthening exercises). There is a low-level evidence to support recreational activity (tai chi and Baduanjin) and walking intervention in the short-term (3 and 6 mos, respectively). However, the effects of these interventions in the longer-term were unable to be ascertained. The conditioning exercise that included aerobic and muscle strengthening exercise reportedly had a greater effect size on physical function than control intervention.

A previous systematic review on the effectiveness of tai chi in OA suggested that it may be effective to control pain.[51] However, it is still inconclusive if this effect is sustained in the longer term. Six included studies investigated the effect/efficacy of martial arts such as tai chi and Baduanjin on hip and/or knee OA. With the exception of one that had followed up for 48 wks,[30] most studies had an intervention and/or follow-up duration of less than 6 mos. The individual studies reported significant improvement in pain and/or function at 3 mos but no significant effect when compared with the control group at 6 mos or beyond. The meta-analysis of two studies also reinforced this with an effect size of −7.94 for physical function (as measured by WOMAC) at 3 mos. However, these MDs are below the threshold for minimal detectable change in the short-term for WOMAC (hip, −9.1[52]; knee, −14.1[53]).

Walking is a low-cost, feasible PA program that can be undertaken as a home-based activity and does not require supervision or special training. The effects of a walking intervention have been investigated by nine studies, with most studies following up for 6 mos or longer. However, the evidence to support its effect on pain and physical function is limited. The meta-analysis for pain with two studies at 3 and 6 mos suggested no effect, whereas for the physical function showed an effect size of −10.38 at 6 mos but not at 12 mos.

The dosage of walking and adherence to the intervention is most likely to have an effect on the significance of the results in studies using walking as an intervention to improve PA. Generally, adherence to walking intervention in the included studies was greater than 60%, ranging up to 80%. However, not all included studies reported adherence to PA after the intervention period (during follow-up). Post-intervention adherence and subsequent inclusion of this data in the analysis

TABLE 2. Summary of dropouts, adverse events, and adherence to intervention as reported in the included studies

Study ID	Dropouts	Adverse Events	Adherence Measure and Result
An et al. (2008)	Seven participants withdrew from the trial; two moved outside of the area of study and five had no time to exercise or were unable to complete the endpoint test.	None	Unknown
Bautch et al. (1997)	Four participants withdrew; reasons unspecified.	Unknown—nil reported	Unknown
Brismee et al. (2007)	EG: Four participants withdrew: two because of travel and illness and two because of reasons unknown. CG: Six participants withdrew, because of loss of interest, personal, and reasons unknown.	Unknown—nil reported	Unknown
Brosseau et al. (2012)	At 18 mos: EG: 44.3% for the walking group, 40.6% for the walking + behavioral group CG: 52.1%	Unknown—nil reported	EG: 80% to intervention CG: 65% adherence to the self-directed control
Evcik et al. (2002)	EG: Five participants withdrew: three out of contact and two unwilling to participate further. CG: Four participants withdrew; all unwilling to participate further.	Unknown—nil reported	Unknown
Focht et al. (2005)	64 participants withdrew; no statistically significant difference between the groups.	Unknown—nil reported	EG: 60% CG: 75% No statistical significant difference between groups.
Fransen et al. (2007)	EG: Four participants withdrew because they disliked the classes or believed the classes exacerbated their knee and back pain.	11 serious adverse events requiring hospitalization reported but none occurred during the classes or were deemed related to the intervention.	Attendance rates EG: 62 (81%) participants attended ≥12 of the 24 available classes.
Hiyama et al. (2012)	None	Unknown—nil reported	Unknown
Huang et al. (2000)	Unknown—nil reported	Unknown—nil reported	Unknown
Hughes et al. (2006)	At 2 mos: Lost 28% and 45% of intervention and control groups, respectively, to follow-up. At 6 mos: Lost 36% and 56% of intervention and control groups, respectively, to follow-up. At 12 mos: Lost 50% and 68% intervention and control, respectively, groups to follow-up.	No adverse events were experienced by participants.	EG: 70% of the participants attended 75% intervention of the sessions.
Lee et al. (2009)	Total dropout was three (one in control and two in wait list). One female patient in the intervention group was withdrawn from the study protocol because of the clinical condition. One moved to another place and one with no reason given.	Unknown—nil reported	Unknown
Mangani et al. (2006)	Unknown	Unknown—nil reported	Reportedly, 64% (n = 279) of the total participants attended 70% or more of the intervention sessions.

Mssier et al. (2004)	EG: 10 dropped out at the first time point and 16 dropped out at the second time point of measurement. CG: 8 dropped out at the first time point and 11 dropped out at the second time point.	Two participants died during the study, of cause unrelated to the interventions. One serious adverse event occurred—where a participant tripped while exercising and sustained a head laceration.	EG: Adherence rates of 60%. CG: Adherence rates of 77% in the first 3 mos and 73% for the remainder of the study period. No significant difference between the groups was observed in adherence.
Messier et al. (2013)	EG: 20 dropped out at the first time point and 16 dropped out at the second time point. CG: 29 dropped out at the first time point and 23 dropped out at the second time point.	Three nonserious adverse events related to the trial included a muscle strain and two trips/falls during exercise sessions that resulted in soreness and bruising. Other 10 serious adverse events were unrelated to the study, which included surgery and/or joint replacement.	Adherence to exercise for the experimental group was 66% in first 6 mos and 54% for 18 mos. Adherence to the intervention for the control group (diet) was 61%.
Miller et al. (2006)	EG: Eight dropped out at 6 mos. CG: Five dropped out at 6 mos.	No adverse events or serious adverse, events were reported.	EG: Participants attended an average of 77.5% of the exercise sessions over the 6-mo study duration. CG: Participants attended 75% of the nutrition sessions.
Peloquin et al. (1999)	10 from the experimental and 3 from the control group dropped out with medical problems unrelated to study and lack of time.	One participant reported exacerbation of knee symptoms.	Average of 86% attendance in the experimental and 82% in the control group was reported.
Peterson et al. (1993)	Five from the experiment group and five from the control group dropped out. One in control group was because of a fall; the rest were all not related to OA experiment.	One participant sustained a hip fracture during session and one participant reported exacerbation of OA symptoms.	Unknown
Salacinski et al. (2012)	Six dropped out from the experimental group and three from the control group.	2 participants stopped participating due to knee pain and 1 due to wrist pain while riding bike.	Average attendance to the intervention (cycling) was 68%.
Schlenk et al. (2011)	Two participants from the experimental group and three from the control group dropped out.	Unknown—nil reported	Self-report diary of activity. Results unknown.
Somers et al. (2012)	Seventy percent (n = 163) of all randomized participants completed the 2-yr study. EG (body weight management including exercises): 22% dropped out during the intervention because of reasons unrelated to the study and 32% dropped out at the final time point. CG (standard care): 20% dropped out during the intervention because of reasons unrelated to the study and 27% dropped out at the final time point.	One adverse event—participant fell off of the treadmill during the exercise session, resulting in superficial injuries.	EG: Average attendance at the intervention session was 65%.
Song et al. (2003)	Reportedly, 43% and 39% dropped out from experimental and control groups, respectively. However, it is unclear which segment of the study they dropped out.	Unknown—nil reported	Unknown

(Continued on next page)

TABLE 2. *(Continued)*

Study ID	Dropouts	Adverse Events	Adherence Measure and Result
Sullivan et al. (1998)	EG: 32% dropped out from the study at the first time point. CG: 49% dropped out from the study at the first time point.	Unknown—nil reported	Self-reported walking distance—which declined over time. EG: Declined by 42% from the postintervention measurement. CG: Declined by 26% from the postintervention measurement.
Talbot et al. (2003)	EG: 2 participants dropped out due to lack of interest. CG: 4 participants dropped out due to causes unrelated to the study.	Unknown—nil reported	EG: Wearing the pedometer and daily recording on the log was 76%. Average compliance rate for meeting the step goal was 48%, ranging from a high of 56% (weeks 4–8) to a low of 35% (weeks 9–12). CG: Average adherence to arthritis self-management course was 77.1%.
Thorstensson et al. (2005)	EG: One with increased knee symptoms and one due to work commitments. CG: Two dropped out because of reasons unrelated to intervention (lack of time and sudden illness).	Unknown—nil reported	Average compliance in the intervention group was 89.9%.
Wang et al. (2009)	No dropout/withdrawal from the study.	One participant had an increase in knee pain initially but reportedly was resolved following modification of that participant's technique.	Adherence to intervention was 85% for the experimental group (tai chi) and 89% for the control group.
Wang et al. (2011)	Two participants in the intervention group (land based) and two from the control group dropped out.	Two participants in the land-based exercise group reported increased pain after exercise.	The adherence to the land-based exercise program was 86%.
Yip et al. (2008)	EG: 11% (n = 5) dropped out at the first time point and 22% dropped out at final assessment time. CG: 26% (n = 13) dropped out at the first time point and 22% dropped out at final assessment time.	Nil reported	Unknown

CG indicates control group; EG, experimental group.

TABLE 3. Quality scoring of the included studies using the Cochrane Risk of Bias tool

Author (Year)	Adequate Random Sequence Generation	Adequate Allocation Concealment	Blinding of Participants	Blinding of Personnel/Care Providers	Blinding of Outcome Assessor	Group Similarity at Baseline	Cointerventions Similar or Avoided	Dropout Rate Described and Acceptable	Intention-to-Treat Analysis	Timing of Outcome Assessments Similar	Adequate Compliance	All Outcome Measures Reported
An et al. (2008)	Unclear	Unclear	No	Unclear	Unclear	Yes	Yes	No	No	Yes	Unclear	Yes
Bautch et al. (1997)	Unclear	Unclear	Unclear	No	Yes	No	Yes	Yes	No	Yes	Unclear	Yes
Brismee et al. (2007)	Yes	Unclear	No	No	Yes	Yes	Yes	No	Yes	Yes	Yes	Yes
Brosseau et al. (2012)	Yes	Yes	No	No	Yes	Yes	Yes	No	Yes	Yes	No	Yes
Evcik et al. (2002)	Unclear	Unclear	Unclear	Unclear	Unclear	Yes	Unclear	Yes	No	Yes	Unclear	Yes
Focht et al. (2005)	Yes	Yes	No	No	Yes	Yes	Yes	Yes	Yes	Yes	No	Yes
Fransen et al. (2007)	Yes	Yes	No	No	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Hiyama et al. (2012)	Yes	Yes	Unclear	Unclear	Yes	Yes	Unclear	Yes	N/A	Yes	Unclear	Yes
Huang et al. (2000)	Unclear	Unclear	Unclear	Unclear	Unclear	Yes	No	No	No	No	Unclear	Yes
Hughes et al. (2006)	Yes	Yes	No	Unclear	Unclear	Yes	Yes	No	No	Yes	Yes	Yes
Lee et al. (2009)	Yes	Yes	No	No	Yes	Yes	Yes	Yes	Yes	Yes	Unclear	Yes
Mangani et al. (2006)	Unclear	Unclear	Unclear	Unclear	Unclear	Yes	Unclear	Yes	No	Yes	Unclear	Yes
Messier et al. (2004)	Yes	Yes	No	No	Yes	Yes	Yes	Yes	Yes	Yes	No	Yes
Messier et al. (2013)	Unclear	Unclear	No	No	Yes	Yes	Yes	Yes	Yes	Yes	No	Yes
Miller et al. (2006)	Unclear	Unclear	Unclear	Unclear	Unclear	Yes	Yes	Yes	No	Yes	Yes	Yes
Peloquin et al. (1999)	Yes	Unclear	Unclear	Unclear	Yes	Yes	Yes	Yes	No	Yes	Yes	Yes
Peterson et al. (1993)	Unclear	Unclear	Unclear	Unclear	Unclear	Yes	Yes	Yes	No	Yes	Unclear	Yes
Salacinski et al. (2012)	Yes	Yes	No	Unclear	Yes	Yes	Yes	No	Yes	Yes	No	Yes
Schlenk et al. (2011)	Unclear	Unclear	Unclear	Unclear	Unclear	Yes	Yes	Yes	Yes	Yes	Unclear	Yes
Somers et al. (2012)	Yes	Yes	No	Unclear	Yes	Yes	Yes	No	Yes	Yes	No	Yes

(Continued on next page)

TABLE 3. (Continued)

Author (Year)	Adequate Random Sequence Generation	Adequate Allocation Concealment	Blinding of Participants	Blinding of Personnel/Care Providers	Blinding of Outcome Assessor	Group Similarity at Baseline	Cointerventions Similar or Avoided	Dropout Rate Described and Acceptable	Intention-to-Treat Analysis	Timing of Outcome Assessments Similar	Adequate Compliance	All Outcome Measures Reported
Song et al. (2003)	Yes	Unclear	Unclear	Unclear	Unclear	Yes	Yes	No	No	Yes	Unclear	Yes
Sullivan et al. (1998)	Unclear	Unclear	Unclear	Unclear	Unclear	Yes	Yes	No	No	Yes	No	Yes
Talbot et al. (2003)	Yes	Yes	Unclear	Unclear	No	Yes	Yes	Yes	N/A	Yes	Yes	Yes
Thorstensson et al. (2005)	Yes	Yes	No	Unclear	Unclear	Yes	Yes	Yes	No	Yes	Yes	Yes
Wang et al. (2009)	Yes	Yes	Yes	No	No	Yes	No	Yes	N/A	Yes	Yes	Yes
Wang et al. (2011)	Yes	Yes	Unclear	Unclear	Yes	Yes	Yes	Yes	No	Yes	Yes	Yes
Yip et al. (2008)	Yes	Unclear	Unclear	Unclear	Yes	No	Yes	No	Yes	Yes	Unclear	Yes

may provide more meaningful findings and the importance of PA. Although all included studies used a graduated walking program, significant differences in function were systematically observed in studies that were most likely to meet the recommended PA guidelines.

The reports of articles with a combination of aerobic, strengthening, and endurance circuit exercises included in this review were mostly positive on pain and physical function. Previously, a number of systematic reviews on exercise therapy interventions have determined its positive effect on pain and function in both short- and long-term.[3,54] Although this may be attributed to a physiological response such as increased muscle strength[55] and balance, it may be prudent to also postulate a social-cognitive paradigm owing to the communal nature of these interventions used in most of the studies.[56]

PA interventions typically teach individuals to pace themselves back to activities, which reflects the positive effect on the functional outcomes in individuals with OA. Nevertheless, the effects may also be attributed to the levels of PA of the included interventions. When these activities are mapped to the compendium of physical activities, the average metabolic equivalent for each of the categories included in the review are 2.5 to 3.8 for walking (codes 17150 to 17200), 4.0 for tai chi (15670), and 7.0 to 8.0 for conditioning exercises (02010; 02040); thus, activities vary from light to vigorous intensity. The conditioning exercises in addition to the higher metabolic equivalent also have the potential to enhance strength, balance, and joint stability and thereby improve function, which may have contributed to better outcomes.

OA is a long-term condition, which often results in chronic pain. Currently, there is very limited evidence to show that pain levels can be changed with recreational activity (martial arts) or walking program. Although these PA interventions may be effective in the long-term in OA, these need to be investigated further.

Risk of Bias

The quality of the included articles as assessed by the risk of bias checklist suggests that the reporting of blinding of participants and providers and the compliance of the study participants need to be stated explicitly. Although the CONSORT guidelines may have been adhered to in most of the included articles, it was unable to be ascertained in the absence of a common taxonomy and/or inadequate reporting.

Strengths and Limitations

To the authors' knowledge, this is the first study to review the evidence for PA interventions in hip and knee OA. However, the review included only peer-reviewed journal publications and excluded conference and thesis publications. Also, the review only considered published data and the authors did not attempt to contact the authors for unpublished data as some of the included studies were published more than a decade ago. Therefore the meta-analysis has to be interpreted with due caution. Furthermore, the review protocol was never registered and therefore a protocol is not available.

CONCLUSION

PA interventions such as recreational activity (tai chi, Baduajin) and walking have very limited evidence to suggest

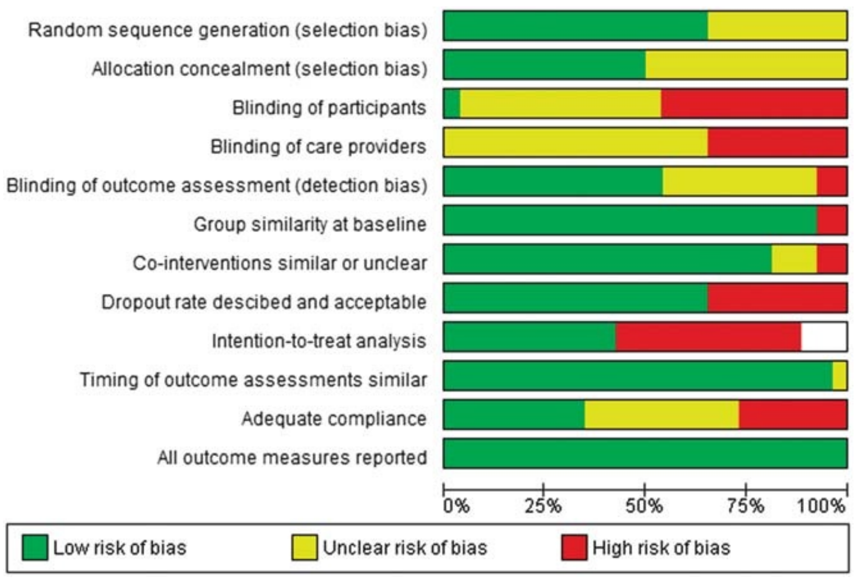


FIGURE 4. Summary of risk of bias assessment.

a positive effect on pain and function in individuals with knee OA in the short-term. The effect of these interventions in the long-term needs future investigations. Conditioning exercises have moderate level of evidence for effectiveness on physical function in individuals with knee OA, in the short- and in the longer-term.

ACKNOWLEDGMENTS

The authors acknowledge the School of Physiotherapy Research Support Fund, University of Otago, which funded the stipend for summer studentship (S. Fernandopulle) and remuneration for the research assistant (D. Manlapaz).

REFERENCES

1. Garstang SV, Stitik TP: Osteoarthritis: Epidemiology, risk factors, and pathophysiology. *Am J Phys Med Rehabil* 2006;85:S2–11
2. Wallis JA, Taylor NF: Pre-operative interventions (non-surgical and non-pharmacological) for patients with hip or knee osteoarthritis awaiting joint replacement surgery—A systematic review and meta-analysis. *Osteoarthritis Cartilage* 2011;19:1381–95
3. Jamtvedt G, Dahm KT, Christie A, et al: Physical therapy interventions for patients with osteoarthritis of the knee: An overview of systematic reviews. *Phys Ther* 2008;88:123–36
4. Fransen M, McConnell S, Bell M: Therapeutic exercise for people with osteoarthritis of the hip or knee: A systematic review. *J Rheumatol* 2002;29:1737–45
5. Fransen M, McConnell S, Harmer AR, et al: Exercise for osteoarthritis of the knee: A Cochrane systematic review. *Br J Sports Med* 2015;49:1554–7
6. McAlindon TE, Bannuru RR, Sullivan MC, et al: OARSI guidelines for the non-surgical management of knee osteoarthritis. *Osteoarthritis Cartilage* 2014;22:363–88
7. Fernandes L, Hagen KB, Bijlsma JW, et al: EULAR recommendations for the non-pharmacological core management of hip and knee osteoarthritis. *Ann Rheum Dis* 2013;72:1125–35
8. Bruyère O, Cooper C, Pelletier J-P, et al: An algorithm recommendation for the management of knee osteoarthritis in Europe and internationally: A report from a task force of the European Society for Clinical and Economic Aspects of Osteoporosis and Osteoarthritis (ESCEO). *Semin Arthritis Rheum* 2014;44:253–63
9. Hochberg MC, Altman RD, April KT, et al: American College of Rheumatology 2012 recommendations for the use of nonpharmacologic and pharmacologic therapies in osteoarthritis of the hand, hip, and knee. *Arthritis Care Res (Hoboken)* 2012;64:465–74
10. Haskell WL, Lee IM, Pate RR, et al: Physical activity and public health: Updated recommendation for adults from the American College of Sports Medicine and the American Heart Association. *Med Sci Sports Exerc* 2007;39:1423–34
11. Caspersen CJ, Powell KE, Christenson GM: Physical activity, exercise, and physical fitness: Definitions and distinctions for health-related research. *Public Health Rep* 1985;100:126–31
12. Khan KM, Thompson AM, Blair SN, et al: Sport and exercise as contributors to the health of nations. *Lancet* 2012;380:59–64
13. Bartels EM, Juhl CB, Christensen R, et al: Aquatic exercise for the treatment of knee and hip osteoarthritis. *Cochrane Database Syst Rev* 2016;3:CD005523
14. Gay C, Chabaud A, Guilley E, et al: Educating patients about the benefits of physical activity and exercise for their hip and knee osteoarthritis. Systematic literature review. *Ann Phys Rehabil Med* 2016;59:174–83
15. Dobson F, Bennell KL, French SD, et al: Barriers and facilitators to exercise participation in people with hip and/or knee osteoarthritis: Synthesis of the literature using behavior change theory. *Am J Phys Med Rehabil* 2016;95:372–89
16. Williamson W, Kluzek S, Roberts N, et al: Behavioural physical activity interventions in participants with lower-limb osteoarthritis: A systematic review with meta-analysis. *BMJ Open* 2015;5:e007642
17. Moher D, Liberati A, Tetzlaff J, et al: Preferred reporting items for systematic reviews and meta-analyses: The PRISMA statement. *PLoS Med* 2009;6:e1000097
18. Higgins JPT, Green S: Cochrane handbook for systematic reviews of interventions. Version 5.0.2. The Cochrane Collaboration. 2008. Updated September 2009. www.cochrane-handbook.org
19. Bellamy N, Kirwan J, Boers M, et al: Recommendations for a core set of outcome measures for future phase III clinical trials in knee, hip, and hand osteoarthritis. Consensus development at OMERACT III. *J Rheumatol* 1997;24:799–802
20. Bennell K, Dobson F, Hinman R: Measures of physical performance assessments: Self-paced walk test (SPWT), stair climb test (SCT), six-minute walk test (6MWT), chair stand test (CST), timed up & go (TUG), sock test, lift and carry test (LCT), and car task. *Arthritis Care Res (Hoboken)* 2011;63:S350–70
21. French HP, Brennan A, White B, et al: Manual therapy for osteoarthritis of the hip or knee—A systematic review. *Man Ther* 2011;16:109–17
22. Ainsworth BE, Haskell WL, Whitt MC, et al: Compendium of physical activities: An update of activity codes and MET intensities. *Med Sci Sports Exerc* 2000;32(9 suppl):S498–504
23. Ainsworth BE, Haskell WL, Herrmann SD, et al: 2011 Compendium of Physical Activities: A second update of codes and MET values. *Med Sci Sports Exerc* 2011;43:1575–81
24. Hughes SL, Seymour RB, Campbell RT, et al: Long-term impact of Fit and Strong! on older adults with osteoarthritis. *Gerontologist* 2006;46:801–14
25. Fransen M, Nairn L, Winstanley J, et al: Physical activity for osteoarthritis management: A randomized controlled clinical trial evaluating hydrotherapy or Tai Chi classes. *Arthritis Rheum* 2007;57:407–14
26. An B, Dai K, Zhu Z, et al: Baduanjin alleviates the symptoms of knee osteoarthritis. *J Altern Complement Med* 2008;14:167–74
27. Brismée JM, Paige RL, Chyu MC, et al: Group and home-based tai chi in elderly subjects with knee osteoarthritis: A randomized controlled trial. *Clin Rehabil* 2007;21:99–111
28. Lee HJ, Park HJ, Chae Y, et al: Tai Chi Qigong for the quality of life of patients with knee osteoarthritis: A pilot, randomized, waiting list controlled trial. *Clin Rehabil* 2009;23:504–11
29. Song R, Lee EO, Lam P, et al: Effects of tai chi exercise on pain, balance, muscle strength, and perceived difficulties in physical functioning in older women with osteoarthritis: A randomized clinical trial. *J Rheumatol* 2003;30:2039–44
30. Wang C, Schmid CH, Hibberd PL, et al: Tai Chi is effective in treating knee osteoarthritis: A randomized controlled trial. *Arthritis Rheum* 2009;61:1545–53
31. Evcik D, Sonel B: Effectiveness of a home-based exercise therapy and walking program on osteoarthritis of the knee. *Rheumatol Int* 2002;22:103–6

32. Hiyama Y, Yamada M, Kitagawa A, et al: A four-week walking exercise programme in patients with knee osteoarthritis improves the ability of dual-task performance: A randomized controlled trial. *Clin Rehabil* 2012;26:403–12
33. Talbot LA, Gaines JM, Huynh TN, et al: A home-based pedometer-driven walking program to increase physical activity in older adults with osteoarthritis of the knee: A preliminary study. *J Am Geriatr Soc* 2003;51:387–92
34. Bautch JC, Malone DG, Vailas AC: Effects of exercise on knee joints with osteoarthritis: A pilot study of biologic markers. *Arthritis Care Res* 1997;10:48–55
35. Brosseau L, Wells GA, Kenny GP, et al: The implementation of a community-based aerobic walking program for mild to moderate knee osteoarthritis (OA): A knowledge translation (KT) randomized controlled trial (RCT): Part I: The Uptake of the Ottawa Panel clinical practice guidelines (CPGs). *BMC Public Health* 2012;12:871
36. Mangani I, Cesari M, Kritchevsky SB, et al: Physical exercise and comorbidity. Results from the Fitness and Arthritis in Seniors Trial (FAST). *Aging Clin Exp Res* 2006;18:374–80
37. Peterson MG, Kovar-Toledano PA, Otis JC, et al: Effect of a walking program on gait characteristics in patients with osteoarthritis. *Arthritis Care Res* 1993;6:11–6
38. Schlenk EA, Lias JL, Sereika SM, et al: Improving physical activity and function in overweight and obese older adults with osteoarthritis of the knee: A feasibility study. *Rehabil Nurs* 2011;36:32–42
39. Sullivan T, Allegrante JP, Peterson MG, et al: One-year follow up of patients with osteoarthritis of the knee who participated in a program of supervised fitness walking and supportive patient education. *Arthritis Care Res* 1998;11:228–33
40. Wang TJ, Lee SC, Liang SY, et al: Comparing the efficacy of aquatic exercises and land-based exercises for patients with knee osteoarthritis. *J Clin Nurs* 2011;20:2609–22
41. Focht BC, Rejeski WJ, Ambrosius WT, et al: Exercise, self-efficacy, and mobility performance in overweight and obese older adults with knee osteoarthritis. *Arthritis Rheum* 2005;53:659–65
42. Messier SP, Mihalko SL, Legault C, et al: Effects of intensive diet and exercise on knee joint loads, inflammation, and clinical outcomes among overweight and obese adults with knee osteoarthritis: The IDEA randomized clinical trial. *JAMA* 2013;310:1263–73
43. Miller GD, Nicklas BJ, Davis C, et al: Intensive weight loss program improves physical function in older obese adults with knee osteoarthritis. *Obesity (Silver Spring)* 2006;14:1219–30
44. Messier SP, Loeser RF, Miller GD, et al: Exercise and dietary weight loss in overweight and obese older adults with knee osteoarthritis: The Arthritis, Diet, and Activity Promotion Trial. *Arthritis Rheum* 2004;50:1501–10
45. Yip YB, Sit JW, Wong DY, et al: A 1-year follow-up of an experimental study of a self-management arthritis programme with an added exercise component of clients with osteoarthritis of the knee. *Psychol Health Med* 2008;13:402–14
46. Thorstensson CA, Roos EM, Petersson IF, et al: Six-week high-intensity exercise program for middle-aged patients with knee osteoarthritis: A randomized controlled trial [ISRCTN20244858]. *BMC Musculoskelet Disord* 2005;6:27
47. Peloquin L, Bravo G, Gauthier P, et al: Effects of a cross-training exercise program in persons with osteoarthritis of the knee. A randomized controlled trial. *J Clin Rheumatol* 1999;5:126–36
48. Somers TJ, Blumenthal JA, Guilak F, et al: Pain coping skills training and lifestyle behavioral weight management in patients with knee osteoarthritis: A randomized controlled study. *Pain* 2012;153:1199–209
49. Salacinski AJ, Krohn K, Lewis SF, et al: The effects of group cycling on gait and pain-related disability in individuals with mild-to-moderate knee osteoarthritis: A randomized controlled trial. *J Orthop Sports Phys Ther* 2012;42:985–95
50. Huang MH, Chen CH, Chen TW, et al: The effects of weight reduction on the rehabilitation of patients with knee osteoarthritis and obesity. *Arthritis Care Res* 2000;13:398–405
51. Lee MS, Pittler MH, Ernst E: Tai chi for osteoarthritis: A systematic review. *Clin Rheumatol* 2008;27:211–8
52. Pua Y-H, Cowan SM, Wrigley TV, et al: The Lower Extremity Functional Scale could be an alternative to the Western Ontario and McMaster Universities Osteoarthritis Index physical function scale. *J Clin Epidemiol* 2009;62:1103–11
53. Williams VJ, Piva SR, Irrgang JJ, et al: Comparison of reliability and responsiveness of patient-reported clinical outcome measures in knee osteoarthritis rehabilitation. *J Orthop Sports Phys Ther* 2012;42:716–23
54. Pisters MF, Veenhof C, van Meeteren NL, et al: Long-term effectiveness of exercise therapy in patients with osteoarthritis of the hip or knee: A systematic review. *Arthritis Rheum* 2007;57:1245–53
55. Runhaar J, Luijsterburg P, Dekker J, et al: Identifying potential working mechanisms behind the positive effects of exercise therapy on pain and function in osteoarthritis; A systematic review. *Osteoarthritis Cartilage* 2015;23:1071–82
56. Clarke SP, Poulis N, Moreton BJ, et al: Evaluation of a group acceptance commitment therapy intervention for people with knee or hip osteoarthritis: A pilot randomized controlled trial. *Disabil Rehabil* 2017;39:663–70