THE EFFECTIVENESS OF INTERVENTIONS TO INCREASE PHYSICAL ACTIVITY AND EXERCISE FOR ADULTS WITH LONG TERM MUSCULOSKELETAL CONDITIONS: A RAPID REVIEW.

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CONTENTS

ABSTRACT

Background: The majority of people with long term musculoskeletal conditions do not meet physical activity guidelines and as such have increased risk of co-morbidity relative to their peers. This rapid review was undertaken as part of the development of a trial intervention: “WALK30X5” The development and feasibility evaluation of a physiotherapy walking programme for people with mild to moderate musculoskeletal conditions (ISRCTN78581097).

Aim: The aim was to undertake a rapid review evaluating the effectiveness of existing interventions of walking programmes, physical activity and aerobic exercise interventions, used to reduce pain and improve function and levels of physical activity, for adults with osteoarthritis, fibromyalgia and back pain.

Methods: The Cochrane Database of Systemic Reviews, the Database of Abstracts of Reviews of Effects, PUBMED plus reference lists of identified reviews were searched for systematic reviews, guidelines and additional trial. Search dates: 1st Jan 2005-30 June 2015. Broad search terms were used. Searches were limited to title and abstract, adults, and English. One reviewer extracted data which a second reviewer checked against source data. Data were synthesised by two researchers and discussed by the team until consensus was agreed upon the strength of evidence. Assessments of quality and risk of bias were reported where incorporated into included publications.

Results: 31 reviews and clinical guidelines included for people with osteoarthritis, 15 for fibromyalgia, 11 for back pain, plus 6 additional trials (7 publications), not included in reviews/guidelines. There was general acceptance within and across reviews that all types of exercise are beneficial and safe for patients. The optimal type, content and dose of interventions are unknown. The variety of interventions, control/comparison groups, outcomes and the use of multi-modal interventions created difficulties in evaluating effectiveness. There were gaps in underlying rationales for interventions and the strategies/theories utilised to promote change in behaviour were rarely discussed.

Conclusions: There are large and important gaps in evidence for interventions to improve physical activity and exercise for people with long term musculoskeletal conditions; the optimal type, content and dose of interventions are unknown due to the lack of evidence. Whilst this rapid review would support the beneficial effect of exercise interventions to improve levels of physical activity for inactive people with long term musculoskeletal conditions these findings should be considered as interim guidance until/unless supported by further evidence.

Key words: Rapid review, physical activity, aerobic exercise, walking programmes, osteoarthritis, fibromyalgia, chronic back pain.

INTRODUCTION

Physical inactivity directly contributes to one in six deaths in the United Kingdom (UK) [1]. There is convincing and consistent evidence of physical, social and mental health benefits from physical activity for both healthy adults and those with disabilities and obesity [2]. Current guidance in the UK recommends adults undertake 150 minutes of moderate intensity activity or 75 minutes of vigorous intensity activity, in bouts of 10 minutes or more, each week [2]. During moderate intensity activity people will breathe faster and experience an increase in heart rate but are still able to talk or converse; whereas during vigorous intensity activity people will breathe very hard, be short of breath, have a rapid heartbeat and not be able to talk/converse comfortably [2]. Prevalence data indicates that 67% men and 55% of women in England reported achieving these recommendations in 2012, with physical activity levels declining with age [3]. A systematic review of people with lower limb osteoarthritis reported 13- 60% of people with knee and hip osteoarthritis met current physical activity guidelines and recommended number of daily steps [4]. The majority of people with musculoskeletal conditions also have increased risk of co-morbidity relative to their peers [5-6].

The effective management of long term conditions (conditions that require ongoing management over years/decades) is recognised as one of the greatest challenges facing the 21st-century National Health Service (NHS) in England: care for people with long term conditions accounts for 55% of general practitioner (GP) appointments, 68% of outpatient and ambulance and emergency (A&E) appointments and 77% of inpatient bed days [7]. Over 10 million people in the UK live with long term musculoskeletal conditions (LTMCs); with the aging population and rising retirement age this number is expected to continue to rise and has become a public health issue [8]. The management of people with long term conditions is a growing burden to the NHS and there is a need for active promotion of self-management and pro-active management for this group of patients [9]. Musculoskeletal conditions account for the largest proportion of years lived with a disability, in the UK; adversely impacting upon activities of daily living and living independently, in addition to causing symptoms such as pain [8].

Walking is a popular, accessible form of physical activity across all age ranges that can substantially lower the risk of many chronic diseases [1, 10]. NICE guidelines (2012) therefore call for the development of walking programmes for insufficiently active adults [10]. As part of the development of a walking programme for people with long term musculoskeletal conditions, a rapid overview of systematic reviews, guidelines and additional trials was undertaken. The main aim was to evaluate the effectiveness of existing interventions of walking programmes, and also physical activity and aerobic exercise interventions, used to reduce pain, and improve function and levels of physical activity for adults with long term musculoskeletal conditions. The review aimed to identify the interventions (and their dose) most likely to increase levels of physical activity for use in a new walking programme and to identify which health outcomes are most likely to improve as a result of the intervention. Although this rapid review was performed specifically to develop a new intervention for a clinical trial, we are freely publishing it to provide a summary of the evidence in this area for health care professionals and people with long term musculoskeletal conditions.

METHODS

Design: The increasing number of systematic reviews available have meant that 'reviews of reviews' are increasingly common and accepted as "the next step" in data syntheses [11]. Such 'reviews of reviews' include 'overviews of reviews', 'meta-reviews', 'umbrella reviews' [12] and may also be part of 'rapid reviews'. Reviews of reviews identify and appraise existing systematic reviews and, by discussing the strength of evidence to date overall, make the best available evidence accessible to decisions makers, clinicians, researchers and patients [11]. These types of reviews can also enable a focus on breadth, allowing the evidence related to a number of treatment or management options to be synthesised [12]. Rapid reviews describe reviews requiring the purposive synthesis of knowledge in an area in a short timeframe, of often 6 months or less, which are useful for policy makers and informed decision making [13] and, in our case, developing a trial intervention. Rapid reviews streamline full review methods and, as a relatively recent development in health care, there are a widespread diversity of methods within the approach which need to be evaluated [14, 13, 15]. This review follows an approach successfully previously to summarise the evidence, and provide an indication of the strength of the evidence [16]. Due to the breadth of the review and the large amount of existing evidence, this review focussed on review level evidence, plus clinical guidelines and randomised clinical trials not yet included in existing reviews.

Databases. Searches were undertaken using three databases [11]: the Cochrane Database of Systemic Reviews, the Database of Abstracts of Reviews of Effects and PubMed. Reference lists of identified reviews were also screened.

Search terms: Broad search terms were used to capture systematic reviews, trials and guidelines for common musculoskeletal conditions and the promotion of physical activity. For example, "exercise" AND "osteoarthritis" AND "systematic review". We also searched for walking programmes. Searches and search results are summarised in Table 1. Searches were limited to title and abstract, adults, and the English language (no resources were available for translations). Search dates were 1st Jan 2005-30 June 2015 since earlier (pre-

2005) evidence would be included in more recent reviews. Clinical searches were undertaken by CML and any uncertainties regarding inclusion/exclusion discussed with another team member.

Review Criteria:

Inclusion criteria: High level evidence regarding physical activity or land-based aerobic exercise interventions, walking and strategies for people with the common long term musculoskeletal conditions of back pain, osteoarthritis and fibromyalgia or adults not meeting recommended levels of physical activity. By high level evidence we mean systematic reviews, clinical guidelines and randomised clinical trials not yet included in systematic reviews. By recommended levels of physical activity we mean the UK guidance that adults undertake 150 minutes of moderate intensity activity or 75 minutes of vigorous intensity activity, in bouts of 10 minutes or more, each week [2]. We included the latest/current versions of guidelines and did not include any earlier versions.

Exclusion criteria: Narrative, non-systematic, reviews were excluded. Acute/early management of conditions was excluded. Reviews of people who were pregnant were excluded. Reviews of non aerobic or specific exercises were excluded; by specific exercise we mean exercise interventions designed to improve balance, range of motion or muscle strength at a specific joint/part of the body rather than a general exercise programme. Reviews including only aquatic interventions were excluded. We also excluded interventions compared against specific types of surgery or manipulation.

Table 1. Summary of search strategy for the rapid review.

Source	Searches and Search Terms	No of hits screened June-Sept 2015
PUBMED 01/01/2005-	1. “exercise” AND “osteoarthritis” AND “systematic review”	82
	2. “exercise” AND “back pain” AND “systematic review”	111
	3. “exercise” AND “fibromyalgia” AND “systematic review”	258
	4. “Physical Activity” AND “systematic review” AND osteoarthritis”	414
	5. “Physical Activity” AND “systematic review” AND “back pain”	327
	6. “Physical Activity” AND “systematic review” AND “fibromyalgia”	131
	7. “walking program*” AND “systematic review”	72
	8. “walking program*” AND “osteoarthritis” AND “trial”	13
	9. “walking program*” AND “back pain” AND “trial”	11
	10. “walking program*” AND “fibromyalgia” AND “trial”	3
Article reference lists	Guidelines identified AAOS, NICE, ACR	3
Cochrane library: Cochrane reviews CCRCT DARE	1. Browsed by musculoskeletal Search narrowed osteoarthritis OR back pain OR fibromyalgia Search narrowed rehabilitation	9
	2. Browsed by “musculoskeletal”	80
Totals	**Reviews and guidelines osteoarthritis**	**31***
	Reviews and guidelines back pain	**11***
	Reviews and guidelines fibromyalgia	**15***
	Trial walking programmes	**7 articles for 6 studies**

** One review included all 3 conditions.*

The team: Clinicians experienced in the treatment and management of patients with long term musculoskeletal conditions (CML, KB). Researchers experienced in the measurement of physical activity, including measures used in the assessment of clinical conditions (CML, KB) and those used in the assessment of health behaviours (CF, PK, KM). Researchers with in-depth knowledge of the available behavioural strategies used to facilitate increasing physical activity levels (CF, PK, KM). All members of the research team were experienced in undertaking systematic reviews.

Data extraction. All included publications were evaluated independently by two researchers (CML and KM). CML extracted data from the clinical publications into tables which KM then checked against the source data. Data were synthesised by CML and KM. All findings, and their interpretation, were then discussed by the team until consensus was agreed upon the strength of evidence.

Quality and risk of bias. Assessments of quality and risk of bias, such as GRADE judgements [17] are reported where these have been incorporated into included reviews. These are included within the data syntheses to inform the interpretation of the quality of the existing evidence. Further GRADE assessments were not undertaken.

Data Analyses. Reviews of reviews, like systematic reviews, should include synthesis/syntheses of findings [18]. The approach to synthesize publications followed the framework from the Economic and Social Research Council project as reported by the Centre for Reviews and Dissemination [19]. This approach consisted of first developing a theory/overview of how the interventions included in the review work, why and for whom. Then a preliminary synthesis of findings of included reviews was undertaken and relationships within and between reviews were explored. These stages were undertaken by CML and KM. Previous meta-analyses findings from publications were reported; no new meta-analyses were undertaken since the rapid review aims to provide an overview of the evidence and not to undertake additional quantitative analyses [20]. The robustness of the synthesis was then discussed by the team at a consensus day and the current state of the evidence for interventions and outcomes was discussed and rated. The team came to a consensus on each area of the review and coded the strength of the evidence for each outcome as green, amber, or red [16]. Green outcomes reflected a body of research with strong or at least sufficient evidence to support the use of an intervention/strategy (based upon magnitude of effect and consistency/amount of evidence). Amber outcomes did not have a strong evidence base; either because the amount of evidence was small, the studies were of poor quality, or the evidence was equivocal with mixed/contradictory results. Outcomes coded red indicate that evidence suggests ineffectiveness. We also used a blue code to denote where effectiveness is unknown due to lack of/insufficient evidence.

RESULTS

Clinical population: The number of reviews and clinical guidelines included in the review were 31 for people with osteoarthritis [20-51], 15 for people with fibromyalgia [35, 50-63] and 11 for people with chronic low back pain [35, 64-73] Characteristics of included guidelines and reviews are presented in Appendix 1. Six trials (7 publications), not included in reviews/guidelines were also included (Appendix 2) [74-80].

Table 2 presents the colour coding evaluation regarding the strength of evidence following the consensus by the team.

Table 2. Summary of the strength of evidence of beneficial effects for physical activity and aerobic exercise programmes for adults with common long term musculoskeletal conditions.

Condition	Evidence of Effectiveness	Optimal type of intervention	Optimal delivery of intervention	Effective dose of intervention	Adherence/ Compliance	Strategies to promote change
Osteoarthritis	Yes	Unclear	Unclear	Amber: common dosages but without justification	Unclear	Unclear
Fibromyalgia	Amber: yes but some conflicting evidence too	Unclear	Unclear	Unclear	Amber: drop out known to be an issue	Unclear
Back Pain	Amber: mainly multi-modal interventions, few solely physical activity.	Amber	Unclear	Unclear	Unclear	Unclear

Key: Green denotes strong evidence, Amber denotes moderate evidence, Red denotes the evidence suggests ineffectiveness, Blue denotes unknown due to lack of existing evidence.

Table 3 presents the outcomes included in previous reviews.

Table 3. Outcomes reported in Reviews, Studies and Guidelines.

	Pain	Function/Disability	Additional outcomes	Objective outcomes
Osteoarthritis	AIMS KOOS NRS, OARSI "Pain" VAS WOMAC	AIMS KOOS, "Function/ Self reported disability" WOMAC,	Self Report: activity physical activity AIMs Depressive symptoms e.g FIQ Patient global assessment of effectiveness Medication use Quality of life Risk of falls self reported SF36 mental health Other: structural osteoarthritis biomarker imaging, total knee joint replacement, muscle properties, cartilage/ osteoarthritis properties, inflammation	Accelerometer sensors, activity monitor, measures of physical activity Aerobic capacity Balance/instability, balance master Biodex Biomechanics Cybex Cycle ergometer, Fitness, cardiovascular fitness Force platforms Gait, gait velocity Inflammation Joint position sense, position sense Lift and carry task time(s) Maximal Oxygen uptake Proprioception ROM, ROM/flexibility Stair climb, stair climb time Strength Time to get in and out of car Timed up and Go Walk distance, walking speed, 60m walk test, 6-minute walk test, time spent walking, Weight/metabolic syndrome, Single/double leg stance, Stiffness
Fibromyalgia (Not all outcomes provided in Publications)	AIMS, Physical Multidimensional pain inventory, VAS, tender points, tenderness	AIMS FIQ, Multidimensional function Self reported physical function,	Adverse events Anxiety Attrition rates Beck depression inventory, Global perceived effect, Global well-being (FIQ) Group differences in depressive symptoms Fatigue, Fatigue FIQ, Fatigue VAS, Health status,Mood Psychological wellbeing Quality of life Sleep	Actigraphy, activity counts per minute 5-7 days Actigraphy 5 days fitness (eg 6 min walk, perceived exertion, flexibility), Aerobic activity reported as target heart rate or percentage age-predicted max heart rate Aerobic intensity Maximum oxygen uptake Measured physical fitness Muscle strength
Walking Programmes for LBP	"Pain"	"Function"/functional disability ODI RMDQ	Physical activity (self report) Pyschosocial beliefs Quality of Life (EuroQol)	

KEY: AIMS = Arthritis Impact Measurement Scales, FIQ = Fibromyalgia Impact Questionnaire, KOOS = Knee Injury and Osteoarthritis Outcome Score, OARSI = Osteoarthritis Research Society International, ODI = Oswestry Disability Index, NRS = numerical rating scale, ROM = range of motion, RMDQ = Roland Morris Disability Questionnaire, SF-36 = 36-Item Short Form Health Survey, VAS = visual analogue scale, WOMAC = Western Ontario and McMaster Universities Arthritis Index

The syntheses for each condition are presented below.

LOWER LIMB OSTEOARTHRITIS Sequential trial analysis shows that there has been sufficient data since 2002 that participation in all forms of exercise interventions, including aerobic, leads to significant benefit in comparison with no intervention control conditions among adults with knee or hip osteoarthritis [47]. Benefits include reduced pain and improved function. This conclusion is supported by a series of reviews comparing exercise interventions to a control condition. For example Fransen et al (2014) reviewed the evidence on the effectiveness of land based therapeutic exercise programmes on reducing pain and improving physical function, in comparison with no intervention control conditions (10 studies, 549 participants): they concluded that land-based exercise programmes consisting of traditional muscle strengthening, functional training and aerobic fitness programmes were associated with reduced pain and improved function among people with symptomatic hip osteoarthritis [27]. A large review (60 studies, 8218 participants) of exercise interventions for patients with lower limb osteoarthritis reported that a wide range of exercises (including strengthening, flexibility plus strengthening, flexibility plus strengthening plus aerobic, aquatic strengthening, and aquatic strengthening plus flexibility exercises) were all significantly more effective for pain relief in comparison to no intervention control conditions [47]. In relation to knee osteoarthritis, Fransen & Connell (2008) reported that land-based therapeutic exercise has at least short term benefit in terms of reduced knee pain and improved physical function (32 studies, 3616 and 3719 participants for pain and function respectively). The magnitude of the treatment effect would be considered small, but comparable to estimates reported for non-steroidal anti-inflammatory drugs [26].

Types of Intervention. The structure of exercise programmes in terms of content is very heterogeneous between studies [24] and there is a lack of consensus regarding the most effective form of intervention. Much of the research into physical activity and osteoarthritis has focused on comparing different 'types' of activity and their impact on pain and function. Other aspects, such as quality of life, have been less explored. Overall, it appears that exercise is beneficial, but the differences between forms of exercise (for example Tai Chi, strength training, walking and hydrotherapy) are unclear [24].

There is less evidence available for the management of hip osteoarthritis than for knee osteoarthritis [25, 47]. Escalante et al. [24] reviewed the effectiveness of different exercise programmes in patients with hip and knee osteoarthritis (20 studies, 2142 participants). Programmes were grouped into five categories: land-based interventions (strength programs, tai chi, aerobic programs, mixed exercise programs) and aquatic intervention (hydrotherapy). The review concluded that exercise programs based on tai chi, aerobic, and mixed exercise led to better results than hydrotherapy programs. This followed an earlier review which concluded that tai chi leads to slightly better results than mixed exercise programs [23].

McAlindon et al (2014) reviewed the effectiveness of different exercise programmes for patients with knee osteoarthritis and concluded that there is good evidence that land-based exercise, water-based exercise, and strength building exercises (both weight-bearing and non-weight-bearing) are appropriate for patients with knee osteoarthritis [33]. In terms of land based training, tai chi had particularly favourable outcomes. Juhl et al (2014) also reported that a range of activities, including aerobic, resistance, and performance exercise, are associated with similar reductions in pain among patients with knee osteoarthritis [30]. Tanaka et al (2013) found that muscle strengthening exercises, with or without weight-bearing and aerobic exercises, were effective for pain in people with knee osteoarthritis; the most effective intervention, particularly in the first 8 weeks of exercise, was non-weight bearing strengthening exercises [44]. A further review examined the effectiveness of proprioceptive exercises on knee osteoarthritis [42]. When compared to a general non-proprioceptive exercise programme, proprioceptive exercises demonstrated similar improved functional outcomes, only providing superior results with respect to joint position sense-related measurements, such as timed walk over uneven ground and joint position angulation error.

There is very little evidence exploring the effects of exercise (aerobic, strengthening or both) upon depressive symptoms; one systematic review (29 studies) has concluded that exercise is associated with reductions in depressive symptoms [31]. However, this review included arthritis and rheumatological conditions and the majority of studies were for the management of fibromyalgia with only 5 including patients with osteoarthritis (one of which included both osteoarthritis and rheumatoid arthritis).

Several guidance documents have been produced on physical activity for patients with symptomatic osteoarthritis of the knee and the hip. The American Academy of Orthopaedic Surgeons (AAOS) recommends that patients with osteoarthritis of the knee participate in self-management programs, strengthening, low-impact aerobic exercises, and neuromuscular education, and engage in physical activity consistent with national guidelines [21]. The ACR (2012) recommends that patients with knee and hip osteoarthritis participate in an aquatic exercise programme, and in aerobic or resistance land-based exercise programmes [28]. The NICE guidelines (2014) advise exercise (local muscle strengthening and general aerobic fitness) as a core treatment for people with osteoarthritis; these guidelines also emphasise the importance of clinician's making judgements and incorporating strategies to facilitate/ensure participation in exercise [34]. Fernandes et al., (2013) emphasised that for people with lower limb osteoarthritis, an individualised daily exercise regimen is recommended, including a) strengthening (sustained isometric) exercise for both legs, including the quadriceps and proximal hip girdle muscles (irrespective of site or number of large joints affected); b) aerobic activity and exercise; and c) adjunctive range of movement/stretching exercises [25].

Walking programmes. Walking programmes have mostly included supervised walking programmes, treadmill and land based [35], although self-directed/unsupervised programmes are starting to be evaluated [75, 76]. Roddy et al (2005) compared the efficacy of aerobic walking and home based quadriceps strengthening exercise in patients with knee osteoarthritis (13 trials) [38]. Both aerobic walking and home based quadriceps strengthening exercise reduced pain and disability from knee osteoarthritis but no difference between the interventions was found. Loew et al (2012) reviewed 9 studies which evaluated walking programmes for the management of knee osteoarthritis, concluding these were effective in the short term in improving stiffness, strength, mobility and endurance. At nine months (one trial only) no differences were found between trial arms [32]. Studies with a dropout rate of more than 20% and interventions lasting less than one month were not included in this review. A recent review of walking programmes for people with chronic musculoskeletal pain (26 studies, 2384 participants) concludes that walking is associated with significant improvements in pain and function than non-exercise or non-walking groups, although long term effectiveness is uncertain [35]. Individual studies have supported the effectiveness of walking [74-5, 78-9]. In one clinical trial (n=115 older adults) a structured supervised community-based walking programme with a behavioural intervention, a supervised walking programme and an unsupervised self-directed walking programme all provided similar improvements in fitness after the six month programmes [78]. Another trial (n=36) evaluated the effects on physical activity, pain and function, of a 12 week progressive walking program with/without glucosamine sulphate intake on physical activity participation and osteoarthritis symptoms in people with mild to moderate hip or knee osteoarthritis [79]. Mean step count promisingly rose from 3920 to 6683 for participants; this was a feasibility trial not powered to evaluate between group differences. Several studies have allowed patients to self-select walking interventions (instructor led, self-directed, pain management) which needs to be taken into account due to the resulting group differences at baseline [74-5, 80].

Delivery and dose of interventions. Many reviews have concluded that there is limited research on the optimal frequency, duration and intensity of exercise which means that, currently, the optimal dose for treatment remains unknown [23, 25, 31, 39]. Not all reviews include clear reports of dose [22]. As can be seen from Additional file 1, whilst the dose of interventions ranges widely, the most commonly provided frequency doses were 2-3 times per week. The duration of interventions also varied widely, from a few weeks to many months. The length of sessions was not always specified but, where reported, varied from 20 minutes to several hours. Trials and reviews provided no/little justification for dosages. Juhl et al (2014) however have reported that pain relief from aerobic exercise increased with the number of supervised sessions, and when supervised exercise was performed at least 3 times a week [30]. No impact of intensity, duration of individual sessions, or patient characteristics (including radiographic severity and baseline pain) was found.

From the additional files it can be seen that the majority of interventions are delivered as hospital/clinic based interventions and/or home exercise programmes. A systematic review examining the effectiveness of home exercise programmes with and without supervised clinic-based exercises in the management (pain and function) of osteoarthritis (19 studies) found a large amount of trials supporting the effectiveness of home exercise programmes with and without supervised clinic-based exercise and a small amount of evidence for other forms of exercise such as balance and proprioceptive training [22]. However, only 6 studies were assessed as being at low risk of bias (n=3 unclear risk of bias and n=10 at high risk of bias) so these findings need to be interpreted with caution.

Another, larger, review (94 trials, 48 of which were included in meta-analyses) has explored the optimal type and dosimetry of exercise programmes to reduce pain and disability for knee osteoarthritis [30]. This review concludes that such programmes should be supervised and should focus upon one aim (such as improving aerobic activity or improving muscle strength or lower extremity performance) rather than being multi-modal in nature. The individualisation of programmes, for factors such as disease severity, was not supported in this review. This conclusion is contrary to that of Fernandes et al. (2013) which recommended that programmes should be both individualised and multi-modal [25].

Walking programmes have shown considerable variation in content and duration of interventions which have ranged from 8 weeks to two years [32, 35, 38]. The optimal dose cannot not specified.

Outcomes. The widespread variety of outcomes reported is summarised in Table 3. Although there is a lack of consensus overall, the majority of research measures pain and function in some way. The WOMAC (Western Ontario and McMaster Universities Arthritis Index) and Visual Analogue Scale (VAS) scores appear to be the most common to measure pain and function.

Adherence/Compliance. Compliance and adherence data are not reported/available in many reviews (Additional file 1). In one review which included compliance as an outcome for exercise interventions for participants with knee osteoarthritis, the data appear unclear [42]. Whilst the text states participants allocated to the proprioceptive exercise regime were more compliant ($p = 0.03$) to their allocated treatment, compared to the non proprioceptive exercise group, the corresponding Forest plot seems to favour the control group.

Walking programmes. In the review by O'Connor et al (2015) 11/26 studies reported a measure of participant adherence [35]: including attendance at exercise classes (n=7), self-reported completion of home exercise (n=2), or self-reported adherence to wearing a pedometer (n=2). Dropout rates ranged from 0-57%. Studies generally included similar populations in terms of demographic characteristics and clinical presentation, as well as interventions that would be routinely available or feasible in clinical practice. The review by Loew et al (2012) excluded studies with dropout rates of greater than 20% [32].

Safety and adverse events. A recent review (49 studies) explored the safety of long term physical activity for older patients with knee pain; concluding that long term low impact therapeutic exercise of 3-30 months duration, is safe for most older adults with knee pain [37]. Only 22 trials reported adverse events and some reports were generalised; moderate adverse events (for example a fall leading to fracture) were rare and ranged from 0-6%.

Walking programmes. In the recent review by O'Connor et al (2015) 11/26 studies reported associated adverse events: including 2 falls resulting in distal radial fractures,1 fall resulting in a hip fracture, 1 case of plantar fasciitis, and 2 cases of allergic skin reactions to metal pedometer clips [35].

Quality and Risk of bias. Reviews provide a mixed evaluation of quality and risk of bias. In some reviews the majority of included studies are considered at high or unclear risk of bias [22, 42]. Some reviews exploring quality rather than risk of bias provide more positive findings with more studies perceived as moderate to high quality [41, 43-45]. One study using both quality and risk of bias tools found 5/11 studies were high quality but there were attrition bias concerns for 7/11 included studies [36]. Another reported a PEDro score average of 6.1 with 7/11 studies having moderate or high GRADE scores [49]. Smith et al., (2013) also report the discrepancy between quality and risk of bias findings; PEDro scores were moderate but many studies appeared at high risk of bias [42]. Unclear or high risk of attrition bias has been raised as a concern in other reviews; Quicke et al (2015) reported unclear or high risk of attrition bias due to incomplete outcome data in over half of studies [37]. The review by Uthman et al (2013) however found high risk of bias to be less of a concern: the generation of the allocation sequence was adequate in most trials (n=42, 60%), allocation concealment was adequate in almost half of the trials (n=25,42%), 31 (52%) masked outcome assessors to treatment allocation, the potential risk of bias likely to be introduced by incomplete data was high in 10 trials (18%) and the risk of selective reporting bias was low in most trials (n=53, 88%) [47]. Levels of evidence, where stated, are presented in Additional file 1 with most guidelines presenting strong recommendations for the use of exercise [21, 28, 33]; although the mix of evidence available, especially for hip osteoarthritis, is reflected too [25, 34].

Walking programmes. O'Connor et al (2015) report that evidence of fair methodological quality suggests that walking is associated with significant improvements in outcome compared with control interventions but longer-term effectiveness is uncertain [35]. Only 5/26 studies contained serious potential sources of methodological bias; inadequate allocation concealment during randomization (n=2) unequal distribution of important confounding variables at baseline not accounted for during analysis (n=2), no masking of outcome assessment (n=1) or a substantial (>50%) dropout rate and subsequent post hoc revision of the intervention groups examined (n=1). 11 studies provided insufficient detail regarding exercise intensity, or it was not sufficient to effect any change in fitness. Follow up periods ranged from 1-18months; mostly 6 months or less. Loew et al (2012) used the Jadad quality rating system [32] and reported the majority of studies to be high-quality (studies with dropout rates of greater than 20%, and with interventions of short duration were excluded).

Strategies to promote change in behaviour. Williamson et al (2015) explored the behaviour change theory underlying physical activity interventions for patients with lower-limb osteoarthritis [48]. All of the included studies (n=7) implemented a self-management strategy to improve self-efficacy and four trials based the interventions on Bandura's Social Cognitive Theory. However due to variability in the delivery and intensity of the interventions, it was not possible to determine which theory and delivery strategy is most effective. A review by Romeo et al (2013) found that booster sessions had a positive effect on adherence to therapeutic exercise, and also found that telephone calls, self-monitoring diaries, graphic feedback, and booster sessions could enhance long term adherence to exercise programmes [39]. Brosseau et al (2012) monitored adherence to lifestyle interventions among patients with moderate knee osteoarthritis [51]. Short-term adherence was greater amongst those who were allocated to supervised community based walking programme with a behavioural intervention and educational leaflet, as opposed to receiving the educational leaflet alone. Adherence was also greater, although non-significant, at 6 and 12 months. The European League against Rheumatism (EULAR) recommends that programmes should be individualised and should encourage behaviour change through the use of goal-setting, action plans, and regular follow-up support to review progress and goals [25]. This review also highlights the conflicting evidence regarding no association between pain and low level of physical activity.

FIBROMYALGIA.

Similar to osteoarthritis, there is widespread variety, and a lack of consensus, regarding the optimal type and dosimetry of intervention.

Type of intervention. BiDondie et al (2014) reviewed existing reviews (n=9) to synthesise the evidence regarding physical activity interventions for adults with fibromyalgia [50]. This review of reviews focussed on pain, multidimensional function (wellness or quality of life), physical function (self-reported physical function or measured physical fitness) outcomes and adverse effects. Findings indicated that aerobic exercise has a beneficial and substantial effect upon pain, multidimensional function and self-reported function for the majority of (but not all) randomised clinical trials. No supporting evidence was found for some recently introduced interventions including Tai Chi and Qigong [50]. Some further support for the effectiveness of exercise in improving global wellbeing is provided in a review of 7 studies by Kelly et al (2010) with equivalents of 8.3% (per protocol analyses) and 7.3% (intention to treat analyse) changes (although the minimal clinically importance difference is thought to be 14%) [60]. Garcia-Hermoso et al reported a large cumulative effect size (0.85) for aerobic exercise programmes, although they also highlighted that many exercise programmes also included education components [58]. In an earlier review the evidence regarding the effect of aerobic exercise upon depression was conflicting [52]. There has also been a review of reviews (n=9) plus recent primary studies (appear to be 16 trials), which has determined that effect sizes for aerobic exercise interventions were small for fatigue and global health, small/no effect for pain, small/medium for depression and medium for function [53]. Recent meta-analyses of Busch et al (2007) and Hauser et al (2010) have further indicated that exercise improves depressive symptoms [61]. Several strength training studies have shown positive effects on disability but this was not associated with reductions in pain [62]. Studies which combined aerobic and strength training showed mixed results, but in the effective interventions decreases in pain and disability were observed and the effects were maintained at follow-up[62]. In addition, two studies reported a lesser worsening of disability levels in the intervention group compared with the control group. Resistance training was less effective at reducing pain than eight weeks of aerobic exercise, but was more effective than flexibility exercise training in improving pain and multidimensional function [54]. Several reviews have commented that men are underrepresented in RCTs [59, 60] and that the evidence may not be applicable for men.

Control groups again, as for osteoarthritis, have included a variety of exercise, education, control/no intervention groups (Additional file 1).

Earlier guidance documents recommended aerobic fitness exercise, although most trials were rated low quality [51] and problems with attrition were evident [52]. Highly individualised and/or multimodal programmes prevented determining which components are effective in treatment [51]. The EULAR guidelines highlighted that small study size and study quality meant that strong recommendations could not be made [56].

Walking programmes. In their review of walking interventions, in addition to the information on this review already provided in the Osteoarthritis section, O'Connor et al (2015), found 2/8 studies for participants with fibromyalgia reported a general increase in pain and muscle stiffness in the intervention groups [35]. One RCT reported that increases in physical activity and function and reductions in pain following a 12 week walking intervention were not sustained at 6 and 12 months [75]. Thus, it is suggested that exercise or activity for individuals with chronic musculoskeletal pain should be supplemented with strategies aimed at maintaining participation [35].

Delivery and dose. Widespread variety within interventions is evident [50, 52] and this prevents the optimal treatment modes and dosages from being known at the current time [50, 57]. Rationales for dosimetry are usually not provided/available. In addition, where trials are highly individualised and/or multimodal this also creates difficulty in establishing effective treatment dosages [51] and exercise is often delivered with other treatments [53]. Recent reviews suggest that patients undertake an aerobic exercise programme consisting of 31-60 minutes of light-moderate intensity aerobic exercise, two or three times per week for at least four weeks, and most for 7-12 weeks [50, 59]. Busch et al (2011) report a duration range of 4-32 weeks and they also found that most interventions are supervised [53]. Another review suggests there may be a recent shift towards home programmes [55]. Researchers have noted that regardless of the activity adopted, it is important to assign workloads which do not exacerbate post-exercise pain [55]. Cazzola et al (2010) found that water-based physical activity offers some advantages over similarly intense land-based exercises, although the data were insufficient to establish its overall superiority [55]. Interventions lasted from seven days to 8 months (most between 12-24 weeks). Other reviews have found that hydrotherapy is not superior to land based exercise [53, 59], although hydrotherapy may have a role in the treatment of severely deconditioned patients [53].

Earlier reviews reported an increased mode of treatment; 60 minutes of exercise each session and longer programmes (8-23 weeks) although three times a week remains the most common number of sessions each week [51]. Busch et al [52] also report longer durations (2 ½ -24 weeks) of aerobic exercise at least 20 minutes a day-2/3 times per week.

Outcomes. There is a wide variety of outcomes included in trials to measure the effects of aerobic exercise [51]; not all outcomes are listed and a full list cannot be provided in Table 3. One review reports 166 outcomes within 34 trials (2276 participants) [52]: pain was the most common outcome (visual analogue n=22 studies), followed by with global well-being, physical performance, tender point count, depression and fatigue. Sleep has also been included [51]. In earlier reviews, few studies included follow-up assessments, but in those which did, limited long term improvements in pain and disability were reported [62].

Adherence/Compliance. Compliance was not calculable in the majority of early studies [57]. Dropout rates are a cause of concern. In one review, the majority of exercise trials had dropout rates above 20% with the highest reporting a dropout rate of 67% [62]. Other reviews have reported attrition rates averaged 27% for 17 aerobic studies [52] and a median of 20% [57].

Safety and Adverse Events. Reviews have reported that no serious side effects have been associated with aerobic exercise in the treatment of fibromyalgia [50]. Another review of reviews, plus recent trials, concludes that adverse events are not consistently reported but do not appear uncommon [53]. A recent review to evaluate the benefits and harms of resistance exercise training in adults with fibromyalgia (including two aerobic training trials) found that, in general, adverse effects were poorly recorded; no serious adverse effects were reported [54]. Other reviews have also found adverse events to be poorly reported

[58-59]. In a review of 35 trials evaluating the effectiveness of aerobic exercise only 11 reported side effects; five reported no side effects and 6 reported increased symptoms and drop out in some cases [59]. Also, although the majority of included studies have reported improvements in disability following aerobic exercise, some interventions have led to an increase in disability for some participants, especially for mixed programmes which were considered less effective [62] 2007). Dupree Jones et al (2006) noted that studies using higher heart rate/higher BORG scale also had higher attrition rates [57].

Quality and risk of bias. The quality assessments of clinical trials in systematic reviews indicate wide variety in the quality of the randomised clinical trials included within them [56, 59]. Trials included in earlier reviews were rated as low quality [51] or moderate [52]. The (small) sample size of many studies, together with their variable quality, made developing recommendations for management difficult [56]. More recent reviews have assessed risk of bias and this also appears problematic; in their review of aerobic exercises only 2 of 35 RCTs met risk of bias assessment criteria, with the majority of studies having moderate/high, or unclear, ratings [59].

A recent review to evaluate the benefits and harms of resistance exercise training in adults with fibromyalgia (n=5 trials) included two trials including aerobic training [54]. The assessment of risk of bias in the review was hampered by poor written descriptions (for example regarding allocation concealment, blinding of outcome assessors) and the evidence was classified as low due to risk of bias assessment and the low quality of included studies.

In addition, the quality of systematic reviews also varies widely. In their review of 8 reviews, BiDondie et al (2014) assessed three reviews as high quality, 4 studies in the middle and two reviews as low quality [50]. The review of reviews and reviews note that the participants included in clinical trials are predominantly female [50, 59].

Walking Programmes. O'Connor et al (2015) found evidence of fair methodological quality, although a small number (5/26) contained serious potential sources of bias as already described [35].

Strategies to promote change in behaviour. Van Koulil et al's (2007) review included a focus on cognitive behavioural approaches such as education programmes providing information on self-management, coping, relaxation, and individual strategies for behaviour change [62]. Three studies investigated the effect of education as a single-method intervention. These studies reported that educational programmes have benefits for self-efficacy and coping, but are not effective in reducing pain or disability. Studies on the effectiveness of multi-method cognitive behavioural approaches have yielded mixed results in terms of impact on pain and disability. Six studies examined the effectiveness of education in combination with exercise. Of the three studies that included follow-up assessments, two studies found reductions in pain and disability at three months, although the longer term effectiveness of these interventions is unclear [62].

LOW BACK PAIN.

Although there is much research into the rehabilitation of people with long term low back pain, this review has identified the lack of studies investigating physical activity for this patient group and the diversity of exercise and comparative interventions.

Type of intervention. A review to determine the effectiveness of physical and rehabilitation interventions for adults with chronic low back pain has identified that there are very few (n=3) physical activity studies; most aerobic exercise in trials has been provided in conjunction with back exercises or back programmes [72]. Overall, there was low level evidence for the effectiveness of exercise compared to usual care; improvements in pain, function and disability were seen in the 3 physical activity trials but these trials were scored as low quality (3-4/11). Similarly, the review by Steiger et al (2012) also found very little evidence concerning physical activity [71]. Most exercise trials included back exercises, or back school or cognitive behavioural therapy or manual therapy; widespread variety is seen. In a further recent review of effectiveness of exercise interventions in reducing pain (45 trials), again aerobic activity interventions were scarce [70]. This review concluded that there are beneficial effects for strength/resistance and co-ordination/stabilisation exercise programmes but combined exercise programmes and cardiorespiratory exercise were ineffective. Overall, evidence suggests that exercise therapy is slightly (small mean improvements) effective/effective at decreasing pain and improving function and disability [64, 66].

There is also some evidence exploring the relationship between activity and outcomes. Hendrik et al (2011) investigated the relationship between free living activity levels after onset of low back pain and measures of pain and disability (12 studies; 7 cohorts and 5 cross-sectional) [68]. Studies were generally moderate or poor quality. One prospective study reported a statistically significant relationship between increased leisure time activity and improved low back pain outcomes, and one cross-sectional study found that lower levels of sporting activity were associated with higher levels of pain and disability. The other studies found no relationship between measures of activity levels and either pain or disability. The review concluded that the activity levels of patients with non-specific low back pain are neither associated with, nor predictive of, disability or pain levels.

Delivery, Dosimetry, Outcomes, Adherence, Compliance, Safety and Adverse events. The lack of interventions investigating physical activity for the treatment of low back pain in existing reviews mean that information regarding optimal delivery and dose, outcomes, adherence and compliance is lacking at this time.

Walking programmes. In addition to the review by O'Connor et al (2015) already mentioned [35], a further systematic review (7 trials) has evaluated the effectiveness of walking to improve disability, function and quality of life for people with chronic low back pain [69]. The review concluded that there is low quality, inconsistent evidence to suggest walking might be as effective as other non-pharmacological management approaches. No study compared walking with a no intervention control. An earlier review (2 RCTs, 2 cohort study, and 1 case control study) of the effectiveness of walking in managing acute and chronic low back pain also found insufficient high quality evidence to determine effectiveness [67]. Recently, Hurley et al (2015) investigated the differences between an individualized walking programme, group exercise class, and usual physiotherapy in mean change in functional disability at 3, 6, and 12 months among people with chronic low back pain (n=246) [77]. Improvements in disability and quality of life were observed within all groups, with no significant between group differences and small between group effect sizes. The mean costs were lowest for the walking programme, which also had the highest adherence, suggesting that supervised walking provides an effective alternative to current forms of chronic lower back pain management.

Outcomes. These are listed in Table 3. The most commonly reported outcomes concern disability, quality of life [69, 77], pain and function/functional disability [35, 77] and self-reported physical activity, psychosocial beliefs and cost diaries [77].

Safety and adverse events. There were no adverse events in the exercise and usual physiotherapy arms in the trial by Hurley et al (2015) [77]. 14 adverse events (increased back, groin and knee pain) were reported for the walking programme group; 7 of these were brief and participants continued with the walking programme and 7 were withdrawn and provided with usual physiotherapy care. More participants (96.7%) would recommend usual care to a friend/colleague, compared to walking (83.3%) or exercise class (82.3%).

Adherence Compliance. In the review by O'Connor et al (2015) 11/26 studies reported a measure of participant adherence: attendance at exercise classes (n=7), self-reported completion of home exercise (n=2), or self-reported adherence to wearing a pedometer (n=2) [35]. In the study by Hurley et al (2015) attrition at 12 months was reported as 26% (20.1% for walking programme) [77].

Quality and Risk of bias. The level of quality in the physical activity trials in the review by van Middelkoop et al (2011) was low: trials were scored as low quality (3-4/11) [72]. Except for adequate randomisation all other criteria were either unmet or unclear. Lawford et al (2015) also found that most studies were at high, or unclear risk of bias despite high CASP scores; with low volume of evidence using the GRADE approach [69]. O'Connor et al (2015) found evidence of fair methodological quality, although a small number (5/26) contained serious potential sources of bias as already described [35].

Most reviews of back pain interventions have not included the impact of behaviour change theory on adherence to or effectiveness of the intervention. One primary study by Hurley et al (2015) trialled the effectiveness of a walking programme and exercise classes in comparison to usual practice in the treatment of chronic back pain [77]. Both interventions were based on the biopsychosocial model and aimed to overcome fear and avoidance of movement. Principles of cognitive behavioural management were incorporated using an operant conditioning approach. The walking programme had the lowest mean costs and the highest level of adherence. O'Connor et al (2015) reviewed the evidence on walking and chronic musculoskeletal pain and concluded that walking is associated with significant improvements in outcome compared with control interventions [35]. However the longer-term effectiveness of walking was uncertain; thus the authors recommended that walking programmes should be supplemented with strategies aimed at maintaining participation.

DISCUSSION

There is general acceptance in reviews that all types of exercise are beneficial and safe for people with long term musculoskeletal conditions. This review shows that the optimal type, content and dose of interventions to improve physical activity for people with common long term musculoskeletal conditions are unknown; there are too many 'missing gaps' and conflicting findings in the evidence. In many areas there are also gaps in the underlying rationale for the interventions utilised in trials and the strategies/theories utilised to promote change in behaviour are rarely discussed. The widespread variety of interventions, control/comparison groups, outcomes and the use of many multi-modal interventions make it difficult to evaluate the effect of aerobic exercise and physical activity interventions. Despite the number of outcomes included, outcomes have tended to concentrate upon symptoms and self-reported function and disability yet mental health, physical independence, autonomy and social participation are also considered important domains by people with osteoarthritis and older adults [25]. Whether we can become more focussed and agree upon a core set of outcomes, considered most likely to show change and relevant to this group of patients, is important to consider when planning future research to lessen the difficulties in reporting and comparing trial findings in the future [81]. The review highlights a lack of research carried out in primary care settings and fitness centres or gyms (either by healthcare staff or fitness instructors) and there is a lack of health economics data available to analyse the cost effectiveness of interventions. There is also a lack of consensus regarding the superiority of multimodal versus focussed interventions [25, 30]. Further investigation is required to identify which approach is most beneficial for patients. In addition, the growing burden to the NHS of long term conditions mean that active promotion of self-management and pro-active management of long term conditions is required [9]. Many existing programmes have been supervised and further investigations evaluating pro-active and self-management interventions are also required. The lack of long term follow up after interventions makes it difficult to assess the extent to changes in levels of physical activity are maintained over time. Longer term follow up needs to be included in future trial designs.

In some areas, especially fibromyalgia, men were under-represented in existing research studies. Whilst generally women have been less represented in many areas of medical research, the lack of men included in studies is concerning because it cannot be assumed that the occurrence and outcomes of conditions such as musculoskeletal diseases, as well as the efficacy of preventative measures, are the same for men and women [82]. The findings of this review cannot be assumed to apply equally to men and women. It is also acknowledged that participation in physical activity for people with long term musculoskeletal conditions is complex and also requires additional research. A recent review exploring the factors associated with physical activity participation in adults with hip or knee osteoarthritis (including 8076 people) identified 170 quantitative correlates of physical activity in adults with hip and/or knee osteoarthritis in 29 publications [83]. For knee osteoarthritis, factors consistently negatively associated with physical activity were increasing age, non-white ethnicity, severity of symptoms and female gender. Greater lower limb function and faster gait speed were positively associated with physical activity. Social (such as support from spouse) and environment (such as outdoor temperature) factors were identified as possible factors influencing physical activity. For hip osteoarthritis, higher body mass index, increased comorbidities, lower mental health and unemployment were negatively associated with physical activity; while better social functioning and health-related quality of life were positively associated with physical activity. Veenhof et al., (2012) have also reviewed factors related to the level of physical activity in patients with hip or knee osteoarthritis [84]. Higher body mass index and older age were related with lower physical activity for hip patients (limited evidence) but unclear for knees. There was conflicting evidence regarding greater depression and avoidance of physical activity in patients with hip ostearthritis and no association between depression and level of physical activity in patients with knee OA (limited evidence). Low levels of physical function and low levels of physical activity were associated for with knee and hip OA (limited evidence). There was also conflicting evidence re: no association between pain and low level of physical activity.

People with chronic low back pain and high levels of disability have been reported as likely to have low levels of physical activity: one review (18 studies; 2495 participants) reports a moderate and negative relationship (r=-0.33 95% CI -0.51 to -0.15) between physical activity and disability [85]. Another review however (7 studies), has explored whether people with chronic low back pain have a lower level and/or altered pattern of physical activity than healthy asymptomatic people and found no conclusive evidence that people with low back pain are less active [65, (Griffin et al., 2012). Sitthipornvoraku et al. (2011) have also reviewed the association between daily physical activity and neck and low back pain (17 studies) [86]. Conflicting evidence was found for the association between physical activity and low back pain; studies were heterogenous and most studies measured leisure time rather than daily physical activity. However there is some evidence that the distribution of activities during the day is different and limited evidence that older adults may be less active than controls. Heneweer et al (2009) have challenged such simple views of activity and pain and suggest that the relation between the level of physical activity and back pain may in fact be a U-shaped curve; where both inactivity and excessive activities (back-unhealthy activity) present an increased risk for back pain [87]. The findings of these reviews suggest the need for further work investigating the relationships between activity and pain and disability in addition to the research needed to fill the 'intervention and dose' gaps identified in this overview.

Although there is limited information available about adherence and compliance, it can be seen from Table 1 that this appears to be an area of concern. The review does highlight that drop out is a concern in studies involving people with fibromyalgia. It is possible that the prevention/management of flare ups, and individualised rate of treatment progression may be important here but additional research would be required to explore this further. Small scale evidence has found that starting an exercise program did not cause exacerbation of pain during the first weeks of training in a small sample of people with symptomatic knee OA (n=39), and that neither pain evolution or adherence seemed to be affected by general healthstatus [88]. However, patients who dropped out had a worse health condition, and lower adherence during supervised sessions was significantly related with higher pre-exercise pain scores (ρ=-.35, $p<.05$) [88]. Strategies to promote adherence therefore also require consideration in future research.

Limitations of this review. A variety of methodological approaches were considered: to register and undertake a Cochrane overview was beyond the remit, timescale and resources of this review. Additionally, overviews often compare multiple Cochrane reviews of interventions for the same condition [14]. To answer our review objective we needed to go beyond a single condition, to include data and, because guidelines and additional trials are included, did not restrict our review to only including Cochrane reviews. However, the Cochrane handbook was referred to extensively during our review and its practice followed wherever appropriate. Previous work has compared rapid and full reviews; whilst rapid reviews were found to be narrower in scope, encouragingly, the essential conclusions did not differ extensively from full reviews [89]. The wide variation of methods described in previous rapid reviews, and the lack of evidence for methodological processes, made it difficult to follow an established approach and we agree that further research is required to establish an agreed and tested approach [15, 20]. In the absence of this, we have tried to clearly describe our methods and reasoning so that readers can understand the processes used in our review. Reports of rapid reviews have previously been criticised for the lack of transparency of terms of methods and we have tried to avoid this problem [13, 20]. The durations of rapid reviews varies; there is an acknowledged balance between time and rigor; compressing the time of a review can adversely affect its rigor [20]. Although ours is a rapid review in terms of approach, the breadth of the review still made the review relatively lengthy in terms of time. We took more time to search and synthesise findings than in many rapid reviews, but the possibility of omissions and errors remains. We restricted our searches to 2005-2015. There is a risk that earlier high quality studies were therefore not included in our review that might have provided key information. However, the review includes a large number of reviews and guidelines which have included earlier research. The number of databases searched was streamlined compared to those usually included in our full reviews and we used broad search terms. Although we included searching the Cochrane and DARE databases specifically to locate reviews, additional reviews meeting the review inclusion criteria might have been missed. However, given the number and nature of the recent evidence sources included in this review, we are believe we may be confident that the findings are current and provide a comprehensive overview of the existing research in this area. As researchers with existing knowledge of this topic we are also aware of the potential introduction of selection bias, publication bias, and language of publication bias that may be introduced when using literature that is readily accessible to researchers [13]. There may also be sources of bias particular to 'rapid reviews' that have yet to be identified and which might become apparent in the future. For these reasons it is accepted, as for all rapid reviews, that this review should be considered as interim guidance only until further overviews become available [13].

Grading the quality of the included evidence in 'reviews of reviews' is acknowledged to be a challenge [12]. This landscape review uses the reported evaluations of quality and assessments of risk of bias from included systematic reviews, which in turn rely upon this information gleaned from trial reports and information requests to authors. Where this information is not reported it prevents, or limits, the strength of evidence and the interpretation of findings being made clearly evident in this review. We have tried to clearly differentiate where information has not been reported (and so is unknown) from areas where the strength of evidence can be provided. In the end, 'reviews of reviews' can only reflect the quality of the reviews and evidence upon which they are based [12] and the lack of evidence for optimal interventions and dosages is clearly evident.

This rapid review did not restrict itself to the sole inclusion of systematic reviews but included additional trials and clinical guidelines. It is our view that the inclusion of trials not yet included in reviews and guidelines have strengthened our review by enabling us to provide a richer overview of the existing evidence, and the landscape within which this evidence is placed. There is a wealth of available evidence surrounding and underpinning our area of research; although the sheer volume of research and guidelines can make managing the evidence difficult [90]. We had long and interesting discussions regarding the optimum approach to review this research landscape and the rapid purposive approach we have used was a pragmatic intuitive decision to achieve our aims. We appreciate others may disagree with this view and hope that our approach will stimulate interesting debate.

CONCLUSIONS

There are large and important gaps in evidence for interventions to improve physical activity and exercise for people with long term musculoskeletal conditions; the optimal type, content and dose of interventions are unknown due to the lack of evidence. Whilst this rapid review would support the beneficial effect of exercise interventions to improve levels of physical activity for inactive people with long term musculoskeletal conditions these findings should be considered as interim guidance until/unless supported by further evidence.

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APPENDIX 1. LAND-BASED EXERCISE AND PHYSICAL ACTIVITY FOR THE MANAGEMENT OF LOWER LIMB OSTEOARTHRITIS, BACK PAIN AND FIBROMYALGIA: BRIEF OVERVIEW OF EXISTING SYSTEMATIC REVIEWS AND RECOMMENDATIONS JAN 2005-25 JUNE 2015

PART ONE: OSTEOARTHRITIS (OA)

Review	Aim	Design	Number of studies	Interventions	Main Outcomes	Summarised Main Results	Conclusions / Additional Comments
AAOS 2013	Clinical practice guideline, "Treatment of Osteoarthritis of the Knee" contains a list of the evidence based treatment recommendations	Review and best evidence synthesis	Document 1234 pges. Main recommendation plus PA data extracted only.	1. Aerobic Exercise Versus Control: Function Study n=1. 2. Aerobic Exercise Versus Control: Functional Task Study n=2 3. Walking Versus Usual Care: Pain & function Study n=1	1. SF36 mental health 2. Lift and carry task time(s). Stair climb. Time to get in and out of car Walk distance Stair climb time 3. AIMS pain AIMS Physical Activity AIMS Arthritis Impact	1.0.08 (-0.26, 0.41) NS 2. Lift and carry task time(s): -0.38 (-0.63, -0.14) Favours aerobic exercise Stair climb: -0.15 (-0.39, 0.09) NS Time to get in and out of car: -0.46 (-0.71, -0.22) Favours aerobic exercise Walk distance: 0.30 (0.06, 0.54) Favours aerobic exercise Stair climb time: -0.14 (-0.45, 0.17) NS 3. Pain. SMD-0.51 (-0.93, -0.10) Favours walking Function: -0.88 (-1.30, -0.45) Favours walking Arthritis impact -0.10 (-0.51, 0.30) NS	Recommendation 1. That patients with symptomatic osteoarthritis of the knee participate in self-management programs, strengthening, low-impact aerobic exercises, and neuromuscular education; and engage in physical activity consistent with national guidelines. Strength of Recommendation: Strong
Anwar et al 2016	To examine the evidence regarding the effect of home exercise programs (HEP) with and without supervised clinic-based exercises in the management of knee OA	Systematic review with M/As, RCTS and case control studies. English prior to 1 sept 2014.	19 studies articles published prior to September 2014	HEP versus inpatient / outpatient physiotherapy or no intervention. Included: open and closed kinetic chain (n=8), stretches (n=3), ROM (n=3), balance (n=4), Proprioception and cold compression (n=1), NMS (n=1), walking (n=1) tai chi (n=1).	Pain and function (WOMAC and VAS widely used)	17/19 19 studies reached high methodological quality on the PEDro scale but 10 were at high risk of bias, 3 unclear RoB and only 6 low risk. Although the methods and home exercise program interventions varied widely in these studies, most found significant improvements in pain and function in individuals with knee OA Exercise programmes reduced Pain (n=11) ES 0.46 (0.24, 0.68) and improved Function (n=9) ES 0.35 (0.15, 0.55).	Large evidence of high-quality trials supports the effectiveness of home exercise programs with and without supervised clinic-based exercises in the rehabilitation of knee OA. In addition, small but growing evidence supports the effectiveness of other types of exercise such as tai chi, balance, and proprioceptive training for individuals with knee OA. No information re: dose.
Escalante et al 2010	To summarise evidence for the effectiveness and structure of exercise programmes for hip and knee OA (pain relief)	Systematic Review: ARC OA diagnosis criteria, quasi-experimental/ RCT, Programme $\geq$ 4 wks, WOMAC pain	33 Searches 1 Feb-15 March 2015	Land based strength n=10 Tai chi n=10, Aerobic n=2, Aquatic n=5 Mixed n= 6	Pain (WOMAC)	Forrest plots rather than precise effect sizes. ?=approximate. Strength; pooled favoured I/V, ES 03-4?CI crossed 0. Tai chi pooled ES 0.6? CI not crossing 0. Aerobic pooled ES 0.55? CI not crossing 0. Hydro pooled ES 0.45? 0 not crossed, pooled mixed ES 0.2? (-0.25, 0.6?)	Few RCTs. Structure/dose very heteregenous, Tai-chi results promising, mixed programmes less so. Home versus clinical setting = similar Duration ranged 6-72 weeks, 1-7 sessions/week (most 2-3), durations not recorded – 90 minutes per session.
Escalante et al 2011	To summarise evidence re: Exercise and functional aerobic capacity in LL OA	Systematic review with M/As	20 studies (19 RCTs n=2093 and 1 CCT n=49); land-based n=17	Marked variability between studies.	Multiple; divided into 1: Strength n=2 2: Tai Chi n=3 3. Aerobic walking	Meta analyses Pooled effect sizes favouring I/V.1.ES 0.31 (0.05, 0.56) n=1 2.ES 0.66 (0.23, 1.09) 3.ES 0.9 (0.7, 1.10) 4.ES 0.47 (0.32. 0.62)	Limited number of trials. Interventions very heterogenous. Exercise appears beneficial, especially walking, but the differences between forms of exercise is unclear.

			Searches March and August 2010.		n=4 4. Mixed n=8 5. Hydrotherapy n=3	5.ES 0.00 (-0.38, 0.39) Duration 4-72 weeks, 3-5 times per week up to 90 minutes per session.	
Fernandes et al 2013	To develop EULAR evidence - based recommendations plus research and educational agenda for non-pharmacological management of hip and knee osteoarthritis.	Systematic review grading levels of evidence I-IV and consensus agreement 0-10.	Summarised information. Search was until Feb 2012	N/A.	11 recommendations	Relevant consensus information includes: people should receive individualised management programme which addresses (increasing) activity and exercise (daily exercise including strengthening and aerobic exercise, range of movement and stretches), individually tailored programme with short and long term goals, intervention/action and regular follow up and evaluation, pacing, linking exercise with daily activities,	Less evidence for hip than knee. Convincing evidence for overall effectiveness of exercise on pain and function for knee OA and, to a lesser extent, hip OA. Inconsistent evidence for exercise and QoL. Optimal dosage and rate of progression remain uncertain. No one form of exercise has proven superior. Mixed exercise programmes (conflicting evidence) are recommended designed to improve/maintain strength, aerobic capacity & ROM; these must meet the minimal requirements to improve or maintain muscle strength, aerobic capacity and/or joint range of motion because some reports suggest mixed programmes are less effective than focussed ones. Integrate exercise into daily life
Fransen & Connell 2008	To determine whether land-based exercise is beneficial in terms of reduced pain or function in knee OA	Systematic review with M/As	32 (n=3616 for pain n=3719 for function) Searched until December 2007	Marked variability between studies.	Pain Physical Function	Meta-analysis revealed a beneficial treatment effect with a standardized mean difference (SMD) of 0.40 (95% confidence interval (CI)0.30 to 0.50) for pain; and SMD 0.37 (95% CI 0.25 to 0.49) for physical function.	Regular exercise, monitored by health professionals, can improve pain and physical function related to knee OA in the short term (especially if more than 12 sessions). Heterogeneity remained marked. Treatment effects would be considered small and comparable to NSAIDs
Fransen et al 2014	Determine benefit of land-based exercise for people with hip OA in terms pain, function and quality of life.	Systematic review with M/As.	10 Studies (9 high quality studies n=549) Inception-March 2013	tai chi n=1. Land-based exercise (strengthening functional, aerobic) individual or group (n=9).	Continuous outcomes: pain, physical function and quality of life). Dichotomous outcomes: proportionof study withdrawals	9 high-quality trials indicating exercise reduced pain (standardised mean difference (SMD) -0.38, (-0.55 to -0.20) and improved physical function (SMD -0.38, -0.54 to -0.05) post treatment. Improvements were sustained at 3-6 month follow ups. Durations mostly 6-12 weeks, 1-3 times per week, up to 60 minutes. Mix of class and indivudualised delivery.	Land-based therapeutic exercise programmes can reduce pain and improve physical function among people with symptomatic hip OA.
Hochberg et al 2012	To update ACR recommendations for the treatment of osteoarthritis of the hip and knee,	Systematic reviews and GRADE and consensus judgement	Up to December 31, 2010	More than 50 different nonpharmacologic and pharmacologic modalities that were previously identified by separate expert panels	All.	Provided recommendations: The ACR strongly recommends that patients with knee and hip OA participate in an aquatic exercise program, and in aerobic or resistance land-based exercise programs. Patients who are overweight should be advised about losing weight. The ACR strongly recommends that patients with hip osteoarthritis participate in aquatic exercise programs and in aerobic or resistance land-based exercise programs. If a patient is overweight, he or she should be advised to lose weight. The ACR has no specific recommendations regarding participation in balance exercises (alone or in combination with strengthening exercises) for hip OA.	
Jansen et al 2011	To determine effects of strength training alone, exercise therapy alone, and exercise with additional passive manual mobilisation on pain and function in people with	Systematic review with M/As	12 Trials (n=1262) January 1990-Dec 2008	Supervised strength training (n=5, 2 including HEP), supervised exercise therapy combination of strength training with active range of motion exercises and aerobic activity (n=5, 3 with HEP), or exercise with	Pain (VAS) , physical function (e.g. WOMAC	Effect size on pain was 0.38 (95% CI 0.23 to 0.54) for strength training, 0.34 (95% CI 0.19 to 0.49) for exercise, and 0.69 (95% CI 0.42 to 0.96) for exercise plus manual mobilisation. Each intervention improved physical function significantly. No randomised comparisons of the three interventions were identified. Meta-regression indicated that exercise plus manual mobilisations improved pain significantly more than exercise alone (p = 0.03). The remaining comparisons between the three interventions	No direct comparison studies found, only indirect comparisons so cannot be certain which treatment is superior. Supervised exercise therapy plus manual mobilisation showed a moderate effect size on pain compared to the small effect sizes for supervised strength training or supervised exercise therapy alone in the short term (post intervention).7 trials incorporated a home exercise programme. Durations: Unrecorded session length - 90 minutes (most one hour or less), mostly 2-3 times per week for

	knee OA compared to control and the effects of these interventions relative to each other.			additional passive manual mobilisation (n=2 with HEP)		for pain and physical function were not significant. Heterogeneity not significant for pain but was for function Q_E (df=9)=18.22 p=0.03.	4-16 weeks (mostly 8-12).
Juhl et al 2014	To identify the optimal exercise program, characterized by type and intensity of exercise, length of program, duration of individual supervised sessions, and number of sessions per week, for reducing pain and patient-reported disability in knee OA.	Systematic review with Meta-regression analyses	94 trials of which 48 were included in analyses. Up to May 2012	RCTs with at least one exercise group and non exercise control. 59 exercise interventions were compared in the 48 trials	Pain, disability (e.g.) VAS, WOMAC, KOOS, AIMS	Similar effects in reducing pain found for aerobic, resistance, and performance exercise (SMD 0.67, 0.62, and 0.48, respectively; P = 0.733). Such single-type exercise programs were more efficacious than programs that included different exercise types (SMD 0.61 versus 0.16; P < 0.001). The effect of aerobic exercise on pain relief increased with increased number of supervised sessions (slope 0.022 [95% confidence interval 0.002, 0.043]). More pain reduction occurred with quadriceps-specific exercise than with lower limb exercise (SMD 0.85 versus 0.39; P = 0.005) and when supervised exercise (at least 3 X per week) was performed (SMD 0.68 versus 0.41; P = 0.017). No impact of intensity, duration of individual sessions, or patient characteristics was found. Similar results were found for the effect on patient-reported disability. Substantial heterogeneity: pain I^2 =62% and disability I^2 =68.8%	Optimal exercise programs for knee OA should have one aim and focus on improving aerobic capacity, quadriceps muscle strength, or lower extremity performance. Programmes should be supervised, carried out 3 times a week and include at least 12 sessions for optimal results. Such programs have a similar effect regardless of patient characteristics, including radiographic severity and baseline pain. The findings show no support for individualisation of exercise programs based on patient characteristics (such as severity).
Kelley et al 2015	To determine the effects of exercise (aerobic, strength or both) on depressive symptoms in adults with arthritis and other rheumatological conditions (AORC)	Systematic review with meta-analyses	2,449 participants (1,470 exercise, 979 control) nested within 29 studies were included. Search dates unclear.	RCTs with exercise only interventions (aerobic, strength or both) which were community deliverable and lasted 4 weeks or more versus control	Depressive symptoms e.g FIQ	Length of training mean = 19 ± 16 weeks, mean frequency 4 ± 2 times per week and mean duration 34 ± 17 minutes per session. Statistically significant exercise minus control group reductions were found for depressive symptoms (g = -0.42, 95% CI, -0.58, -0.26, Q = 126.9, P <0.0001, I (2) = 73.2%). The number needed-to-treat was 7 (95% CI, 6 to 11) with an estimated 3.1 million (95% CI, 2.0 to 3.7) United States adults not currently meeting physical activity guidelines. Using Cohen's U_3 Index, the percentile reduction was 16.4% (95% CI, 10.4% to 21.9%).	Exercise is associated with reductions in depressive symptoms among selected adults with AORC. A need exists for additional, well-designed and reported studies on this topic. Wide ranging doses: 1-7 days per week (most commonly =3), 20 minutes-3 hours for up to 6 months. The majority of studies were for fibromyalgia, only 4-5 for OA (one = OA and Rheumatoid arthritis).
Loew et al 2012	To evaluate aerobic walking programmes for the management of osteoarthritis of the knee. To produce guidelines. Patientshad to be at least 40 years old and have a healthy body mass	Systematic review with meta-analyses	Nine studies (10 full-text articles) were included in the review; eight were RCTs and 1 was a controlled clinical trial. The total sample size was unclear.	Exercise interventions had to last for at least one month. Most studies included supervised exercise. Some also included multicomponent exercises or strength training. Most were delivered 2-3 times daily-3) a week for 3 months (range 8 wks	Pain relief, functional status, and quality of life, Range of outcomes used.	3 studies were poor quality (under 3 points) and the rest high quality (by scoring 3 points) on the Jadad scale. Blinding of patients and the trial staff providing the interventions was not possible. Patients who received walking programmes had significantly less pain than those in control groups (SMD -0.47, 95% CI -0.71 to -0.23; three trials; I²=0%), better endurance assessed using a five-minute or six-minute walk test (SMD-0.68, 95% CI -0.96 to -0.41; two trials; I²=46%), and improved aerobic capacity at three months (difference in	Evidence from 7 high-quality studies demonstrated that facility, hospital, and home-based aerobic walking programs with other therapies are effective interventions in the shorter term for the management of patients with OA to improve stiffness, strength, mobility, and endurance. Several aerobic walking programs showed significant and beneficial effects on QOL compared with a control; this effect was not maintained after an unsupervised period of walking program at 9 months. The trials were heterogeneous.

	index (BMI) of below 25kg/m2.		Mean ages of participants ranged 56 - 76 yrs.	to 18/12). Most control group treatments incorporated educational sessions.		change from baseline 19.8%, one trial). No clinically-relevant difference was found at nine months for aerobic capacity (one trial).	Studies with more than 20% dropout rate were excluded from this review.
McAlindon et al 2014 OARSI	To develop concise, up-to-date, patient-focused, evidence-based, expert consensus guidelines for the management of knee OA, to inform patients, physicians, and allied healthcare professionals worldwide.	Systematic review grading level & quality of evidence & estimated effect sizes. Experts voted on appropriate-ness of treatmenst.	From date of last review (2010) to March 2013		Level of evidence, Pain and function	Core treatments for knee OA included exercise (land-based and water-based), self-management and education, strength training, and weight management. Good levels of evidence (Systematic reviews and M/As). Land-based exercise ES pain= 0.34 (0.19-0.49) to 0.63 (0.39-0.87); function 0.25 (0.03-0.48).	
NICE 2014	To provide guidelines and recommendations for OA.	Evidence-based appraisal of (M/As, GRADE plus narrative for qualitative) a vast amount of literature as well as on expert opinion, especially where the evidence base is particularly lacking. Up to 7th May 2013		All	Multiple, especially interested in clinical differences.	The guidelines advise people with OA to exercise as a core treatment irrespective of age, comorbidity, pain severity or disability. Exercise should include local muscle strengthening and general aerobic fitness. It has not been specified whether exercise should be provided by the NHS, or whether healthcare professionals should provide advice and encouragement to the person so that they can carry out the intervention themselves. Exercise has been found to be beneficial but the clinician needs to make a judgement in each case on how to effectively ensure participation. This will depend upon the person's individual needs, circumstances and self-motivation, and the availability of local facilities.	
O'Connor et al 2015	To review the evidence examining effects of walking interventions on pain and self-reported function in individuals with chronic musculoskeletal pain (adults with chronic low back pain, OA, or fibromyalgia).	Systematic review and meta-analyses. January 1980 to March 2014	RCTs and quasi RCTs Twenty-six studies (2384 participants) were included. 24 RCTs; 12 OA, 8FM, 1 chronic MSK and 5 LBP. Suitable data from 17 studies were pooled for meta-analysis.	Walking compared with nonexercise or nonwalking exercise control group. In most studies (19/ 26; 73%), walking was supervised (hospital clinic, gymnasium, other). Walking mainly treadmill or land-based. Some combined supervised with walking at home. 6 were home-based. 3 used pedometers (stepbased goals) 3 used time-based walking goals. 13 included a walking-only intervention group, (remainder combined walking with cointervention- most commonly educational or alternative exercise.	Pain and function.	Interventions were associated with small to moderate improvements in pain at short-term (mean difference, -5.31; 95% CI, -8.06 to -2.56) and medium-term (mean difference, -7.92; 95% CI, -12.37 to -3.48) follow-up. Improvements in function were observed at short-term (mean difference, -6.47; 95% CI, -12.00 to -0.95), medium-term (mean difference, -9.31; 95% CI, -14.00 to -4.61), and long term (mean difference, -5.22; 95% CI, -7.21 to -3.23) follow-up. Mean duration of final follow-up = 1.8$\pm$0.4 months for studies with short-term outcomes (less than 8wk post randomization), 4.9$\pm$1.9 months for studies with medium-term outcomes (>2-12mo), and 18.4$\pm$7.6 months for studies with long term outcomes (>12mo).11 studies associated adverse events: included 2 falls resulting in distal radial fractures,1 fall resulting in a hip fracture, 1 case of plantar fasciitis, and 2 cases of allergic skin reactions to metal pedometer clips. 2 FM studies reported a general increase in reporting of pain and muscle stiffness in the intervention group. One cLBP reported temporary exacerbations in pain levels in a small number of participants,	Evidence of fair methodological quality suggests that walking is associated with significant improvements in outcome compared with control interventions but longer-term effectiveness is uncertain Walking appears to have a slightly greater effect on function than pain. Sample sizes ranged from 3-439. A small number of studies (n=5) contained serious potential sources of methodological bias; inadequate allocation concealment during randomization (n=2) unequal distribution of important confounding variables at baseline not accounted for during analysis n=2), no masking of outcome(n=1) assessment or a substantial (>50%) dropout rate and subsequent post hoc revision of the intervention groups examined (n=1).11 studies did not provide enough detail regarding exercise intensity, or it was not sufficient to effect any change in fitness. 11/26 reported a measure of participant adherence . These included attendance at exercise classes (n=7), self-reported completion of home exercise (n=2), or self-reported adherence to wearing a pedometer (n=2).Studies generally included similar populations in terms of demographic characteristics and clinical presentation, as well

				Controls: education, usual care, other exercise, passive I/V (relaxation/massage), and a 6-8 week preintervention baseline phase. Duration 1-18 months (most 3months or less).		attributed to unaccustomed activity levels. Drop out rates 0-57%. Follow ups = 1-18 months (most 6 months or less).	as interventions that would be routinely available or feasible in clinical practice.
Pister et al 2007	To determine the long term effectiveness (>=6 months after treatment) of exercise therapy on pain, physical function, and patient global assessment of effectiveness in hip &/or knee OA	Systematic review with best evidence synthesis	11 studies (n=1521) Searches until November 2005	Exercise therapy or exercise therapy plus booster sessions post treatment versus usual care or education or ultrasound	exercise therapy on pain, physical function, and patient global assessment of effectiveness	Five high-quality and 6 low-quality RCTs. Strong evidence for no long term effectiveness on pain and self-reported physical function, moderate evidence for long term effectiveness on patient global assessment of effectiveness, and conflicting evidence for observed physical function. For exercise programs with additional booster sessions, moderate evidence was found for long term effectiveness on pain, self-reported and observed physical function.	The positive post treatment effects of exercise therapy on pain and physical function in patients with OA of the hip and/or knee are not sustained in the long term. Long term effectiveness was only found for patient global assessment of effectiveness. There was wide variety of modes, content and doses of exercise in interventions. There were attrition bias concerns for 7 studies.
Quicke et al 2015	To determine whether long term physical activity is safe for older adults with knee pain.	Systematic review and narrative synthesis of existing literature	49 studies (48 RCTs n=8920 and one single case study) inception until May 2013.	78 physical activity intervention groups in RCTs. Mode, intensity and duration varied widely. 76 intervention grps were moderate to vigorous and all I/Vs were low impact. 46 intervention groups were “mixed” aerobic, strengthening and stretching	Adverse events, pain, function, structural OA biomarker imaging, total knee joint replacement	RCTs varied in quality and included an array of low impact therapeutic exercise interventions of varying cardiovascular intensity. There was no evidence of serious adverse events, increases in pain, decreases in physical function, progression of structural OA on imaging or increased TKR at group level. The case control study concluded that increasing levels of regular physical activity was associated with lower risk of progression to TKR.	Long term low impact therapeutic exercise lasting 3 to 30 months is safe for most older adults with knee pain. This review supports current clinical guideline recommendations. Less than half of RCTs (n=22) reported adverse events and some reports were generalised; Moderate adverse events (eg fall leading to fracture) ranged from 0-6% in trials i.e. were rare, and a minority of pts experienced mild events such as minor pain on activity. Unclear or high risk of attrition bias due to incomplete outcome data in over half of studies.
Roddy et al 2005	To compare the efficacy of aerobic walking and home based quadriceps strengthening exercises in patients with knee OA.	Systematic review and meta-analyses	13 RCTs Search dates: 1966 to September 2003	Strengthening (n=9) walking n=3 walking versus strengthening n=1 , dynamic versus isometric resistance training (n=1)	Pain, self reported disability	RCTS varied in quality. Pooled effect sizes for pain were 0.52 for aerobic walking and 0.39 for quadriceps strengthening. For self reported disability, pooled effect sizes were 0.46 for aerobic walking and 0.32 for quadriceps strengthening.	Both aerobic walking and home based quadriceps strengthening exercise reduce pain and disability from knee OA but no difference between them was found on indirect comparison. The optimal way to deliver strengthening exercise remains unclear. There was considerable variation in content and duration of interventions; durations ranging 8wks – 2 years.
Romeo et al 2013	To investigate the role of therapeutic exercise and/or manual therapy in the treatment of hip osteoarthritis	Systematic review (meta-analyses not possible)	10 RCTs from May 2007 to April 2012) English or Italian	Eight concerning therapeutic exercise (including 2 aquatic) and two manual therapy	Predominantly pain, function. A few studies included others e.g. (adherence, QoL, medication use ADL, walking, fall risk).	Few high quality studies. At mid- and long term follow-up land-based exercises showed insufficient evidence of effectiveness for pain and quality of life, but positive results for physical function. Water exercises significantly reduced fall risk when combined with functional exercises. Programs that contained progressive and gradual exposure of difficult activities, education and exercises seem to promote better outcomes, higher adherence to	In Table 2: Pisters et al 2010 seems to be included twice? Wide variety of designs, outcomes, modes, duration and intensity and frequencies. Small samples sizes. Most common was a 12 week programme, 1-2 sessions per week, 20-45 minutes per session.

						home program and increased amount of physical activity (such as walking).	
Runhaar et al 2015	To identify possible physiological mediators in the relation between physical exercise and improvements of pain and function in OA patients.	Systematic review	94 studies evaluating 112 intervention groups were included.	knee OA =96 out of 112 gps. Hip OA = 5, hip & knee OA=1, LL OA =1, Ankle OA = 1 hand OA=2, multiple joints OA=1. Strengthening 40 I/V gps, Strengthening plus another exercise type = 59, Flexibility + exercise =44, Aerobic =25, performance training=13	Inflammation, gait, strength, muscle properties, cartilage/OA properties, ROM/flexibility, Biomechanics, Weight/metabolic syndrome, bone properties, proprioception, balance/instability, aerobic capacity.	12 categories of possible mediators were formed. Muscle strength (61 groups) and ROM/flexibility (21 gps) were the most measured categories of possible mediators. 60% (31 out of 52) of the studies showed a significant increase in knee extensor muscle strength and 71% (22 out of 31) in knee flexor muscle strength over the intervention period. All studies evaluating extension impairments (n=5) and 10 out of 12 studies (83%) measuring proprioception found a significant change from pre-to post-intervention.	An increase of upper leg strength, a decrease of extension impairments and improvement in proprioception were identified as possible mediators in the positive association between physical exercise and OA symptoms. Only strength and ROM/Flexibility were explored in details: insufficient studies existed to evaluate the other possible mediators. Dose varied: daily-weekly (most interventions were 3 or 5 times per week) and ranged from a single work out to 18 months (commonly between 1-3 months).
Silva et al 2012	To examine evidence regarding the effects of therapeutic exercise on the balance of women with knee osteoarthritis (OA).	Systematic review, levels of evidence	9 RCTs (833 pts) Jan2000 to July 2010 in English, Portugese or Spanish	Aerobic and strength, Tai Chi, balance, hydrotherapy, vibrating platform ex, strength with weights, education	Single/double leg stance, pain, QoL, stiffness, balance, strength, fitness, function, position sense, speed walk. e.g: KOOS, TUG, force plat-forms, balance master, Cybex, VAS, cycle ergometer, timed stairs, Biodex,	Eight of these 9 studies were classified as having high methodological quality on the PEDro Scale (no Risk of bias tool). Sample size in the review averaged 30 subjects per group (one study used 90 subjects per group).Although the methods and interventions regarding balance varied widely in these studies, most found significant improvement in the balance of women with knee OA.	5/9 studies included men as well as women (percentage of women higher in studies). Dosage: Most were 2-3 times per week. Duration ranged 4 weeks to 24 months; most common was 8 weeks. There was a wide variety of interventions, outcomes and findings.
Smith et al 2012	To determine the effectiveness of proprioceptive exercises for knee OA : comparing ex programme with PE to rehabilitation with no PE or not intervention.	Systematic review and meta-analyses	7 RCTs including 560 participants Inception to Dec 2011	Proprioceptive exercise versus non treatment (n=3) or non proprioceptive exercise (n=4).	Primary= Function at one year (WOMAC, KOOS, TUG, Stairs, 60m walk test). Secondary, pain, general or QoL measures, JPS, ROM, strength, compliance and acceptance.	PeDRO scores moderate. Only one RCT reported primary outcome (NS difference WOMAC scores between 2 exercise arms) at 1 year. Compared to non intervention, proprioceptive exercises significantly improved functional outcomes in people with knee OA during the first 8 weeks ($p < 0.02$). When compared against a general non-proprioceptive exercise programme, proprioceptive exercises demonstrated similar outcomes, only providing superior results with respect to joint position sense-related measurements such as timed walk over uneven ground ($p = 0.03$) and joint position angulation error ($p < 0.01$). Information in the paper regarding compliance is unclear.	Proprioceptive exercises are efficacious in the treatment of knee OA. There is some evidence to indicate the effectiveness of proprioceptive exercises compared to general strengthening exercises in functional outcomes. Durations often 4-8 weeks, frequency often 3-5 times per week (not all reported). PEDro scores were moderate but many studies appeared at high risk of bias: 3/7 report between gp differences, 4/7 were small sample size, 4/7 used blind outcome assessment. It was not possible to analyse some outcomes due to lack of data.
Tanaka et al 2013	To investigate improvement in various impairments by exercise interventions in patients with knee	Systematic review and M/A and GRADE approach	33 trials (3192 pts). Inception to Feb 2012	Strengthening (with/ without WB), balance, stretching, walking, Tai chi, Baduanjin, functional exercise, computerised proprioception facilitation exercise, ROM. Some added	Data on pain, stiffness, muscle strength, range of motion, flexibility, maximal oxygen uptake, and position sense were synthesized.	23 high quality PEDro scores, 6.2 across all. SMD (95% CI) of effect of exercise on pain (VAS): 0.77 (0.29, 1.24). SMD (95% CI) of effect of exercise on pain (WOMAC): 0.43 (0.29, 0.57). SMD (95% CI) of effect of exercise on stiffness (WOMAC): 0.24 (0.05, 0.44). SMD (95% CI) of effect of exercise on knee extensors muscle strength: 0.37 (0.24, 0.50) and knee flexors muscle strength: 0.57	GRADE findings: Meta-analysis provided high quality evidence that exercise intervention improves maximal oxygen uptake, and moderate-quality evidence that exercise intervention also improves pain, stiffness, knee extensor and flexor muscle strength, and position sense. Whether exercise interventions improve knee extension and flexion range of motion was undetermined. Dose: <1-7 sessions

	osteoarthritis (OA).			diet, patellar taping or hydrotherapy.		(0.42, 0.77). SMD (95% CI) of effect of exercise intervention on knee extension ROM: 0.89 (0.49, 1.30) and flexion: 0.51 (0.12, 0.90). SMD (95% CI) of effect of exercise on flexibility: 0.34 (-0.32, 1.01)and on maximal oxygen uptake: 0.22 (0.07, 0.37)	per week (most commonly 3 X per week) 5-72 weeks duration (many between 8-12 wks).
Tanaka et al 2013	To investigate the differences in effectiveness between strengthening and aerobic exercise for reducing pain in people with knee OA	Systematic review with M/As	8 trials Inception to 20 March 2013.	11 exercise groups in 8 studies. 6 gps in 4 trials =non WB muscle strengthening, 2 gps in 1 study=WB strengthening, 3gps= aerobic exercise.	Pain (self report)	PEDro scores ranged 4-8. The overall effect of exercise was significant with an effect size SMD: -0.94 (95% CI -1.31 to -0.57). Subgroup analyses showed a larger SMD for non-weight-bearing strengthening exercise: -1.42 (-2.09 to -0.75) compared with weight-bearing strengthening exercise : -0.70 (-1.05 to -0.35), and aerobic exercise: -0.45 (-0.77 to -0.13).	Muscle strengthening exercises with /without weight-bearing and aerobic exercises are effective for pain relief in people with knee OA. For pain relief by short-term exercise intervention, the most effective exercise among the three types is non-weight-bearing strengthening exercise. Low quality studies showed moderate treatments effects, higher quality studies showed small mean treatment effect. Most studies ex 3X a week for 6-8 weeks.
Tanaka et al 2014	To investigate the influence of land-based exercise frequency and duration on pain relief for people with knee OA.	Systematic review with M/As	17 trials (1816 pts) Until 30 December 2010	23 exercise groups in 17 trials: 17 strengthening and 6 aerobic exercise . These gps were then divided into 2 subgroups – up to 3 sessions per week and more than 4 sessions per week and also divided according duration (up to 8 weeks programme and 9 or more groups).	Pain NRS, VAS, WOMAC, OARSI, AIMS.	15/17 PEDro scores of at least 5 but 5 were at high risk of bias . M/A showed pain significantly reduced, medium effect size SMD (95% CI): -0.57 (-0.74, -0.4.)Strengthening groups: strengthening exercise programs of ≥9 weeks duration and 4 or more times per week showed greater trial effects than those who performed up to 3 sessions/week. Strengthening up to 3 sessions a week for 8 or more weeks had lesser effect than up to 8 weeks (effect on pain relief does not increase with time). Heterogeneity was not confirmed in aerobic exercise subgroups. Frequency of interventions ranged 1-7 times per week (most = 3) 8-72 weeks (most = 8).	Differences in exercise frequency and duration influence pain relief in effects of strengthening exercises but do not influence the effect size of aerobic exercise for people with knee OA. There was high statistical heterogeneity in subgroups of strengthening ex.
Tanaka et al 2016	To examine the effect of exercise therapy on the walking ability of individuals with knee OA.	Systematic review with M/As GRADE	28 RCTs (2991 participants). Up to October 2014.	Muscle strengthening, balance, stretches, walking, cycling, Baduanjin, functional exercise, computerised proprioception facilitation exercises, ROM. (Some added diet, hydro, patellar taping)	Total distance walked (6-minute walk test); the amount of time spent walking (the time to walk arbitrary distances); and gait velocity.	10/28 PEDro less than 6 and mean = 6,1 across all. M/As provided low quality evidence that exercise therapy increased the total distance walked in the 6-minute walk test, in comparison with the effects of the control interventions SMD (95% CI) 0.44, (0.27 to 0.60). M/As provided low or moderate-quality evidence that the amount of time spent walking and gait velocity were improved more by exercise therapy than by the control interventions (the amount of time spent walking, SMD: -0.50 (-0.70 to -0.30), gait velocity SMD: 1.78 (0.98 to 2.58).	Exercise therapy can improve the amount of time spent walking, gait velocity, and maybe the total distance walked. Mod to large effects sizes but low quality evidence due to GRADE. Notable statistical heterogeneity among the trials
Uthman et al 2013	1. Determine whether exercise interventions are more effective than no exercise control 2. Compare different exercise	Systematic review; trial sequential analyses plus comprehens ive synthesis	60 studies (8218 pts):44 knee, 2 hip and 14 mixed. Inception to March2012	12 exercise comparisons plus no exercise controls. Number of trials comparing similar is small.	Primary measure pain intensity and function (negative values =improved function or pain relief)	Allocation sequence was adequate in most trials (n=42, 60%); allocation concealment was adequate in almost half of the trials (n=25,42%); 31 trials (52%) masked outcome assessors to treatment allocation; incomplete data was high in 10 trials (18%); selective reporting bias was low in most trials (n=53, 88%). Flexibility plus strengthening +/- aerobic,	As of 2002 evidence (largely from knees) had accumulated showing benefit of exercise over no exercise. A combined approach (strength, flexibility and aerobic) is likely to be most effective.

	interventions	using network meta-analysis methods				strengthening, aquatic +/- flexibility were all significantly effective in relieving pain (large and medium effects). Overall difference in function versus control = -1.32 units (medium effect size) on 0-10 WOMAC scales for combination of strengthening, flexibility and aerobic. Combined intervention of strengthening, flexibility and aerobic exercise was significantly more effective that no exercise for improving function SMD (95%CI): -0.63 (-1.16, -0.10).	
Wallis et al 2013	To determine the proportion of people with hip and knee OA that meet physical activity guidelines recommended for adults and older adults.	Systematic review with M/As GRADE	Knee OA n=21 studies (3266 participants). For hip OA n=11 studies involving 325 participants.	PA monitoring: studies with a minimum of 1 day of monitoring (16 of the 18 studies used in the M/As reported at least 7 days)	activity monitor	The majority of trials = high quality. Knee OA, averaged 50 min PA per week (95% CI = 46, 55) of MVPA when measured in bouts of ≥10 min, 131 min per week (95% CI= 125, 137) of MVPA, and 7753 daily steps (95% CI = 7582, 7924). High quality evidence that 13% (95% CI = 7, 20) completed ≥150 min per week of MVPA in bouts of ≥10 min, low quality evidence that 41% (95% CI = 23, 61) completed ≥150 min per week of MVPA in absence of bouts, moderate quality evidence that 19% (95% CI = 8, 33) completed ≥10,000 steps per day, and low quality evidence that 48% (95% CI ¼ 31, 65) completed ≥7000 steps per day. For hip OA, participants averaged 160 min PA per week (95% CI = 114, 216) of MVPA when measured in bouts of ≥10 min, 189 min per week (95% CI = 166, 212) of MVPA, and 8174 daily steps (95% CI = 7670, 8678). Proportion meta-analyses provided low quality evidence that 58% (95% CI = 18, 92) completed 150 min per week of MVPA in absence of bouts, low quality evidence that 30% (95% CI = 13, 50) completed ≥10,000 steps per day, and low quality evidence that 60% (95% CI = 47, 73) completed 7≥000 steps per day. A small to moderate proportion of people with knee and hip OA met PA guidelines and recommended daily steps.	
Williamson et al 2015	Evaluate effectiveness of OA behavioural interventions on sustained PA or cardiovascular fitness, over a minimum of 6 months, in lower limb OA populations.	systematic review and M/As.	11 RCTs (2741 participants),	Majority of included interventions implement an arthritis self-management programme targeting coping skills and self-efficacy.Miinimum 6/12 follow up.	measures of PA (self-reported and objectively measured), self efficacy and cardiovascular fitness.	36% of studies had attrition greater than 20% beyond 12 months. 7 studies used self-report measures, the pooled effect of these studies was small with significant heterogeneity between studies SMD (95%CI) 0.22 (−0.11 to 0.56) z=1.30 p=0.19, I^2 statistic of 85%. Subgroup analysis of 6–12 month outcome reduced heterogeneity and increased intervention effect compared to control 0.53 (0.41 to 0.65),z=8.84 p<0.00001 I^2 of 66%.	Arthritis self-management programmes achieve a small, significant improvement in PA in the short term. Effectiveness of intervention declines with extended follow-up beyond 12 months with no significant benefit compared to control. The small number of studies (11 RCTs) limited ability to define effective delivery methods. OA studies need to include PA in baseline characteristics. Bandura's self-efficacy theory most used but only a minority report measuring mediators of change.

Zacharias et al 2014	Evaluate effectiveness of exercise-based rehabilitation programs (minimum duration 6/wks) for improving lower limb muscle strength in individuals with hip or knee osteoarthritis (OA).	Systematic review GRADE criteria M/As where appropriate	Inception until Feb 2013. Forty RCTs were included, 11 in M/As.	Knee OA n=35, Hip OA n=1, mixed n=4. and the majority (77%) involved resistance based exercise programs. Low intensity resistance exercise n=25, high n=15, multimodal n=7, hydro n=4, aerobic n=1	Strength knee flexors and extensors n=38	PEDro for quality average 6.1 (range3-8). GRADE on 11 studies in M/A 2= high, 5= moderate, 2= low and 2 =very low . High quality evidence for improved knee extension (standardized mean difference (SMD) = 0.47, 95% confidence intervals (CI) 0.29, 0.66) and flexion strength (SMD = 0.74, 95% CI 0.56, 0.92) with low-intensity resistance program when compared to a control at short term follow-up. There was moderate quality evidence for a large effect favouring high-intensity resistance programs (SMD = 0.76, 95% CI 0.47, 1.06) when compared to a control. This effect was sustained at intermediate term follow-up (SMD = 0.80, 95% CI 0.44, 1.17.	When compared to a control group, high-intensity resistance exercise demonstrated moderate quality of evidence for large and sustained improvements for knee muscle strength in knee OA patients Durations mostly 6-12 wks, only 3 > 12 wks.). Few studies reported on outcomes at long term (LT) follow-up. Only one study reported on a population with hip OA.

Key for tables: AAOS = American Academy of Orthopaedic Surgeons, ADL = activities of daily living, AIMS = Arthritis Impact Measurement Scales, ACR = American College of Rheumatology, CCT = clinical controlled trial, ES = effect size, Ex=exercise, FIQ = Fibromyalgia Impact Questionnaire, FM = fibromyalgia, JPS = joint position sense, KOOS = Knee Injury and Osteoarthritis Outcome Score, LBP = low back pain, LL = lower limb, OA = osteoarthritic, OARSI = Osteoarthritis Research Society International, ODI = Oswestry Disability Index, PA = physical activity, Qol = quality of life, M/As = meta analyses, MVPA = moderate to vigorous physical activity, NRS = numerical rating scale, NS = non significant, mnths = months, RCT= randomised controlled trial, RoB = risk of bias, ROM = range of motion, RMDQ = Roland Morris Disability Questionnaire, SF-36 = 36-Item Short Form Health Survey, SMD = standardised mean difference, TKR = total knee replacement, TUG= timed up and go test, v= versus, VAS = visual analogue scale, WB = weighbearing, wks = weeks, WOMAC = Western Ontario and McMaster Universities Arthritis Index, 95% CI = 95% confidence interval.

PART TWO: FIBROMYALGIA

Review	Aim	Design and	Number of studies	Interventions	Main Outcomes	Summarised Main Results	Conclusions and Additional Comments
BiDondie et al 2014	To identify, evaluate, and synthesize systematic reviews of physical activity interventions for adults with fibromyalgia	Umbrella review using existing systematic reviews and AMSTAR	9 reviews (including 2 narrative syntheses, 60 RCTs 3816 pts) Dates: Jan 1 2007-Mar 31st 2013.	Specific physical activity (e.g aerobic, aquatics, resistance)	Pain, multidimensional function (wellness or quality of life), physical function (self-reported physical function or measured physical fitness) and adverse effects	Quality varied widely (high n=3, mid n=4, low n=2). Further M/As not possible due to heterogeneity of the sample. Positive results “substantial and convincing evidence” of diverse exercise interventions on pain, multidimensional function, and self-reported physical function, and no supporting evidence for new (to FM) interventions (i.e., qigong, tai chi). Reporting of adverse effects = patchy.	The variability of the interventions in the reviews prevented answering important clinical questions to guide practical decisions about optimal modes or dosages (i.e., frequency, intensity, duration). Majority of interventions were 3 times a week, moderate intensity, 31-60 minutes duration for 7-12 weeks. Participants predominantly female
Brosseau et al 2008 Part 1	Guidelines for Aerobic fitness exercises for management of FM	Ottawa panel graded evidence AGREE criteria i.e. clinical and statistical significance	16 (13 RCTs, 3 CCTs). Unclear if 2 RCTs report data from the same trial so no of patients either 791 or 822. Date: until Dec 2006	Aerobic fitness – few details available. Land based and hydrotherapy. Some included fitness plus exercises (strengthening, flexibility and relaxation)	Quality of life, pain, fatigue, sleep, global perceived effect, depression	Jadad scale for quality 6=high quality and low = 10. Emerging (and mixed) evidence to support aerobic fitness programmes, especially for pain relief and quality of life. 24 positive recommendations (10 grade A, 1 grade B, 13 Grade C+); only 5 of these were of clinical benefit. Conflicting evidence. Wide variety of outcomes used.	Recommends aerobic fitness exercise, although most trials were rated low quality. Highly individualised and/or multimodal programmes prevented determining which components are effective for FM. Varied dosage; majority 3 sessions per week, 20-120 minutes (mode = 60 minutes) duration for 8-23 weeks. Small sample sizes (only 1 study n>100)
Busch 2007 and 2008	To evaluate the effects of exercise training including cardiorespiratory (aerobic), muscle strengthening, and/or flexibility exercise on global well-being, selected signs & symptoms, and physical function in pts with FMS	Systematic review (Cochrane) Systematic review with M/As of aerobic-only exercise interventions compared to untreated controls	2276 subjects across 34 RCTs; 1264 subjects were assigned to exercise interventions. Meta analyses of 6 studies. Dates: Inception to July 2005	The 34 studies comprised 47 interventions that included exercise. Duration 2 ½ - 24 weeks. Aerobic ex at least 20 mins a day 2-3 X week, Strengthening 8-12 reps 2-3 X wk	Large variety of outcomes (n = 166). Most common: Pain = 10-cm VAS (n=22); global well-being = FIQ (n = 13); physical performance (aerobic) = 6-minute walk test (n =6) and maximum oxygen uptake (n = 7); Tender point count (n=12); Depression: Beck Depression Inventory, VAS (n=5 each). Fatigue FIQ fatigue VAS (n=10) Effects of several disparate interventions on individuals with FMS were summarized using standardized mean differences (SMD)	There is moderate quality evidence that aerobic-only exercise training at recommended intensity levels has positive effects global well-being (SMD 0.49, 95% confidence interval (CI 0.23 to 0.75) , physical function (SMD 0.66, 95% CI 0.41 to 0.92) , possibly on pain (SMD 0.65, 95% CI -0.15 to 2.03) and tender points (SMD 0.26, 95% CI -0.23 to 0.65). Conflicting evidence regarding effect of aerobic exercise upon depression	moderate evidence that supervised aerobic exercise training has beneficial effects on physical capacity and FMS symptoms. Strength training may also have benefits on some FMS symptoms. Further studies on muscle strengthening and flexibility are needed. Further research on the long term benefits needed. Adherence to aerobic exercise interventions of many of the studies was poor (high attrition – averaged 27% (range 0-67%) for the 17 aerobic studies). Few serious adverse events reported, but a lack of agreement whether protracted increases in FM symptoms should be reported as adverse effects of exercise. Varied interventions, for 6-24 weeks durations. Participants were predominantly female. Generally small sample sizes: 5 of the 34 studies met the standard of 50 subjects per group.

Busch et al 2011	To review the effects of exercise and physical activity for individuals with fibromyalgia, summarizing recent reviews and describing new advances	Review of reviews and recent primary studies (AMSTAR and PEDro)	5 systematic reviews with M/As, 4 narrative reviews, and 16 recent RCTs appear to be included	3 reviews had MA/s – effect sizes summarised	*Effect sizes* — *Aerobic* / *Strength* / *Mixed* / *Aquatic* Pain — small/no / large (limited data) / Large / medium Fatigue — small Global Health — small / large (limited data) / no effect / medium Physical function — medium / large / large CardioVas medium strength / large Depression — small/med / large (limited data) / no effect / large (limited data) [small effect: 0.2–0.49; medium effect: 0.5–0.79; large effect: ≥0.8].		Aerobic exercise reduced pain, fatigue, depression, health related QoL and physical fitness. Adverse events not consistently reported but do not appear uncommon. Exercise often delivered with other treatments – multimodal. Hydro not superior to land based – similar (but might have role in severely deconditioned pts) Varied interventions (mostly supervised) lasting 4-32 weeks.
Busch et al 2013	To evaluate the benefits and harms of resistance exercise training in adults with fibromyalgia. We compared resistance training versus control and versus other types of exercise training	Systematic review (Cochrane)	5 studies (one 3-arm) 219 women with fibromyalgia, Up to 5 March 2013	2 RCTs: 8 wks progressive resistance versus aerobic training. 3 RCTs:16 to 21 weeks of moderate- to high-intensity resistance training versus control 1 RCT: 12 wks of low-intensity resistance and elastic tubing versus flexibility	21 outcomes : 7 designated as major outcomes: multidimensional function, self reported physical function, pain, tenderness, muscle strength, attrition rates, and adverse effects.	Significant differences favouring Resistance training interventions over control gp(s) for multidimensional function FIQ total ↓16.75 units on a 100-point scale; 95% CI -23.31 to -10.19), self reported physical function (-6.29 units on a 100-point scale; 95% CI -10.45 to -2.13), pain (-3.3 cm on a 10-cm scale; 95% CI -6.35 to -0.26), tenderness (-1.84 out of 18 tender points; 95% CI -2.6 to -1.08), and muscle strength (27.32 kg force on bilateral concentric leg extension; 95% CI 18.28 to 36.36).Differences between Resistance and aerobic groups= NS for multidimensional function , self -reported physical function or tenderness. Statistically significant ↓pain (0.99 cm on a 10-cm scale; 95% CI 0.31 to 1.67) favouring aerobic gps. Significant differences between a resistance gp and a flexibility gp favouring the resistance training gp for multidimensional function (-6.49 FIQ units on a 100-point scale; 95% CI -12.57 to -0.41) and pain (-0.88 cm on a 10-cm scale; 95% CI -1.57 to -0.19), but not for tenderness or strength.	Evidence was classified low quality due to the low number of studies and risk of bias assessment. Evidence suggested that 8 weeks of aerobic exercise was superior to moderate-intensity resistance training for improving pain in women with fibromyalgia. NS differences in attrition rates between the interventions. In general, adverse effects were poorly recorded, but no serious adverse effects were reported. Assessment of risk of bias was hampered by poor written descriptions (eg, allocation concealment, blinding of outcome assessors). The lack of a priori protocols and lack of care provider blinding were also concerns. Aerobic interventions (walking, treadmill) were 8-16 weeks in duration, 20-60 minutes, 3 x week (one summary states the I/V was supervised).
Cazzola et al 2010	Examine effectiveness of physical exercise for FM RCTs involving 1 type of exercise	Systematic review (narrative). Studies using different types of ex or multimodal were excluded	27 RCTs. Between Jan 1985-August 2010	15 landbased, 7 hydro, 5 muscle strengthening. Most studies exercised at mild/mod intensity, 2-3 X per wk for 30-60 mins for 12-32 weeks	Anxiety, depression, psychological, well being, physical function, pain, tender points.	Physical aerobic and strengthening exercise improves physical fitness, functional state and the symptoms of FM. Greatest agreement found for physical function – more conflicting evidence for pain and "extra-skeletal symptoms" (tender points, pain). Most interventions were supervised and based in rehab centres – but there is a shift towards home programmes.	Wide variation in intervention and control groups and outcomes. Land based v hydrotherapy: insufficient data to see if hydro superior in reducing spontaneous pain or depression. This review excluded ex versus ex and multimodal I/Vs. I/Vs lasted from 7 days to 8 months (most between 12-24 wks), unspecified – 60 minutes sessions, provided daily – unspecified (most 2-3 times per week)
Carville et al 2008 EULAR	To develop evidence-based recommendations for the management of fibromyalgia syndrome.	Systematic review and Delphi consensus	146 studies:39 pharmacologic al and 59 non-pharmacologic al in final recommend-ations.	Exercise studies: Pool-based n= 2 Aerobic n=10 Strength n=3 Mixed n= 1	Pain assessed by the visual analogue scale (VAS) and function assessed by the fibromyalgia impact questionnaire (FIQ).	9 recommendations. Heated pool treatment with or without exercise is effective in FM. Individually tailored exercise programmes, including aerobic exercise and strength training can be beneficial to some patients with FM.	In many studies sample size was small and the quality of the study was insufficient for strong recommendations to be made. Quality in exercise studies was very variable. Although poor evidence, the committee felt that given the safety and benefit of exercise to

			Until end Dec 2005.				general health exercise should be included as a recommendation.
Dupree Jones et al 2006	To present a comprehensive evidence table of exercise studies for health care researchers	review (narrative analyses) of RCTs and uncontrolled trials	46 exercise studies (39 RCTs, 6 single gp studies and 1 non randomised); 3035 pts. Until Dec 2005	Most included aerobic, strength, flexibility alone or in combination. 33 land based, 7 hydro, remainder mixed. 5 studies =weight training	Symptoms – FIQ or health status, aerobic intensity	Sessions: 1-5 X per wk; 2-3 times most common, 15-180 minutes per session (average 60 minutes). Programmes 4-24 wks (median 12 wks). Attrition in people with FM 0-67% (range 0-67%, median 20%) Most fitness measures improved in people who could tolerate the I/V (esp high intensity ex). Most interventions did not meet activity guidelines (30 mins most days). Studies using higher heart rate, Borg scale had higher attrition. Low/mod intensity exercise relieved FM symptoms and improved sleep and mood.	Optimal dose not known. The strongest evidence was in support of aerobic exercise a treatment prescription for fitness and symptom and improvement. In general, the greatest effect and lowest attrition occurred in exercise programs that were of lower intensity than those of higher intensity (which could flare symptoms). Older people and men underrepresented. Compliance not calculable in majority of studies. No studies individually tailored interventions for participants.
Garcia - Hermoso et al 2015	To summarize evidence for the effectiveness and structure of exercise programs on functional aerobic capacity (6 minute walk test) in patients with fibromyalgia syndrome.	Systematic review	12 RCTs in abstract 13 in paper.	Land based: 3 aerobic programmes, strength n= 2 mixed n=2. Aquatic n=4 Mixed land and pool n=3. Many included education.	Functional aerobic capacity (6-minute walk test).	PEDro: 75% of studies met at least 50% of criteria, Aerobic I/Vs 2-24 wks, frequency 0.5-2 sessions per week, duration 45-40mins. Strength= 12-24 wks, 2 sessions per week 30-60 mins. Mixed=aerobic, strength and flexibility, 24 wks, 2 sessions pwe wk 45-60 mins. Aquatic=4-24 wks,1-3 sessions per week 20-60 mins. Land and pool: 12 wks, 0.5-3 sessions, 20-60 minutes. Mean attendance=79.3% (60-90). Mean attrition 21.2% (13-47%). Only possible to ES for one mixed programme. The main cumulative evidence indicates that the programs based on aerobic exercise alone and on aquatic exercises have large (effect size=0.85 95%CI 0.57, 1.12) aerobic) and moderate (effect size=0.44 95% CI 0.15, 0.73) aquatic) effects.	Aerobic and aquatic exercises at the proper intensity favour the increased functional aerobic capacity of fibromyalgia patients; however, most studies do not adequately detail the intensity of the exercises. Moderate intensity exercise (aerobic and aquatic exercise) performed at least two times per week and 30-60 minutes a day is effective for increasing functional aerobic capacity. Adverse events poorly reported generally. 6/13 had no longer term follow up.
Hauser et al 2010	To assess whether aerobic exercise (AE) has beneficial effects on pain, sleep, fatigue, depressed mood, quality of life; to assess volume and intensity of treatments; to assess whether on-going exercise is needed to maintain effects	Systematic Review with M/As and pre-specified sub-group analyses	35 RCTs (2494 pts) Inception to and through 2009	28 RCTs= Ex v controls, 7 Ex v another EX programmes. Most commonly, AE supervised by a trainer (32 studies): e.g. cycling, walking, jogging, dance, rhythmic or boxing movements. Multi-component interventions were excluded.	Aerobic activity reported as target heart rate or percentage age-predicted max heart rate in most studies (27 studies). Great variety in pain, sleep, fatigue, mood and quality of life outcomes	Majority of studies were rated as unclear/ moderate/high risk of bias. Post intervention: AE reduced pain SMD (95% CI): -0.31 (-0.46, -0.17); fatigue: -0.22 (-0.38, -0.05); depressed mood: -0.32 (-0.53, -0.12); quality of life: -0.4 (-0.6, -0.2) and improved physical fitness: 0.65 (0.38, 0.95). Effects on mood, quality of life and fitness were maintained at follow up; continuing exercise associated with positive outcome at follow up. AE had no positive effect on sleep or on pain, fatigue and sleep at follow up. Wide variety of outcomes. Side effects reported in 11: 5= none, 6 patients had adverse event.	Quality varied in studies. Concluded that slight to moderate exercise 2-3 times per week for at least 4-6 weeks plus encouragement to continue to maintain. Due to the majority of participants being female, the evidence may not be applicable for men. 11/35 reported side effects (5 no effects, 6= increased symptoms and drop out in some cases. NS differences between land and aquatic. Most commonly, 7->12 weeks, 3 X per week at intensity levels <50% maximum heart rate.
Kelley et al 2010	To determine the effects of exercise on global well-being using a single instrument (FIQ) and	Systematic review with cumulative meta-analysis. Standardized	7 Studies (473 pts only n=6 of which were men)	3 studies focused on aerobic exercise, 1 on strengthening, 3 included aerobic & strengthening	Global well-being (most commonly assessed using the Fibromyalgia Impact Questionnaire (FIQ)	Generally low/unclear risk of bias (high risk for blinding). Improvements in global well-being were observed for per-protocol (*g* and 95%CI , -0.39, -0.69 to -0.08) and intention-to-treat (-0.34, -0.53 to -0.14) analyses. No statistically	NS difference between ITT and PP analyses. Other research indicates 14% change in FIQ is MCID. . Exercise improves global well-being in community -dwelling women with fibromyalgia.

	when analyzed separately according to intention-to-treat and per-protocol analyses.	effect size (*g*) used for FIQ outcomes.	January 1 1980- January 1, 2008	exercise. Wide variety in dosage and intensity.		significant within-group heterogeneity (per-protocol, Qw = 6.04, *p* = 0.20, *I*2 = 33.8%; intention-to-treat, Qw = 3.19, *p* = 0.53, *I*2 = 0%) and no between-group differences for per-protocol and intention-to-treat outcomes (Qb = 0.07, *p* = 0.80). Changes were equivalent to improvements of 8.2% for per-protocol analyses and 7.3% for intention-to-treat analyses.	Optimal exercise programs for improving global well-being in adults needs further research. Men underrepresented. Optimal dose unknown . Duration: 12-23 wks. Frequency: Majority 3 X wk. Majority were supervised.
Kelley and Kelley 2014	To identify the effects of exercise (aerobic, strength or both) on depressive symptoms in adults with osteoarthritis, rheumatoid arthritis, fibromyalgia and systemic lupus erythematous.	a systematic review of previous meta-analyses which reported SMDs	2 M/As available, both for FB (Busch 2007 and Hauser 2010 – see above) (870 pts) Inception to July 4th 2013	Aerobic and/or strength training intervention(s) lasting an average of at least four weeks.	Group differences in depressive symptoms	Methodological quality was 91% and 82% (AMSTAR). Negative SMDs indicated benefit. Exercise minus control group reductions in depressive symptoms were found for both meta-analyses (SMD, -0.61, 95% CI, -0.99 to -0.23, p = 0.002; SMD, -0.32, 95% CI, -0.53 to -0.12, p = 0.002). Percentile improvements (U_3) were equivalent to 22.9 and 12.6. The number needed to treat was 6 and 9 with an estimated 0.83 and 0.56 million US people with fibromyalgia potentially benefitting.	Exercise improves depressive symptoms in adults with fibromyalgia. However, a need exists for additional meta-analytic work on this topic. Majority of pts were women. Dose-response of exercise is unknown.
O'Connor et al 2015	To review the evidence examining effects of walking interventions on pain and self-reported function in individuals with chronic musculoskeletal pain (adults with chronic low back pain, OA, or fibromyalgia).	Systematic review and meta-analyses. January 1980 to March 2014	RCTs and quasi RCTs Twenty-six studies (2384 participants) were included. 24 RCTs; 12 OA, 8FM, 1 chronic MSK and 5 LBP. Suitable data from 17 studies were pooled for meta-analysis.	Walking compared with nonexercise or nonwalking exercise control group. N=19/ 26 (73%), were supervised (hospital clinic, gymnasium, other). Walking mainly treadmill or land-based. Some combined supervised with walking at home. 6 were home-based. 3 used pedometers (stepbased goals) 3 used time-based walking goals. 13 included a walking-only intervention group, (remainder combined walking with cointervention-most commonly educational or alternative exercise. Controls: education, usual care, other exercise, passive I/V (relaxation/massage), and a 6-8 week preintervention	Pain and function.	Interventions were associated with small to moderate improvements in pain at short-term (mean difference, -5.31; 95% CI, -8.06 to -2.56) and medium-term (mean difference, -7.92; 95% CI, -12.37 to -3.48) follow-up. Improvements in function were observed at short-term (mean difference, -6.47; 95% CI, -12.00 to -0.95), medium-term (mean difference, -9.31; 95% CI, -14.00 to -4.61), and long term (mean difference, -5.22; 95% CI, -7.21 to -3.23) follow-up. Mean duration of final follow-up = 1.8±0.4 months for studies with short-term outcomes (less than 8wk post randomization), 4.9±1.9 months for studies with medium-term outcomes (>2-12mo), and 18.4±7.6 months for studies with long term outcomes (>12mo).11 studies associated adverse events: included 2 falls resulting in distal radial fractures,1 fall resulting in a hip fracture, 1 case of plantar fasciitis, and 2 cases of allergic skin reactions to metal pedometer clips. 2 FM studies reported a general increase in reporting of pain and muscle stiffness in the intervention group. One cLBP reported temporary exacerbations in pain levels in a small number of participants, attributed to unaccustomed activity levels. Drop out rates 0-57%. Follow ups = 1-18 months (most 6 months or less).	Evidence of fair methodological quality suggests that walking is associated with significant improvements in outcome compared with control interventions but longer-term effectiveness is uncertain Walking appears to have a slightly greater effect on function than pain. Sample sizes ranged from 3-439. A small number of studies (n=5) contained serious potential sources of methodological bias; inadequate allocation concealment during randomization (n=2) unequal distribution of important confounding variables at baseline not accounted for during analysis n=2), no masking of outcome(n=1) assessment or a substantial (>50%) dropout rate and subsequent post hoc revision of the intervention groups examined (n=1).11 studies did not provide enough detail regarding exercise intensity, or it was not sufficient to effect any change in fitness. 11/26 reported a measure of participant adherence . These included attendance at exercise classes (n=7), self-reported completion of home exercise (n=2), or self-reported adherence to wearing a pedometer (n=2).Studies generally included similar populations in terms of demographic characteristics and clinical presentation, as well as interventions that would be routinely available or

				baseline phase. Duration 1-18 mths - most 3mths or less.			feasible in clinical practice.
van Koulil et al 2007	overview of the effects of non-pharmacological treatments for patients with fibromyalgia (FM), including cognitive-behavioural therapy, exercise training programmes, or a combination of the two	Systematic review – only exercise part included in this table (CBT and combined CBT and Ex not included)	18 studies. Until Jan 2006	10 studies aerobic Strength training n=3 5 mixed aerobic and strengthening	VAS, tender points, FIQ, Multidimensional pain inventory, Physical fitness (eg 6 min walk, perceived exertion, flexibility), AIMS, VAS, Beck depression inventory,	Aerobic: 6/10 studies found improvement in disability. Pain and mood were “rarely mentioned” and one study found an increase in disability. Strength: 2/3 studies improvements in disability, not in mood or pain. Aerobic exercise in combination with muscle-strength training: 5 trials with mixed results: 3= decrease in pain and disability. 2= a lesser worsening of disability levels in the intervention group compared with the control group. The small sample size and low statistical power of some studies makes it hard to detect significant effects. Results could also be biased due to high dropout rates, particularly in treatment groups, suggesting perhaps that the treatment was not matched to the patient’s needs.	The effects of non-pharmacological interventions are limited and positive outcomes largely disappear in the long term (little long term follow up though). Within the various populations with FM, treatment outcomes showed considerable individual variations. Specific subgroups of patients characterised by relatively high levels of psychological distress seem to benefit most from nonpharmacological interventions. I/Vs inadequate in sufficiently reducing symptoms and distress for people with FM.
van Weering et al 2007	To gain an insight into the daily physical activities of patients with chronic pain or fatigue versus asymptomatic controls.	Systematic review Qual analysis.	Inception up to September 2006 12 studies included in review of which one was FM and 1 FM + chronic fatigue syndrome	1 FM study (n=16 FM n= 28 controls) 1 study FM and CFS (FM/CFS n=38, 27 health controls)	1. Actigraphy, activity counts per minute 5-7 days 2. Actigraphy 5 days	Overall: Large heterogeneity in methods and pain syndromes in review methodological qual for FM = 7/9. 1. Fibromyalgia patients have similar mean daytime activity com-pared with healthy controls . 2. Patients had similar average activity levels (p=.47) as those of controls. Patients had significantly lower peak activity levels and spent less time in high-level activities when compared with healthy controls (p=0.003)	Inconclusive. Limited research available.

Key for tables: AAOS = American Academy of Orthopaedic Surgeons, ADL = activities of daily living, AIMS = Arthritis Impact Measurement Scales, ACR = American College of Rheumatology, CCT = clinical controlled trial, ES = effect size, Ex=exercise, FIQ = Fibromyalgia Impact Questionnaire, FM = fibromyalgia, JPS = joint position sense, KOOS = Knee Injury and Osteoarthritis Outcome Score, LBP = low back pain, LL = lower limb, OA = osteoarthritic, OARSI = Osteoarthritis Research Society International, ODI = Oswestry Disability Index, PA = physical activity, Qol = quality of life, M/As = meta analyses, MVPA = moderate to vigorous physical activity, NRS = numerical rating scale, NS = non significant, mnths = months, RCT= randomised controlled trial, RoB = risk of bias, ROM = range of motion, RMDQ = Roland Morris Disability Questionnaire, SF-36 = 36-Item Short Form Health Survey, SMD = standardised mean difference, TKR = total knee replacement, TUG= timed up and go test, v= versus, VAS = visual analogue scale, WB = weighbearing, wks = weeks, WOMAC = Western Ontario and McMaster Universities Arthritis Index, 95% CI = 95% confidence interval.

PART THREE: LOW BACK PAIN

Review	Aim	Design	Number of Studies	Interventions (if appropriate)	Main outcomes/ approaches	Summarised Main results	Conclusions
Brumit et al 2013	To review the efficacy of motor control exercise approach and general exercise rehabilitation strategies for LBP.	PubMed clinical queries from 1966 to March 2013. Narrative synthesis	7/15 RCTS included here. General exercise (GE) n=7 (excluded 8 motor control / stabilisation trials i.e. MCE)	7 studies assessed the effects of a GE treatment approach for patients with LBP, with 6 studies comparing outcomes against an MCE group	Pain and disability	When a GE approach was compared with MCE, most studies reported no difference in outcomes between groups. Two studies reported significant between-group differences favouring the GE approach	Exercises appear appear to reduce pain and disability in patients with subacute or chronic LBP. When MCE was compared with a GE approach, there were no between-group differences, however, superior outcomes were reported in 2 studies with GE.
Griffin at al 2012	To determine if people with chronic low back pain have a lower level and/or altered pattern of physical activity (PA) than healthy asymptomatic people	Systematic review of non experimental studies . Quality appraisal using modified Newcastle-Ottawa Scale for case-control studies and meta-analyses.	7 studies Inception to end December 2009)	Adult patients n=4 (18–65 years), older adults (≥65 years) n=2, adolescents (<18 years) n=1	Self report measures (questionnaires) +/- an objective measure of PA (accelerometry, pedometers, heart rate monitors,calorimetry, doubly labelled water technique. 5 studies measured PA over seven days,1 study over 24 hours & 1 over 2 wks	NS differences for overall PA in pooled data from 18-65 adults (SMD -0.06, 95%CI 0.52 to 0.41 p=0.81) and adolescents (SMD 0.44 95%CI -0.31 to 1.19). Aged over 65 participants with pain are less active than controls (SMD -0.26, 95%CI -0.44 to -0.08 p=005). 2 pooled studies (aged 18-65) showed patients spent more time lying during the daytime and evening. 1 study reported slower cadence during the day and another reported slower cadence over long walks (>500 steps). Quality: N=5 included controls without recent history of low back pain, other 2 reported controls were 'healthy' or 'asymptomatic' (considered inadequate due to high prevalence of LBP in general population). N=2 adequately controlled for work status (in terms of physical demand) in addition to age and sex . Most used a reliable and objective measure of PA in a healthy population, only two used valid tool for measuring PA in chronic LBP. N=2 adequately reported on the sampling procedure (others unclear). N=1 adequately justified sample size used.	No conclusive evidence that people with back pain are less active but there is some evidence that the distribution of activities during the day is different. Limited evidence suggests older adults are less active than controls. Studies were generally small (only 1 seemed adequately powered) and cross-sectional. All studies used a different measurement tool to assess free-living PA.

Hayden et al 2005	To evaluate the effectiveness of exercise therapy in adult nonspecific acute, subacute, and chronic low back pain versus no treatment and other conservative treatments.	Systematic review with M/As. Quality assessed (appropriate randomization, adequate concealment of treatment allocation, adequacy of follow-up, outcome assessment blinding)	61 RCTs (6390 pts): acute (n=11),sub-acute (n=6), chronic (n=43), unclear (n=1) Up to October 2004.	Varied: individually designed and delivered, strengthening or trunk-stabilizing exercises. Conservative care was often added including behavioural and manual therapy, advice to stay active, and education.	Self-reported pain intensity, condition-specific physical functioning and global improvement, and return to work or absenteeism	Only a few high quality RCTs. Suggests that exercise therapy is effective in chronic back pain relative to comparisons at all follow-up periods. Pooled mean improvement (of 100 points) was 7.3 points (95% CI, 3.7 to 10.9) for pain and 2.5 points (1.0 to 3.9) for function at earliest follow-up. In studies investigating patients, mean improvement was 13.3 points (5.5 to 21.1) for pain and 6.9 points (2.2 to 11.7) for function, compared with studies where some participants had been recruited general population. Some evidence suggests effectiveness of a graded-activity exercise program in subacute LBP in occupational settings, (evidence for other types of exercise therapy in other populations is inconsistent). In acute LBP, exercise therapy and other programs were equally effective; pain: 0.03 (1.3 to 1.4).	Exercise therapy is slightly effective at decreasing pain and improving function in adults with chronic LBP, particularly in health care populations. In subacute LBP populations, some evidence suggests that a graded activity program improves absenteeism, although evidence for other types of exercise is unclear. In acute low back pain populations, exercise therapy is as effective as either no treatment or other conservative treatments. Limitations include low-quality studies, heterogeneous outcomes, inconsistent and poor reporting, and possibility of publication bias.
Hendrik et al 2010	To explore the effectiveness of walking in managing acute and chronic back pain.	Systematic review (RCTs and non RCTs) with quality rating (Downs and Black checklist)	4 studies (English language) RCTs (n=2), case control (n=1) and cohort (n=1). Inception to "present"	Walking as main intervention or adjunct to other interventions. 3= treadmill, 1 free living. 2 used treadmill as an adjunct to traction, 1 used increased walking on treadmill, 1 used free walking as 1 of 3 I/Vs (with lumbar stabilisation, flexibility exercises and soft tissue mobilisation if indicated +/- walking	Pain visual analogue scales (n=3) and Brief Pain Inventory (n=1). Self report questionnaire: Roland Morris Disability questionnaire.	Quality scores ranged from 14-27 out of 31. Reporting and bias were generally scored as good, external validity and reporting of confounding were poor. Only 1 study scored for power, sample sixes were small/very small for 3 studies. The study rated highest found that walking did not have a statistically significant benefit on back pain compared to spinal exercise or conventional therapy. The poorer studies (scoring 14-18) found that walking had a positive effect when combined with traction, exercises or at sel-f selected treadmill speed.	Insufficient high quality evidence to determine effectiveness. Few studies (generally small sample sizes) with heterogeneous designs. No studies of walking as sole intervention. No studies included control groups. Studies were mainly treadmill walking with one trial arm advising participants to walk one hour three times a week.
Hendrik et al 2011	To investigate the relationships between free living activity levels after onset of low back pain (LBP) and measures of pain, and disability in patients with NSLBP.	Systematic reviews (RCTs and non RCTs). M/As not possible (disparity in methods, PA measures, outcomes and analyses. Quality=modified Downs and Black checklist	Twelve studies (seven cohort and five cross-sectional) were included. 1990 to January 2009	1 = 1 objective measure of PA, others = various PA Recall questionnaires. Self-report questionnaires n=4 ((MET levels). 1 required the participant to state (yes/no) re: participation in exercise or activity outside work. 1 used recall instrument validated in LBP.	Depression (BDI) BPAQ Baecke PA questionnaires, PA levels, Pain (amount, symptoms, frequency), catastrophising , EE energy expenditure, MET metabolic equivalent task, NRS, Disability- ODI, QBPDS Quebec back pain disability scale, RMDQ 24-item Roland Morris, TSK Tampa scale kinesiophobia,	Studies were generally moderate to poor quality (only 1 scoring highly on the criteria for external validity). Potential bias and confounding issues were poor to moderately good for all studies. 1 prospective study reported a statistically significant relationship between increased leisure time activity and improved outcomes. 1 cross-sectional study found that lower levels of sporting activity were associated with higher levels of pain and disability. All others (n = 10) found no relationship between measures of activity levels and either pain or disability. Heterogeneity of study designs, particularly in terms of activity measurement, made comparisons between studies difficult.	Suggests that activity levels of patients with NSLBP are neither associated with, nor predictive of, disability or pain levels. No evidence was found for detrimental effects from engaging in higher levels of activity in patients with LBP. Current recommendations for patients with LBP to maintain, restore and increase their activity as part of their overall management should probably continue to be made. Validated activity measurement in prospective research is required to better evaluate the relationships between PA and LBP.

Lawford et al 2016	To establish the effectiveness of walking alone and walking compared to other non-pharmacological management methods to improve disability, quality of life, or function in adults with chronic low back pain.	Systematic review & narrative synthesis (M/As not possible). CASP, GRADE approach	7 RCTs (869 participants) Inception to 3rd March 2015	Land walking n=5, treadmill n=1, land + treadmill n=1. Walking compared to usual care (3), supervised ex classes(2) strength ex(1) ,medical exercise & conventional therapy (1). 1 compared treadmill to over-ground walking, 1 compared support website +pedometer -based walking to pedometer-based walking only.	Disability: ODI, RMDQ, QoL SF-36 and EuroQol.4/7 did not specifically recruit sedentary or inactive participants, 3/7 did not assess baseline PA levels or monitor changes in PA throughout the walking intervention	High CASP but majority were unclear or high risk of bias. 5 RCTs = walking significantly improved disability status or quality of life, with these improvements being maintained in the long term (⩾ 6 months) in three studies.3 studies compared walking to usual care, 1 found walking to be significantly more effective, the other 2 studies reported NS differences. No evidence that walking was more effective than other management methods such as usual care, specific strength exercises, medical exercise therapy, or supervised exercise classes. One study found over-ground walking to be superior to treadmill walking, and another found internet-mediated walking to be more beneficial than non-internet-mediated walking in the short term.	Low quality, inconsistent, evidence to suggest that walking is as effective as other non-pharmacological management methods at improving disability, function, and quality of life in adults with chronic low back pain. Low volume of evidence using the GRADE approach. No study compared walking with a no intervention control.. Dose ranged 40 mins 2X wk to individually graded programmes ↑each walk. Durations 4wks-12 mnths
O'Connor et al 2015	To review the evidence examining effects of walking interventions on pain and self-reported function in individuals with chronic musculoskeletal pain (adults with chronic low back pain, OA, or fibromyalgia).	Systematic review and meta-analyses. January 1980 to March 2014	RCTs and quasi RCTs Twenty-six studies (2384 participants) were included. 24 RCTs; 12 OA, 8FM, 1 chronic MSK and 5 LBP. Suitable data from 17 studies were pooled for meta-analysis.	Walking compared with nonexercise or nonwalking exercise control group. N=19/ 26 (73%), were supervised (hospital clinic, gymnasium, other). Walking mainly treadmill or land-based. Some combined supervised with walking at home. 6 were home-based. 3 used pedometers (stepbased goals) 3 used time-based walking goals. 13 included a walking-only intervention group, (remainder combined walking with cointervention- most commonly educational or alternative exercise. Controls: education, usual care, other exercise, passive I/V (relaxation/massage), and a 6-8 week preintervention baseline phase. Duration 1-18	Pain and function.	Interventions were associated with small to moderate improvements in pain at short-term (mean difference, -5.31; 95% CI, -8.06 to -2.56) and medium-term (mean difference, -7.92; 95% CI, -12.37 to -3.48) follow-up. Improvements in function were observed at short-term (mean difference, -6.47; 95% CI, -12.00 to -0.95), medium-term (mean difference, -9.31; 95% CI, -14.00 to -4.61), and long term (mean difference, -5.22; 95% CI, -7.21 to -3.23) follow-up. Mean duration of final follow-up = 1.8±0.4 months for studies with short-term outcomes (less than 8wk post randomization), 4.9±1.9 months for studies with medium-term outcomes (>2-12mo), and 18.4±7.6 months for studies with long term outcomes (>12mo).11 studies associated adverse events: included 2 falls resulting in distal radial fractures,1 fall resulting in a hip fracture, 1 case of plantar fasciitis, and 2 cases of allergic skin reactions to metal pedometer clips. 2 FM studies reported a general increase in reporting of pain and muscle stiffness in the intervention group. One cLBP reported temporary exacerbations in pain levels in a small number of participants, attributed to unaccustomed activity levels. Drop out rates 0-57%. Follow ups = 1-18 months (most 6 months or less).	Evidence of fair methodological quality suggests that walking is associated with significant improvements in outcome compared with control interventions but longer-term effectiveness is uncertain Walking appears to have a slightly greater effect on function than pain. Sample sizes ranged from 3-439. A small number of studies (n=5) contained serious potential sources of methodological bias; inadequate allocation concealment during randomization (n=2) unequal distribution of important confounding variables at baseline not accounted for during analysis n=2), no masking of outcome(n=1) assessment or a substantial (>50%) dropout rate and subsequent post hoc revision of the intervention groups examined (n=1).11 studies did not provide enough detail regarding exercise intensity, or it was not sufficient to effect any change in fitness. 11/26 reported a measure of participant adherence . These included attendance at exercise classes (n=7), self-reported completion of home exercise (n=2), or self-reported adherence to wearing a pedometer (n=2).Studies generally included similar populations in terms of demographic characteristics and clinical presentation, as well as interventions that would be routinely available or feasible in clinical practice.

				months (most 3months or less).			
Searle et al 2015	To determine which exercise interventions are the most effective at reducing pain compared to other treatment for adults with chronic low back pain	Systematic review with M/As and modified Down and Black quality assessment.	45 trials: thirty-nine included in the meta-analysis up to October 2014 Comparisons included wait list or usual activities, GP care, electrotherapy and manipulative therapies.	Trials separated into 4gps, coordination /stabilisation n=12 (gait, balance, agility, coordination, and proprioceptive), strength/resistance (n=11), cardio - respiratory n=6 (regular, purposeful, continuous exercise) and combined trials n=14 (multiple eg strengthening, stretching, endurance & aerobic). Majority were supervised (n=40).	Low back pain measures	Downs and Black15 scores ranged from 54% to 96% (mean = 76%) 13 trials did not provide randomisation details, just over half reported power calculations. Combined meta-analysis revealed significantly lower chronic low back pain with intervention groups using exercise compared to a control group or other treatment group SMD (95% CI): -0.32, (-0.44 to -0.19) and, after adjustment for publication bias SMD:-0.15 (-0.25 to -0.05, p<0.1). Separate exploratory subgroup analysis showed a significant effect for strength/resistance and coordination /stabilisation programs. The combined exercise treatment group generally showed a positive effect; 11/14 trials reporting results that favour the exercise intervention over the control treatment. However, only 3 reported results with statistical significance (Gladwell et al SMD:-0.56 (-1.08 to -0.03), Jousset et al SMD:-0.49 (-0.92 to -0.05), Sherman et al SMD:-0.65 (-1.09 to -0.22).	Interventions and outcomes considered as similar. Beneficial effect for strength/resistance and coordination/stabilisation exercise programs over other interventions in the treatment of chronic low back pain and that cardiorespiratory and combined exercise programs are ineffective. Only 11 trials provided details of any adverse events related to the interventions. A further12 trials did not report details of adherence. Combined exercise: no particular modality showed consistent results (3 trials with significant results used pilates, individualised exercise program and yoga). Trials =1.5 - 18 wks duration.
Steiger et al 2012	To analyse the specificity of the effect size of exercise therapy in chronic LBP by examining the relationship between the changes in clinical outcome and the changes in the targeted aspects of physical function after exercise therapy.	Systematic review RCT or non RCT in English or German PEDro& Downs & Black quality assessment	16 studies (1,476 participants)	From Table 3: only one seemed to have an aerobic arm, One mentioned aerobic activity (static cycling and jogging) in warm up and another in the control group. Most included back exercises (such as strengthening, balance, stability, stabilisation, functional) or, back school, Education, CBT, manips..wide range	Clinical outcome: pain, disability Physical Function: muscle strength, mobility, muscular endurance)	There was little evidence supporting a relationship between the changes in pain or physical function and the changes in performance for the following measures: mobility (no correlation in 9 studies, weak correlation in 1 study), trunk extension strength (7 and 2, respectively), trunk flexion strength (4 and 1, respectively) and back muscle endurance (7 and 0, respectively). Changes in disability showed no correlation with changes in mobility in three studies and a weak correlation in two; for strength, the numbers were four (no correlation) and two (weak correlation), respectively. PEDro scores ranged from 4-8 (mode = 4); studies generally reported adequate randomisation and between group comparisons but blinding, adequate follow up times, intention to treat analyses were generally inadequate or unclear,	Findings do not support the notion that the treatment effects of exercise therapy in cLBP are directly attributable to changes in the musculoskeletal system Very little PA included in this review so limited value to this landscape review

van Middlekoop et al 2011	To determine the effectiveness of physical and rehabilitation interventions for adults with chronic non-specific low back pain.	Systematic review with quality rating using GRADE approach. Meta-analyses used where possible/appropriate. RoB assessed	Of 83 trials n=37 exercise trials (3957 pts) were included Existing Cochrane reviews and Databases searched until up to 22 Dec 2008.	Very few PA activity programmes included. Most aerobic exercise was in conjunction with back exercises (strengthening, stretches, core stabilisation or specific back exercises , endurance etc) or back programmes (not included in this overview).	Relevant studies 1. Chatzitheodorou 2007 (n=20) 12 week programmes of aerobic exercise versus control group (passive modalities). 2. Koldas 2008 (n=60) 6 wks Aerobic exercise treadmill v 6 wks Physical therapy; superficial heating, ultrasound, Aqua sonic and TENS v 6 Wks 3. Turner 1990 (n=96) Behavioral v Exercise: increasing aerobic fitness (fast walking, slow jogging), warm-up, cool-down stretching v Behavioral + exercise v Waiting list control group.	From the Supplementary information re: characteristics . Chatzitheodorou 1. Pain (McGill Pain Questionnaire): effect size 2.34 for exercise and 0.03 control. Disability (RMDQ): effect size 1.68 for exercise and 0.03 for control. Regular high-intensity aerobic exercise alleviated pain, disability and psychological strain in subject with chronic low back pain but did not improve serum cortisol concentrations. 2. Koldas. Follow-up: 6 weeks (post-treatment), 1 month after treatment (2.5 month) Pain (VAS/100), Disability (RM 0-24) Results and conclusions: All approaches were effective in diminishing pain and increasing aerobic capacity in patients with chronic LBP. 3. Turner. Follow-up: 8 weeks, 6 months, 12 months. Pain (McGill), Function (SIP). All 3-treatment groups remained significantly improved from pretreatment, with no significant differences among treatments.	Very few PA studies. Quality scores n=2 3/11 and n=1 4/11. Except for adequate randomisation all other criteria were either unmet or unclear. Overall, low level of evidence for the effectiveness of exercise compared to usual care. Overall the review found NS treatment effects of exercise therapy compared to no treatment/waiting list controls were found on pain intensity and disability. Compared to usual care, pain intensity and disability were significantly reduced by exercise therapy at short-term follow-up. Adverse events were not reported in included studies. None of the significant differences found in this overview study reached a difference larger than 10%. The differences found in this overview must be regarded as small and not clinically relevant. There is heterogeneity in some of the analyses among the studies.
van Weering et al 2007	To gain insight into the daily PA of patients with chronic pain or fatigue versus asymptomatic controls.	Systematic review Qualitative analysis.	12 studies rated for quality (Cochrane Back Group approach), two of which were low back pain . English, German or Dutch. Inception up to September 2006	2 LBP studies in 12 studies: Study1.n=47 Study 22. n=11	Study 1. overall level of activity combining static or dynamic activity, intensity of trunk movements and walking step frequency average per hour via Dynaport over 5 days (not weekend). 2. average daily metabolic rate/resting metabolic rate via Doubly labelled water technique for 14 days	Large heterogeneity in methods and pain syndromes. Study 1. Activity levels were similar during the day (p=0.66) but chronic pain participants were significantly lying down more that controls and had a lowered activity level during the evening (p=0.01) Study 2. No significant differences	Inconclusive. Very limited LBP research. Overall: Results reported in the literature with respect to the activity level of patients with chronic pain or fatigue compared with controls were too heterogeneous to give sufficient evidence and were not conclusive.

Please note: reviews which compare treatments (such as surgery) with general exercise, rather than explore the effects of exercise per se, have been excluded from this review.

Key for tables: AAOS = American Academy of Orthopaedic Surgeons, ADL = activities of daily living, AIMS = Arthritis Impact Measurement Scales, ACR = American College of Rheumatology, CCT = clinical controlled trial, ES = effect size, Ex=exercise, FIQ = Fibromyalgia Impact Questionnaire, FM = fibromyalgia, JPS = joint position sense, KOOS = Knee Injury and Osteoarthritis Outcome Score, LBP = low back pain, LL = lower limb, OA = osteoarthritic, OARSI = Osteoarthritis Research Society International, ODI = Oswestry Disability Index, PA = physical activity, Qol = quality of life, M/As = meta analyses, MVPA = moderate to vigorous physical activity, NRS = numerical rating scale, NS = non significant, mnths = months, RCT= randomised controlled trial, RoB = risk of bias, ROM = range of motion, RMDQ = Roland Morris Disability Questionnaire, SF-36 = 36-Item Short Form Health Survey, SMD = standardised mean difference, TKR = total knee replacement, TUG= timed up and go test, v= versus, VAS = visual analogue scale, WB = weighbearing, wks = weeks, WOMAC = Western Ontario and McMaster Universities Arthritis Index, 95% CI = 95% confidence interval.

APPENDIX 2. ADDITIONAL RCTS AND STUDIES (FURTHER TO SYSTEMATIC REVIEW BY O'CONNOR ET AL 2015) RE: WALKING PROGRAMMES FOR PEOPLE WITH MUSCULOSKELETAL CONDITIONS (FROM 2005)

Study	Participants (sample size)	Intervention (time of intervention)	Main Outcome Measures	Summarised Results
Bruno et al 2006 Quasi-experimental design.	163 adults with arthritis able to ambulate independently.	Self selected to Group 1: 90 minute arthritis pain management presentation (YOU can break the pain cycle) (n=91 females/11 men). Group 2: 6 week long supervised Walk with Ease walking programme 3 times a week including discussion about a related topic, 10-40 minutes walk (n=26 females/3 men). Group 3: both 1 and 2. (27 females and 5 men).	Self report survey covering arthritis knowledge, general health, arthritis selfmanagement, confidence about doing things, physical abilities, health distress and how arthritis affects their lives. Performance measures, 6 minute walk test, squat test and timed functional walking test at maximal speed. Gp 1 FU = pre and post presentation, 6/ 52 and 4 months FU. Gp 2 FU pre / post (6/52) and 4/12s.	N=86 completed the study. Survey summary: People self selecting Gp 2 showed greater confidence in ability to do things and were less depressed, had lower distress scores and less pain that those who chose to attend Gp 1. Gp 1 post test improved knowledge scores, not maintained at 6 weeks and increased at 4 months. Gp 2 showed an increased time exercising at 6 wks but not maintained at 4 months. Performance tests – "all groups indicated a significant difference" in 6 min walk test post intervention but not maintained at 4 months (no specific values presented). No other differences. Adherence: subjects apparently did not continue aerobic exercise to the 4 month follow up time.
Callahan et al 2011 Quasi-experimental design.	462 adults with self-reported arthritis	Patients selected either instructor led (3 times a week for 1 hr) or self-directed 6 week revised Walk with Ease programme (using the WWE workbook).	Timed chair stands, turn tests, single-leg stance, walking speed, 2 minute step test, self report function (PROMIS HAQ score) Pain, stiffness and fatigue (VAS scales) . Secondary measures = self efficacy (ASE and SEPA), attitudes (RAI). Measurements pre and post intervention plus one year follow up self report data only.	362 followed up at one year. No adverse events. 42% (n=192) chose group, 58% (n=270) self-directed. Baseline characteristics were described for n=403 who completed the 6/52 follow up; Gps were significantly different at baseline for education, standing balance, balance, functional mobility and self efficacy in favour of the self-directed group. Post intervention, both groups showed significant modest or moderate improvements in all performance measures bar 2 minute step test. For fast walking the improvement is significantly greater in the instructor-led group. Both groups modestly or moderately improved their self report scores, NS differences between the groups. At one year, both gps showed modest improvements in ASE pain but self directed group maintained or improved HAQ, pain VAS, stiffness VAS, RAI while group participants lost ground.
Fontaine et al 2011 RCT	73 adults (70 women 3 men) 18 years or older, ACR FM diagnostic criteria. Mean (SD) age of participants was 47.2 (11.1) years, and 84% were white. Mean duration o fFM was 7.4 (6.2) years.	12-week randomized controlled trial of the effects of lifestyle physical activity (LPA) on symptoms and function among adults with fibromyalgia. 6 X 60-minute group sessions over 12 weeks designed to increase moderate-intensity physical activity by helping participants find ways to accumulate short bouts of physical activity throughout the day. Versus: Participants	Questionnaires: FIQ,pain VAS , the 7-item Fatigue Severity Scale, 20-item Center for Epidemiologic Studies Depression Scale (CES-D), digital tender point examination (ACR criteria), 6-minute walk test. Post intervention, 6- and 12-month follow-up also asked, "Since the start of the	LPA participants increased average daily step count by 54%, improved self-reported functioning by 18%, reduced their pain by 35%. 53/73 participants (73%) who completed the 12-week intervention also completed the 6- and 12-month follow-up assessments. Failure to complete FU was unrelated to gp allocation (P = 0.657). NS on any study variables between those who did or did not complete FUs. Significant effect for condition (P = 0.038), but not for time (P =0.197) or time × condition interaction

		assigned to the fibromyalgia education (FME) control group met monthly for 3 months and were provided a minimal intervention that provided FM education and social support.	study, how much change has there been in your FM?" (7-point scale "very much better" - "very much worse," with lower scores), 7 day step count before each assessment (pedometer). 4 assessments: i.e., baseline, postintervention, 6- and 12-month.	(P = 0.117). The effect of condition was driven by a significant baseline to post intervention difference between LPA and FME (P = 0.002). No significant condition or time effects on the FM Impact Questionnaire (FIQ) scores. However, there was a significant condition × time effect (p = 0.022) between comparisons of LPA and FME at baseline to post intervention and at post intervention to the 6-month FU (p's = 0.008 and 0.015, respectively). The beneficial effects of LPA on FIQ scores found at the baseline to post intervention comparison with FME were not maintained at 6-months: LPA group's FIQ scores increased at 6-month FU, they decreased for FME. There was a significant time effect (P = 0.003) for CES-D scores, driven by a significant reduction in the scores for both gps between their post intervention and 6-month follow-up assessments (P= 0.009). There was also a significant condition effect (P = 0.001) on the perceived improvement variable indicating that LPA participants reported significantly greater improvement than did FME participants at post intervention and at 6- and 12-month FU (P's = 0.001, 0.020, and 0.014, respectively).
Hurley et al 2015 RCT	246 participants with CLBP aged 18 to 65 years (79 men and 167 women; mean age ± SD: 45.4 ± 11.4 years)	Individualized 8 wk progressive walking programme (WP) with pedometer which aimed to progress to 30 minutes of brisk walking 5 times a week by week 5 (then continue). Versus group exercise class (EC i.e Back to Fitness programme) of one hour for 8 weeks, and unrestricted usual physiotherapy (UP, control consisting of education, advice, manual therapy, exercise etc) in mean change in functional disability at 6 months. App participants received a copy of "the back book".	Self-report measures of functional disability, pain, quality of life, psychosocial beliefs, and physical activity. WP (n = 82), EC (n = 83), or UP (n = 81) and followed up at 3 (81%; n = 200), 6 (80.1%; n = 197), and 12 months (76.4%; n = 188). Cost diaries were completed at all follow-ups.	Significant improvements over time on the Oswestry Disability Index (Primary Outcome), the Numerical Rating Scale, Fear Avoidance-PA scale, and the EuroQol EQ-5D-3L Weighted Health Index (P < 0.05), but no significant between-group differences and small between-group effect sizes (WP: mean difference at 6 months, 6.89 Oswestry Disability Index points, 95% confidence interval [CI] -3.64 to -10.15; EC: -5.91, CI: -2.68 to -9.15; UP: -5.09, CI: -1.93 to -8.24). Attrition – n=188 (74%) remained at 12 months. WP had lowest mean cost and greatest adherence rate (of 79.9%; EC 62.3% and UP 48%). Mean contact with physiotherapist: WP= 6.4, EC=4.7 and UP = 3.6. 19.7% reported minor adverse events. Adverse events: WP increased LBP n=5, groin n=1 and knee pain n=1 for a few days but pts were able to continue WP and another 7 (increased LBP n=5, groin n=1 and knee pain n=1) were withdrawn from the walking programme and had UC. No adverse events in EC or UC.NS differences in satisfaction at 3/12, although more UP pts would recommend UP to friend/colleague (96.7%) compared to WP (83.3%) or EC (82.3%).
Larose et al 2013	115 older adults with knee OA	3 programs (6months): a structured supervised community-based aerobic walking program with a behavioral intervention (WB; n = 41); a supervised program of walking only (W; n = 42); and an unsupervised self-directed walking program (n = 32)	Maximal oxygen uptake (VO_2peak), exercise test duration, and workload, heart rate, and ventilation at maximum aerobic capacity in older adults with knee OA after 6 months of WB, W, or self-directed walking.	VO_2peak improved by 4% in female walkers (+0.9 ± 2.5 mL O2·kg−1·min−1; p < 0.001) and 5% in male walkers (+1.3 ± 2.7 mL O2·kg−1·min−1; p < 0.001). The change in fitness was similar with all 3 walking interventions. Low- to moderate-intensity walking may improve and/or prevent decrements in cardiorespiratory fitness in older adults with OA.
Ng et al 2010 **Feasibility trial**	36 low active adults (age 42-73) with hip or knee OA (men=11, women=17), pain, stiffness, crepitus and ADL difficulties for the previous month, able to walk 15 minutes, able to participate in moderate-intensity exercise.	All participants were given 1500mg glucosamine sulphate for 6/52 for 6/52. Then randomised to 12/52 progressive walking programme "Stepping Out" either 3 or 5 days a week. The study aimed to compare the effectiveness of two frequencies of walking (3 and 5 days per week) and three step levels (1500, 3000 and 6000 steps per day). Consultations, walking guides, log sheets, pedometers were included.	Time spent on physical activity (PA) via Active Australia PA questions. WOMAC pain, stiffness, function, Self-paced step test, WOMAC pain after lower limb movement test. Measurements at baseline, 6,12,18 and 24 weeks.	N=28 completed the study. Recruitment was also difficult. During the first 6 weeks of the study (glucosamine supplementation only), physical activity levels, physical function, and total WOMAC scores improved (P < 0.05). No adverse effects attributed to programme. NS differences were found between groups (feasibility study so not powered for this). Mean step count for all participants rose from a mean of 3920 (SD 2441) day 1 of programme to 6683 (SD 3403). Combined group scores (weeks 6-24) showed significant improvements for physical activity (P<0.001) Self-paced step (P<0.001) WOMAC pain (P=0.01), stiffness (p=0.06) Function

				(p<0.001). Pain after Step (p<0.001). On average, participants in the 3 day group walked 3 days per week (mean days/week = 3.07 (standard deviation (SD) 0.82) days), but participants in the 5 day group did not walk 5 days per week (mean days/week = 3.93 (SD 1.09) days).
Nyrop et al 2011	"walk with ease" WWE participants who were self-identified as "employed" (n=94 of 462). Participants were on average age 55 years, 88% women, and 61% white. The mean body mass index was 32 kg/m2, and 81% had more than a high school education.	WWE programme (see Callahan) . 94 participants identified themselves as currently "employed" and answered the WALS at baseline and 6 weeks (post intervention). At 1-year follow up, 69 participants were self-identified as employed and completed the WALS.	Workplace Activity Limitation Scale (WALS) at 6-week (post-intervention;) and 1-year follow up	Overall WALS scores improved significantly from a mean ± SD of 6.7 ± 3.99 at baseline to 5.5 ± 4.20 at 6-week follow up (P < 0.001, effect size 0.30). Improvements were maintained at 1-year follow up, i.e., no change from 6-week follow up (P = 0.87). One-half of the individual items that comprise the WALS showed significant improvement at 6 weeks, of which 5 were related to mobility. Work place activities reported by participants as "some" or "a lot" of difficulty at baseline, i.e., "crouch/bend/kneel/work in awkward positions," "stand for long periods," and "lift/carry/move objects," showed some of the highest improvements at 6 weeks. "Concentrate/keep your mind on the job" also improved significantly, although it was not rated as a substantial difficulty at baseline.

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