Fibromyalgia treatment: the role of exercise and physical activity

Fibromyalgia, a disease of chronic widespread pain, fatigue, poor sleep, stiffness and many other symptoms, is associated with considerable disability and is estimated to affect 3.4% of the population. Optimal management of fibromyalgia is still in question, but exercise is recommended as one component of multidisciplinary management programs. In this review, we examine the effects of land-based and aquatic aerobic, strength and mixed exercise, as well as composite programs including exercise, on five important outcome constructs (global well-being, pain, tender points, physical function and depression). We detail adverse effects, attrition rates and adherence to exercise, as well as identify methodological problems in the published research. We provide evidence-based recommendations for exercise/physical activity for improvement of fibromyalgia symptoms and physical function and explore the importance and clinical implications of moving towards the application of the 2007 physical activity guidelines developed by the American College of Sports Medicine and the American Heart Association for individuals with fibromyalgia.

KEYWORDS: active lifestyle ■ ACSM/AHA guidelines ■ aerobic exercise ■ aquatic exercise ■ exercise ■ fibromyalgia ■ physical activity ■ physical therapy ■ strength training ■ symptom management

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Fibromyalgia

Fibromyalgia is a common [1] and disabling [2] condition associated with a wide array of symptoms including pain, poor sleep, fatigue, depression and stiffness [3,4]. In 1990, the American College of Rheumatology (GA, USA) published classification criteria for the diagnosis of fibromyalgia, consisting of widespread pain for at least 3 months and pain on digital palpation with 4 kg of pressure in at least 11 of 18 specified sites [5]. The estimated prevalence rate is 3.4% across all ages [1]. Despite the abundant attention this condition has received in the past two decades, there are many questions related to its etiology, pathophysiology and management. It is not surprising that a European panel of experts has recommended that "comprehensive evaluation of pain, function and psychosocial context are needed to understand (fibromyalgia) completely, owing to its complex, heterogeneous nature" [6]. Although many issues remain unresolved, a substantial body of research provides greater understanding of the effects of exercise on symptoms and physical function in individuals with fibromyalgia.

Management of fibromyalgia

Despite investigation of a wide range of options, optimal management of fibromyalgia is still unknown. Evidence-based guidelines [6–8] and reviews [9–19] have examined a range of pharmacologic and nonpharmacologic management options. Goldenberg and colleagues [8] concluded that pharmacologic and nonpharmacologic interventions have clinical benefits and advocated use of a stepwise program, emphasizing education, certain medications, exercise and cognitive therapy. Adams and Sim [9] recommended that a combination of interventions in a multimodal approach, including exercise, education and psychological interventions, holds most promise in the management of fibromyalgia. A European multidisciplinary taskforce studying fibromyalgia management [6] stated that: "optimal treatment mandates a multidisciplinary approach with a combination of nonpharmacologic and pharmacologic treatment tailored according to pain intensity, function, associated features, such as depression, fatigue and sleep disturbance, in discussion with the patient" [6]. The recommendations for nonpharmacologic interventions included exercise, cognitive behavioral therapy, relaxation, rehabilitation, physiotherapy and psychological support.

Exercise studies have demonstrated that individuals with fibromyalgia are physically deconditioned, with low levels of cardiorespiratory endurance [20–23] and decreased muscle strength and endurance [24,25]. Studies have also demonstrated that individuals with fibromyalgia are able to

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perform aerobic, flexibility and muscle strength training programs. While exercise has been identified as a component of fibromyalgia management, not all clinically relevant and practically important aspects of this modality have been clarified.

Physical activity & exercise defined

This review examines the evidence for prescription of exercise and recreational physical activity for individuals with fibromyalgia. Exercise training (referred to in this review as exercise) is "planned, structured, and repetitive bodily movements performed to improve or maintain one or more components of physical fitness" [26]. Exercise employs the principles of overload and progression, and specifies intensity, frequency and duration of exercise in order to achieve its goal of improving physical fitness. Exercise can be further subdivided into aerobic, strength and flexibility training, all of which can result in specific improvements in the respective target areas. By contrast to exercise, recreational physical activity includes any physical activity for recreational purposes and sport, without necessarily presuming a specific emphasis on fitness or competition. While recreational physical activity (referred to as physical activity in this review) implies a less prescriptive endeavor than exercise, there is overlap between the two, owing to both the ways that each is recommended by clinicians and the ways that each is undertaken and performed. For example, a walking program that is undertaken for enjoyment as a recreational activity may be shaped into an exercise program as an individual begins to (or is advised to) walk more briskly for longer periods of time or more frequently. To date, the research focus has been on exercise for individuals with fibromyalgia. We will explore the application of both structured exercise programs and less prescriptive physical activity programs for individuals with fibromyalgia.

Purpose

The purposes of this paper are:

- To review the effects of exercise and physical activity in adults with fibromyalgia;
- To discuss clinical implications of incorporating exercise and/or physical activity in their lives;
- To evaluate the findings of studies on exercise for fibromyalgia in the context of current physical activity guidelines;
- To suggest future directions for exercise and physical activity as management tools in this population.

Method

We searched for randomized clinical trials (RCTs) without language restriction using Medline (1966 to September 2008), the Cumulative Index to Nursing and Allied Health Literature (CINAHL®) (1982 to September 2008), the Excerpta Medica Database (EMBASE) (1974 to September 2008), and the Cochrane Controlled Trials Register (2008, issue 3). We used keywords and medical subject headings (MESH) headings to denote fibromyalgia and a wide spectrum of physical activity and exercise. Sources were also identified by examining reference lists from relevant research reports. After screening citations and abstracts, full text articles were examined. Studies of adults with fibromyalgia using: published criteria for diagnosis of fibromyalgia [5,27–30], randomized designs including either an untreated control group or a nonexercise intervention, and at least one intervention in which exercise/physical activity was a significant component were included in this review.

Types of interventions

In this review, we focused exclusively on three types of exercise: aerobic, strength and flexibility, excluding from consideration other types, such as balance. We classified exercise interventions first into land-based and aquatic categories. Within land-based and aquatic categories, exercise was classified by type(s) (excluding warm-up and cool-down): aerobic, strength, or flexibility for those that included only one type of exercise, or mixed (which included some combination of aerobic, strength and flexibility training). These interventions were also described as 'exercise-only' interventions, in contrast with composite interventions that included both exercise and nonexercise components. Within composite interventions, the exercise components were identified according to the description above. No restrictions on frequency, intensity or duration of exercise were made beyond the requirment that the exercise component of composite interventions be a substantial part of that treatment.

Data extraction & management

Study characteristics and point estimates for outcome measures were extracted from each study. When multiple measurements were taken across time, we based our calculations of effect sizes and meta-analysis on data collected at approximately 12 weeks. This duration was chosen because there is ample evidence that physiological adaptation will occur by 12 weeks; this was a common length for the programs being studied and,

therefore, would allow better comparison across studies. We preferentially extracted intention-to-treat data if available. Some authors have been contacted to obtain more data, but this has not been executed systematically.

Methodological quality assessment

Using the 11 item internal validity subscale of the van Tulder methodological quality assessment instrument [31], we classified studies into low and moderate-to-high methodological quality categories using arbitrary groupings of four or less for low-quality studies, and five to 11 for moderate-to-high quality studies. For full details of our application of this scale see Busch *et al.* [32].

Evaluation of congruence of exercise/physical activity with recognized guidelines

We evaluated congruence of exercise interventions with the American College of Sport Medicine (ACSM; IN, USA)/American Heart Association (AHA; TX, USA) (ACSM/AHA) guidelines for physical activity and public health for adults [33] and for older adults [34]. As part of this evaluation, we classified the intensity of exercise interventions using the classification of physical activity intensity advocated by ACSM in 2009 [35]. The guidelines for adults [33] recommend that healthy adults aged 18–65 years need moderate-intensity aerobic physical activity for a minimum of 30 min for a minimum of 5 days per week, or vigorous intensity aerobic physical activity for a minimum of 20 min on 3 days per week (or a combination of the two). Moderate intensity is described as activity requiring between three and six metabolic equivalents and vigorous as activity above six metabolic equivalents. The physical activity can be carried out either continuously or in blocks of 10 min or more, using any mode of aerobic exercise involving use of major muscle groups in rhythmic activities. For muscle strengthening, the ACSM 2009 guidelines [35] advise resistance training for 2–3 days per week with at least 48 h separating the exercise training sessions for the same muscle group. To improve muscular fitness, "adults should train each muscle group for a total of 2–4 sets with 8–12 repetitions at 60–80% of the one repetition maximum per set with a rest interval of 2–3 min between sets. For older and very deconditioned persons, one or more sets of 10–15 repetitions of moderate intensity (i.e., 60–70% one repetition maximum) resistance is recommended" [35].

The ACSM/AHA recommendations for older adults [34] address individuals who are 65 years and older and adults aged 50–64 years with clinically significant chronic conditions and/or functional limitations that affect movement ability, fitness or physical activity. These guidelines differ between adults in their definition of aerobic intensity and recommended intensity of strength training. Moderate intensity aerobic activity is described as a rating of five or six on a ten-point scale and vigorous activity as a seven or eight. The recommendation for strengthening exercises is also 8–10 exercises involving the major muscle groups, but advises using a set of 10–15 repetitions using resistance that represents moderate to high effort (5–6 and 7–8 on a scale in which zero is 'no effort' and ten is 'maximal effort'). These guidelines also advocate flexibility activity for at least 2 days per week for at least 10 min and the use of balance exercises. We evaluated flexibility training according to the ACSM 1998 position stand that describes dosage requirements as: frequency of exercise equal to or greater than two days per week, intensity to a position of mild discomfort, and three–four repetitions of each stretch held for a duration of 10–30 s [36].

Outcome measures

We grouped the outcome measures into five constructs: global well-being or perceived improvement in fibromyalgia symptoms as assessed by the study participant or observer, pain intensity, tender points, observed physical function (reflected by tests evaluating the cardiorespiratory system, muscle strength or flexibility), and depression. When researchers reported more than one measure for any one construct, we used the following order of preference for analysis:

- Global well-being: fibromyalgia impact questionnaire (FIQ) total, subject-rated visual analog scale (VAS) or ordinal scale, health professional-rated change, quality of life scale, sickness impact profile total;
- Pain: VAS, FIQ pain subscale, ordinal scale;
- Tender points: dolorimetry, total myalgic score, tender point count;
- Physical function: selected on a case-by-case basis depending on researchers' stated objectives;
- Depression: Beck cognitive, Beck total, Center for Epidemiologic Studies-Depression scale, FIQ-depression, arthritis impact measurement scales-depression subscale.

We also extracted data related to adverse events and effects using the definitions proposed by Loke 2007 [37].

Data analysis & synthesis

The data analysis was based on interventions rather than studies, since some studies provided more than one relevant comparison that involved exercise. In this review, we only analyzed comparisons derived from studies of moderate-to-high methodological quality owing to the limited number of studies comparing a strength intervention with a control, we analyzed data from all studies employing strength training regardless of methodological quality.

For analysis of interventions, we calculated effect sizes (standardized mean differences, [SMD]) with 95% CI using means and standard deviations of change scores for each intervention. When not available, standard deviations of change scores were derived directly from confidence intervals of change scores, or were estimated from the pre-test and post-test standard deviations (or standard errors) where these were provided (see Busch *et al.*) [32].

We evaluated clinical homogeneity based on exercise type and similarity of comparators. We conducted meta-analyses using Review Manager (RevMan [computer program], version 5.0, Copenhagen: The Nordic Cochrane Centre, The Cochrane Collaboration) on comparisons judged to be sufficiently homogeneous. To evaluate studies not included in meta-analyses, we used Review Manager to generate SMDs. We used Cohen's categories to evaluate the magnitude of the effect sizes (small effect: 0.2–0.49, medium effect: 0.5–0.79 and large effect: ≥0.8) [38].

We evaluated the magnitude of change using relative percentage change, specifying a clinically important difference at 30% based on the work of Farrar *et al.* [39] in the area of chronic pain. This is consistent with the findings of Dunkl *et al.* [40] who examined responsiveness of measures of clinical improvement in fibromyalgia. Relative percentage improvement was calculated as the mean change in the treatment group, minus the mean change in the control group, divided by the pooled mean for the baseline scores for the variable.

Results

We identified 45 RCTs that met the selection criteria. Foreign language studies in German, Spanish and Turkish were translated; only one study met the selection criteria [41].

The salient characteristics of these studies are summarized in Supplementary Table 1. Across the 45 studies, 3276 subjects with a confirmed diagnosis of fibromyalgia were included in analyses with 1888 subjects in 65 exercise interventions. The average sample size for the exercise groups was 28.2 (standard deviation: 16.3, range: 5–84). Mean age ranged from 27.5–58 years in 44 studies (age was missing in one study) and 96% of study participants were female.

The 45 studies encompassed seven aquatic interventions and 58 land-based interventions. A total of 18 studies had more than one exercise intervention allowing head-to-head comparisons between exercise regimens. Among land-based interventions, there were 21 aerobic, four strength, three flexibility, 14 mixed and 15 composite. Aerobic exercise interventions included walking (indoor, outdoor and treadmill), running, low-impact aerobics, cycle ergometer, aerobic dance (instructor and videotape format), aerobic games and swimming. One aerobic intervention was described as a lifestyle physical activity program. Strength training involved resistance machines, free weights, theraband and body weight (e.g., squats). The most common mixed programs included aerobic, strength and flexibility training. Most composite interventions included mixed exercise. A total of 17 of the 45 studies provided data for long-term effects (12 weeks to 4 years post-intervention).

A large variety of measures were used to evaluate the five outcome constructs. Most commonly used measures were as follows: pain – the 10 cm VAS; global well being – the FIQ; cardiorespiratory physical performance – the 6-min walk and maximal oxygen uptake; tender points – the tender point count; and depression – the Beck Depression Inventory and the depression visual analog scale.

Evaluation of congruence with ACSM/AHA guidelines for physical activity

Among studies using aerobic exercise (including aerobic-only and mixed interventions), four studies described exercise interventions that met ACSM/AHA guidelines for aerobic physical activity [42–45]. Most studies were insufficient with respect to frequency of activity; a smaller number of interventions provided intensity below the recommended levels or did not provide sufficient detail to determine whether the intervention met the guidelines.

Among studies using strength training (including strength-only and mixed interventions), five studies met the ACSM/AHA criteria [46–50]. Other studies using strength exercise either did not provide sufficient training stimulus or sufficient detail to determine congruence with the guidelines. Two studies met recommendations for flexibility training [51,52]. Most studies did not provide sufficient detail to evaluate their flexibility program or component.

Adverse effects

A total of 22 out of 45 studies did not mention either the presence or absence of adverse events or effects. Five studies explicitly reported observing no adverse effects related to training [49–51,53,54]. Of the remainder, 11 studies reported adverse effects specifically from training occasionally linked to withdrawal from the exercise groups [55,56]. Most of the adverse effects attributed to exercise were increased muscle pain, stiffness or fatigue, however, a case of tinea pedis [57] and a variety of musculoskeletal problems, including plantar fasciitis [43], impingement syndrome [57], ischialgia [58] and a metatarsal stress fracture [59], were also reported. No serious adverse effects (e.g., death, permanent disability or prolonged hospitalization) were reported. Three studies mentioned problems not associated with the exercise programs [45,60,61].

Adherence

While a few researchers reported good adherence to various exercise interventions (high-intensity cycle ergometry [42], strength training [46,48] and aquatic exercise [62,63]), other researchers [52,55,64,65] reported that participants had serious problems adhering to the exercise programs owing to increased incidence of fibromyalgia symptoms. Of the 12 new studies reported since our Cochrane review [32], ten reported adherence information, primarily by attendance records. Criteria for 'completers' ranged from a low of 50% [60] to several studies with greater than 90% attendance [62,63,66]. Of interest, heart rate was also monitored in six studies, although adherence reported in those papers only described attendance.

Attrition

Not all studies provided attrition data specific to groups, however, based on 42 studies providing group-by-group data, the mean attrition rates for exercise interventions were as follows: aerobic 22 ± 18%, strength 5 ± 9%, flexibility 13 ± 5%, mixed exercise 16 ± 13%, and composite interventions 17 ± 17%. There was no significant difference in attrition rates among exercise-only interventions. Mean attrition was 10 ± 11% and 14 ± 20% in untreated control groups and in the nonexercise comparator groups, respectively.

Methodological quality of included studies

Scores for the internal validity scale of the van Tulder methodological assessment are provided in Supplementary Table 1. The mean van Tulder score for internal validity was 5.5 out of a possible total of 11. A total of 31 studies were classified as moderate to high quality (score ≥ 5) and 14 as low quality. The most common problems affecting internal validity were deficits in concealment of treatment allocation, compliance with treatment, patient blinding, care-provider blinding, control of co-intervention and valid randomization. Small sample size was a methodological weakness of most included studies; only five [44,54,56,59,61] of the 45 included studies met the standard of 50 subjects analyzed per group [67].

The 31 studies rated as moderate-to-high quality on the van Tulder tool were selected for further analysis and synthesis. The remainder of the results section focuses exclusively on these 31 studies. They included 44 exercise interventions: six aquatic exercise protocols and 38 land-based protocols (12 aerobic, three strength, two flexibility, nine mixed exercise and 12 composite). A total of 11 studies had two exercise interventions, and one study had three. In addition to exercise interventions there were 14 untreated control groups and 17 nonexercise interventions.

Meta-analysis

We evaluated all appropriate comparisons in medium- to high-quality studies for clinical heterogeneity and decided to restrict the meta-analysis comparisons of exercise interventions to untreated control groups. The results for the meta-analysis are provided in Table 1.

Aerobic interventions from six studies that incorporated a control group [58,59,68–71] were meta-analyzed. The meta-analyses demonstrated a statistically significant small effect for global well-being [59,68,70,71] (SMD: 0.42, 95% CI: 0.18–0.65), and medium effects for physical function [58,59,68,71] (SMD: 0.66; 95% CI: 0.41–0.92) and depression [58,59,69,71] (SMD: 0.54, 95% CI: 0.02–1.06). No

Table 1. Meta-analyses of effects of aerobic, mixed exercise, aquatic and strengthening exercise-only interventions compared to untreated controls.

Exercise type	Global well-being	Pain	Tender points, standardized mean difference (95% CI)	Observed measured physical function, standardized mean difference (95% CI)	Depression, standardized mean difference (95% CI)	Ref.
Aerobic Training	0.42 (0.18, 0.65)	NS	NS	0.66 (0.41, 0.92)	0.54 (0.02, 1.06)	[58,59,68–71]
Strengthening	1.43 (0.76, 2.10)	–	–	1.55 (0.78, 2.33)	–	[46,48]
Mixed Exercise	NS	1.00 (0.13, 1.87)	NS	Aerobic test: 0.99 (0.39, 1.59); Strength test: 0.68 (0.11, 1.26)	NS	[50,60,64,72]
Aquatic Exercise	0.63 (0.27, 1.00)	0.51 (0.14, 0.88)	–	Strength test: 0.90 (0.39, 1.42)	–	[62,63,73]
Composite	0.53 (0.32, 0.75)	NS	NS	0.72 (0.22, 1.22)	0.27 (0.04, 0.51)	[52,56,68,74]

Values are standardized mean difference (95% CI).
NS: Nonsignificant.

significant effects were found for pain or tender points. While Schachter *et al.* provided two eligible aerobic interventions, to minimize clinical heterogeneity [59], we chose to include only the long bout intervention, which was more similar to the other aerobic interventions in the meta-analysis.

Strength interventions from two RCTs [46,48] were meta-analyzed for two outcomes. A large, significant effect was found for global well-being (SMD: 1.43, 95% CI: 0.76–2.10) and physical function (SMD: 1.55, 95% CI: 0.78–2.33). Pain, tender points and depression were measured in only one of the two studies – a large number of significant results were found in each outcome.

Mixed interventions from four studies [50,60,64,72] were meta-analyzed: significant large-sized effects were found for pain intensity [50,60,64,72] (SMD: 1.00; 95% CI: 0.13–1.87) and aerobic function [50,60,64] (SMD: 0.99; 95% CI: 0.39–1.59), while a significant medium-sized effect was found for muscle strength [50,60,64] (SMD: 0.68; 95% CI: 0.11–1.26). No significant effects were found for global well-being, tender points or depression when mixed exercise interventions were compared to untreated control groups.

Aquatic exercise interventions from three RCTs [62,63,73] were meta-analyzed for three outcomes. A significant medium-sized effect was found for global well-being [62,63,73] (SMD: 0.63; 95% CI: 0.27–1.00) and pain [62,63,73] (SMD: 0.51; 95% CI: 0.14–0.88). A significant large-sized effect was found for strength [62,63] (SMD: 0.90, 95% CI: 0.39–1.42). Significant large-sized effects were also found for tender points [63] and depression [62], however, these were based on data arising from single studies.

Composite interventions from four RCTs [52,56,68,74] that compared exercise plus education to an untreated control were meta-analyzed. Medium-sized significant effects were found for global well-being (SMD: 0.53, 95% CI: 0.32–0.75) and observed physical function [52,68,74] (SMD: 0.72, 95% CI: 0.22–1.22). A significant small-sized effect was found for depression [52,56,74] (SMD: 0.27, 95% CI: 0.04–0.51). The effects of exercise and education on pain and tender points were not significant.

Analysis of studies that were excluded from meta-analyses

In this section and in TABLE 2, positive, significant effects indicate that the first intervention improved the outcome more than the second intervention.

Table 2. Standardized mean differences for interventions from medium- to high-quality studies not meta-analyzed*.

Study	Intervention 1	Intervention 2	Global well-being, standardized mean difference (95% CI)	Pain, standardized mean difference (95% CI)	Tender Points, standardized mean difference (95% CI)	Physical function‡, standardized mean difference (95% CI)	Depression, standardized mean difference (95% CI)	Ref.
Exercise versus exercise								
Assis *et al.* (2006)	Land aerobic	Aquatic aerobic	-0.94 (-1.48, -0.41)	Ordinal data	–	1.12 (0.57, 1.67)	-0.71 (-1.23, -0.19)	[57]
Bircan *et al.* (2008)	Aerobic	Strengthening	NS	NS	NS	NS	NS	[53]
Buckelew *et al.* (1998)	Mixed only	Composite (mixed plus biofeedback)	NS	NS	NS	–	NS	[72]
Jentoft *et al.* (2001)	Aquatic mixed	Land-based mixed	0.93 (0.22, 1.64)	NS	–	NS	NS	[47]
Jones *et al.* (2002)	Strength	Flexibility	0.55 (0.02, 1.09)	0.66 (0.12, 1.20)	NS	NS strength NS flexibility	NS	[51]
Jones *et al.* (2008)	Composite (mixed plus pyridostigmine)	Mixed plus placebo med	NS	NS	NS	NS	NS	[60]
King *et al.* (2002)	Aerobic	Composite (aerobic plus education)	-0.52 (-0.97, -0.06)	–	NS	NS	–	[68]
McCain *et al.* (1988)	Aerobic	Flexibility	–	NS	0.78 (0.12, 1.90)	1.12 (0.45, 1.79)	–	[42]
Richards *et al.* (2002)	Aerobic	Composite (relaxation plus flexibility)	NS	NS	NS	–	–	[54]
Rooks *et al.* (2007)	Mixed (aerobic, flexibility)	Mixed (aerobic, strength, flexibility)	NS	NS	–	NS	NS	[49]
Schachter *et al.* (2003)	Aerobic long bout	Aerobic short bout	NS	NS	NS	NS	NS	[59]
van Santen *et al.* (2002b)	Aerobic, high intensity	Mixed	NS	NS	NS	NS	NS	[75]
Exercise versus nonexercise – aerobic								
King *et al.* (2002)	Aerobic	Education	NS	–	NS	NS	–	[68]
Schachter *et al.* (2003)	Short bout	Control	NS	-1.04 (-1.49, -0.60)	NS	0.50 (0.08, 0.93)	NS	[59]
Sencan *et al.* (2004)	Aerobic	Paroxetine	–	NS	NS	–	-1.07 (-1.74, -0.41)	[69]
Wigers *et al.* (1996)	Aerobic	Stress management	–	NS	NS	0.97 (0.22, 1.72)	-1.05 (-1.80, -0.29)	[58]
Exercise versus nonexercise – aquatic								
Altan *et al.* (2004)	Aquatic mixed	Balneotherapy	NS	NS	NS	-0.72 (-1.32, -0.12)	0.88 (0.27, 1.49)	[76]

Positive values indicate intervention 1 is superior to intervention 2, negative values indicate intervention 2 is superior to intervention 1.
‡Objective test of physical function.*
FM: Fibromyalgia; NS: Nonsignificant.

Table 2. Standardized mean differences for interventions from medium- to high-quality studies not meta-analyzed*.

Study	Intervention 1	Intervention 2	Global well-being, standardized mean difference (95% CI)	Pain, standardized mean difference (95% CI)	Tender Points, standardized mean difference (95% CI)	Physical function‡, standardized mean difference (95% CI)	Depression, standardized mean difference (95% CI)	Ref.
Exercise versus nonexercise – mixed								
Martin *et al.* (1996)	Mixed	Relaxation	NS	–	1.01 (0.33, 1.69)	5.79 (4.28, 7.31)	–	[77]
Redondo *et al.* (2004)	Mixed land plus aquatic	Cognitive behavior training	NS	NS	NS	NS	NS	[81]
Rooks *et al.* (2007)	Mixed (aerobic, flexibility)	FM self-help course	NS	NS	–	0.88 (0.35, 1.41)	NS	[49]
Rooks *et al.* (2007)	Mixed (strength, aerobic, flexibility)	FM self-help course	NS	NS	–	1.10 (0.56, 1.64)	NS	[49]
van Santen *et al.* (2002)	Mixed	Biofeedback	NS	-2.07 (-2.62, -1.53)	NS	NS	–	[64]
Exercise versus nonexercise – composite								
Buckelew *et al.* (1998)	Composite (mixed plus biofeedback)	Biofeedback	NS	-0.64 (-1.19, -0.09)	NS	–	NS	[72]
Buckelew *et al.* (1998)	Composite (mixed plus biofeedback)	Control	0.58 (0.25, 0.90)	NS	0.64 (0.30,0.98)	–	0.32 (0.00, 0.63)	[72]
Burckhardt *et al.* (1994)	Composite (aerobic plus education)	Education	NS	NS	NS	NS	NS	[74]
Hammond *et al.* (2006)	Composite (cognitive behavior education including mixed)	Relaxation	0.40 (0.06, 0.75)	NS	–	–	NS	[44]
Jones *et al.* (2008)	Composite (mixed plus pyridostigmine)	Diet recall (control) plus placebo medication	NS	NS	NS	NS	NS	[60]
Keel *et al.* (1998)	Composite (self management techniques including mixed)	Relaxation	NS	NS	–	–	–	[95]
King *et al.* (2002)	Composite (aerobic plus education)	Education	0.51 (0.06, 0.97)	–	NS	NS	–	[68]
Lemstra *et al.* (2005)	Composite (multidisciplinary with mixed)	Wait list control	1.22 (0.25, 0.90)	0.69 (0.23, 1.15)	–	–	NS	[66]
Rooks *et al.* (2007)	Composite (mixed plus FM self-help course)	FM self-help course	1.03 (0.5, 1.55)	NS	–	0.90 (0.38, 1.42)	0.71 (0.20, 1.22)	[49]

**Positive values indicate intervention 1 is superior to intervention 2, negative values indicate intervention 2 is superior to intervention 1.*
‡Objective test of physical function.
FM: Fibromyalgia; NS: Nonsignificant.

Comparison of two exercise interventions

Direct comparisons between various exercise interventions were carried out in 12 studies (Table 2). Of the 12 head-to-head comparisons, significant effects were found in five studies [42,47,51,57,68]. Notable among the comparisons demonstrating significant findings were aerobic versus flexibility exercise for tender points and physical function [42], as well as strength versus flexibility exercise for global well-being and pain [51]. Also of interest, aquatic exercise had a superior positive effect compared to land-based exercise in global well-being [47,57] and depression [57], whereas land exercise was more effective in improving physical function [57].

Notable among the seven head-to-head comparisons that did not demonstrate significant findings [49,53,54,59,60,72,75] were two that included strength versus aerobics: a comparison of aerobic versus strength exercise [53] and a comparison of mixed (aerobic plus strength plus flexibility) versus mixed (aerobic plus flexibility) [49]. Also of particular interest was an investigation of fractionation of aerobic exercise [59], and a study of exercise-intensity (self-selected intensity mixed exercise versus moderate-to-vigorous intensity aerobic) [75].

Comparisons of exercise interventions with control or nonexercise interventions

Among studies comparing aerobic exercise with nonexercise comparators, physical function was measured in three studies and improved significantly in two of these studies. Stress management [58] and the antidepressant paroxetine [69] both improved depression significantly more than exercise. Pain worsened in one comparison of aerobic exercise to an untreated control [59]. When a program that combined mixed aquatic and land-based exercise was compared to balneotherapy, a large-effect size was found for depression [76]. When mixed exercise was compared to a variety of nonexercise interventions in five studies, significant effects were noted in only five of the 20 outcomes examined. Three studies showed large significant improvement effects in physical function with exercise. Tender points improved significantly in one study with exercise [77], while pain was relatively worse in another study [64].

Comparisons of composite interventions with control or nonexercise interventions

Examining eight studies that compared composite interventions with nonexercise comparators, a number of positive, significant effects were noted. The most noteworthy was that global well-being improved with the composite intervention relative to the comparator in five studies [44,49,66,68,72]. Beyond this, depression improved in two studies [49,66], and tender points improved in Buckelew *et al.* [72]. Physical function improved in Rooks *et al.* [49], which compared a composite program of mixed exercise plus a fibromyalgia self-help course with the fibromyalgia self-help course alone and found that the composite program produced improved global well-being, depression and physical function. By contrast, the same composite program compared with a less diverse mixed-exercise intervention did not result in significant differences. Of these eight studies, one outcome showed conflicting results. Pain improved in Lemstra *et al.* [66] but worsened in Buckelew *et al.* [72].

Clinically important differences

Among the 12 aerobic interventions included in the medium- to high-quality studies, clinically important differences (i.e., ≥30%) were found in global well-being [59], tender points [58,69] and depression [58] (see Table 3). Among the four strength protocols, clinically important differences were found in global well-being in two studies [46,48], pain in one study [46] and in depression in another study [46]. Among the six aquatic protocols, clinically important differences were found in global well-being and pain in one study [62]. Among the nine mixed protocols, clinically important differences were found in global well-being in one study [78] and in depression in two studies [49,72]. Among the 11 remaining protocols that included exercise, clinically important differences were found in global well-being in one study [52] and in depression in five studies [56,61,66,72,76].

Long-term effects

Long-term follow-up of interventions, which were compared to untreated control groups, was carried out for four aerobic interventions, one aquatic mixed exercise intervention, one mixed exercise intervention and four composite interventions. The five studies comparing an aerobics intervention to an untreated control [58,68–70] included durations of follow-up varying from 6 weeks to 4.5 years. In the Da Costa *et al.* [70] study, significant improvements emerged in pain and global well-being at follow-up that were not revealed immediately following the intervention, whereas King *et al.* [68] found no between group differences in any outcome at any point. In the other studies, improvements

in global well-being [70], depression [70], physical function [70], tender points [69] and pain [69] were maintained. In contrast, Wigers *et al.* [58] reported that improvements in pain, tender points and work capacity were not maintained, but the follow-up period was very lengthy (4.5 years) and the researchers noted that most subjects were no longer exercising.

The aquatic mixed exercise intervention by Gusi *et al.* [62] had sustained improvements in depression and muscle strength at 12 weeks following the intervention, and Buckelew *et al.* [72] reported that a land-based mixed exercise intervention resulted in improvements in self-reported physical function and self-efficacy at 1-year follow up.

Each of the four studies that undertook long-term follow-up of composite interventions demonstrated positive findings. Mannerkorpi *et al.* [79], in an uncontrolled follow-up to Mannerkorpi *et al.* [52], noted that participants in the composite intervention had maintained improvements in FIQ total, FIQ physical function, short form 36 (SF36) physical function, SF36 general health and grip strength up to 6 months, as well as FIQ pain, FIQ fatigue, physical function and SF36 bodily pain, social function and vitality up to 24 months. Zijlstra *et al.* [61] noted that at 3 months follow-up, the spa group were significantly better than controls in the physical component of health status measure RAND 36-item health survey (RAND-36), pain, fatigue, subject evaluated general health, number of tender points, graded tender point score and FIQ total. Cedraschi *et al.* [56] noted that at 24 months follow-up, significantly more patients in the treatment group than in the control group had engaged in a new physical activity. At 15 month follow-up, Lemstra *et al.* [66] reported that the intervention group had maintained significant changes in pain and depression, although they had regressed to baseline in health status.

Discussion

Main findings

Over the last two decades, interest in the role of exercise in the management of fibromyalgia has been strong. A total of 12 new RCTs have been published in the past 4 years alone. Methodological quality of the research has improved steadily over time, providing a clearer picture of the effects of exercise for fibromyalgia. This review identified 45 RCTs published between 1988 and September 1998, involving over 3200 participants. A variety of land and aquatic exercise interventions were investigated and data on outcomes in five areas were extracted, analyzed and synthesized. A wide range of exercise protocols were studied; no serious adverse effects were reported.

Meta-analyses were carried out on five intervention categories versus untreated controls and significant effects were noted for global well-being (in aerobic, strength, aquatic and composite interventions), pain (in mixed and aquatic interventions), physical function (in all intervention categories) and depression (in aerobic and composite interventions). Studies comparing a composite intervention, including exercise with untreated controls, demonstrate their positive effects and are consistent with recent recommendations of multidisciplinary management for fibromyalgia [7,8]. This body of literature also contained several studies comparing two types of exercise as well as comparing exercise to nonexercise interventions. These studies help elucidate clinical implications, such as the relative benefits of various types of exercise, which will be discussed below.

Effects of exercise on symptoms & function by type of exercise

Using meta-analysis, we demonstrated that aerobic exercise was associated with significant positive effects on global well-being, aerobic physical function and depression, without any change in pain or tender points when compared with untreated controls. Based on isolated comparisons, aerobic exercise appeared to have advantages over flexibility exercise [42], showing greater improvements in tender point count and physical function. An isolated finding of increased pain has also been reported when two bouts of low-impact aerobic dance per day were compared with an untreated control [59].

Meta-analysis of two small studies [46,48] suggested that strength exercise produces large effects on global well-being and physical function (muscle strength). Evidence arising from single studies suggested that strength training also results in large improvments of pain [46], tender points [48] and depression [46] compared with controls. While we find these results encouraging, we have concerns about their generalizability. First, they arise from two small studies, and second, despite vigorous exercise protocols, the attrition rates were reported as zero, whereas the mean attrition values for all other exercise types was 18 ± 14%. Based on isolated comparisons, a lighter program of strength exercise was superior to flexibility training in

Table 3. Clinically significant improvements (30% greater improvement than controls at post-test).

Comparison	Global well-being (FIQ total, SF36)	Pain	Tender points	Physical function	Depression
Aerobic only versus control	Schachter *et al.*, (2003) [59]	–	Wigers *et al.* (1996) [58] Sencan *et al.* (2004) [69]	–	Wigers *et al.* (1996) [58]
Strength only versus control	Hakkinen *et al.*, (2001) [46] Valkeinen *et al.*, (2004) [48]	Hakkinen *et al.* (2001) [46]	–	–	Hakkinen *et al.* (2001) [46]
Aquatic versus control	Gusi *et al.*, (2006) [62]	Gusi (2006) [62]	–	–	–
Mixed versus control	Valkeinin *et al.*, (2008) [78]	–	–	–	Buckelew *et al.* (1998) (versus control) [72] Rooks *et al.* (2007) (mixed aerobic plus strength versus self-help) [49]
Other interventions including exercise	Mannerkorpi *et al.* (2000) [52]	–	–	–	Cedraschi *et al.* (2004) [56] Zijlstra *et al.* (2005) [61] Buckelew *et al.* (1998) [72] Altan *et al.* (2004) [76] Lemstra *et al.* (2005) [66]

FIQ: Fibromyalgia impact questionnaire; SF36: Short form 36.

global well-being improvement and pain reduction [51]. Further investigation is required to validate the findings of these studies and to provide a clearer understanding of the optimal range of intensity for improvement in symptoms and physical function in this population.

From the meta-analysis and individually analyzed studies, it appears that mixed exercise programs can improve pain and physical function (both aerobic endurance and muscle strength), however, not global well-being or depression. The absence of positive effects on global well-being and depression suggests that programs of aerobic excercise or strength alone may be more advantageous in improving symptoms of fibromyalgia.

Meta-analysis of three recent trials showed that aquatic mixed exercise is effective for improving global well-being and pain [62,63,73]. In addition, single studies reported positive effects of aquatic mixed exercise on tender points [63] and depression [62]. Aquatic exercise was superior to land-based exercise for global well-being [47,57] and depression [57], although not for physical function. For those studies that provided detailed adherence information [62,63,73], adherence was very high (75–95%) suggesting that warm-water exercise may be better tolerated by people with fibromyalgia. Possible reasons for a positive effect on pain in aquatic exercise include an increase in peripheral β-endorphins, decreased susceptibility to muscle microtrauma and reduced impact on weight-bearing joints [73]. The combination of exercise in a pleasant environment and decrease in pain may contribute to the changes in global well-being. Aquatic exercise may also be of special benefit, helping individuals with fibromyalgia who are very deconditioned or afraid of increasing pain to begin an exercise regime [80]. Of interest, two aquatic mixed studies also reported a significant improvement in strength [62,63], despite inclusion of what appeared to be minor strength components. Perhaps the improvement in strength may be attributed to the deconditioned state of the study participants, or perhaps the training stimulus was stronger than we assessed it to be, since methods for determining the intensity of strength exercise performed in water have not been established.

In this review, we have focused on data for short-term effects (e.g., typical 12-week interventions). Approximately a third of studies have included a follow-up period of several weeks, and six have re-evaluated participants at 1 year [54,61, 81] or more [58,66,72] after the interventions. A range of findings has been observed in the long-term follow-ups (i.e., latent improvements, absence of change, maintenance of positive effects and erosion of positive effects). Typically, participation in physical activity during the follow-up phase has not

been sufficiently monitored to evaluate whether sustained effects or further improvements are related to physical activity participation during the study period or effects of continuing exercise in these studies.

Good progress has been made in understanding the effects of exercise for individuals with fibromyalgia, however, there are still insufficient studies to warrant recommendations for optimal exercise types and protocols. There is good evidence for improvement with aerobic, strength, mixed and aquatic exercise delivered singly or together with other treatment methods. No difference in value has been found between aerobic and strength exercise [53], aerobic and mixed exercise [75] or mixed (aerobic plus flexibility) and mixed (strength plus aerobic plus flexibility) [49]. Although there is less research examining and supporting flexibility exercise, we recognize that flexibility exercise is commonly included in the warm up and cool down of aerobic and strength programs. These findings suggest that clinicians can recommend a wide range of physical activities for symptom management and improvement in physical function. Encouraging clients to choose according to their preferences and lifestyles is an important step in facilitating better adherence to regular physical activity.

The relationship between physical activity intensity and symptom improvement merits examination. Two problems have impeded our ability to define this relationship. First, this can be attributed to changes over time in the classification of exercise intensity, and second, the poor reporting of exercise intensity actually performed by participants. In the past, exercise intensity was commonly described in terms of the percentage of maximum oxygen uptake (% $\dot{V}O_{2max}$) or percentage of maximal (or predicted maximal) heart rate (% HR_{max}). Exercise intensity is now described in terms of the percentage of oxygen uptake reserve (% $\dot{V}O_2R$) (equivalent to percentage of heart rate reserve, % HRR) or % HR_{max}. In addition, the relative percentages of these variables used to describe various intensities of exercise have changed over time. For example, participants in Gowans *et al.* [71] exercised at moderate to vigorous intensities of 60–75% HR_{max}, (according to the 2000 ACSM classifications [82]. Using the 2009 classifications, this program now represents light to moderate intensities [35] (see Table 4). Adherence to the exercise protocols has been described sporadically and when descriptions are present they usually only address attendance. Until reporting includes greater detail about physical activity prescribed and activity actually performed by participants, a dose-response relationship between intensity and symptom improvement cannot be determined with any confidence.

Physical activity recommendations for symptom management & improvement of physical function

It is clear from the analysis that a variety of types of land-based and aquatic exercise can benefit individuals with fibromyalgia. Recommendation for physical activity should begin with a discussion of realistic expectations and goals. Although our analysis revealed statistically significant improvements in global well-being, pain, physical function and depression for many exercise-only interventions, most results did not reach the clinically important threshold of 30% improvement relative to untreated controls [40]. Thus, clinicians should avoid promising large improvements in symptoms or physical function with physical activity programs.

Before establishing an exercise program, clinicians must ensure appropriate health screening is undertaken [35]. Gowans *et al.* discusses additional considerations that should be taken into account prior to aquatic exercise [80]. Since individuals with fibromyalgia may be quite deconditioned, aerobic intensity should be slowly increased from low to moderate. Similarly, duration should be increased gradually; the deconditioned client may benefit from multiple short bouts, gradually increasing to the target of 30 min or more per day in sessions of no less than 10 min. Strength exercise should also be increased slowly. A temporary reduction of intensity for individuals who experience increased pain also appears to be a fundamental strategy for individuals with fibromyalgia. Detailed suggestions for implementation of exercise and physical activity programs are presented by Rooks *et al.* [49], Jones *et al.*[83], Jones and Clark [84], Mannerkorpi and Iversen [85] and Ambrose *et al.* [86].

Physical activity recommendations to prevent adverse health consequences from a sedentary lifestyle for individuals with fibromyalgia

The sedentary lifestyle and physical deconditioning associated with fibromyalgia places individuals at greater risk for diseases associated with physical inactivity. Loevinger *et al.* [87] has reported that women with fibromyalgia are at increased risk of metabolic syndrome and should be educated about the benefits of physical activity.

The recently published guidelines for physical activity for adults and older adults [33,34,88] are based on the best available evidence regarding the amount of regular physical activity needed to "promote and maintain health, reduce risk of chronic disease and premature mortality" [33]. These guidelines emphasize 30 min of moderate-intensity physical activity, however, they do not exclude vigorous-intensity exercise and do encourage performance of greater amounts of physical activity. In addition, they incorporate muscle-strength training two or more times per week. We believe that the guidelines should be considered part of a holistic approach to physical activity for individuals with fibromyalgia. Although we acknowledge that for a sedentary individual, even a small increase in activity should be encouraged, we believe that individuals with fibromyalgia and clinicians working with them should consider the guidelines as a 'gold standard' at which to aim.

The best way to build a program that will be acceptable to clients with fibromyalgia that achieves the guidelines for both aerobic and strength recommendations is currently unclear from the literature on fibromyalgia and exercise. The current literature focuses heavily on symptoms and physical function (fitness). Even as applied (in this body of literature, two to three days a week was common), attrition and adherence to interventions were poor. In order to achieve the increased frequency indicated in the guidelines, it seems apparent that we need to move beyond traditional exercise prescription and explore new approaches that include less prescriptive physical activity. For example, physical activities of daily living performed at moderate intensities (such as brisk walking) can contribute to the accumulation of 30 or more min of moderate-intensity physical activity, thus helping to meet the recommendations for aerobic activity. We clearly need research-based strategies to enhance adherence and for more effective monitoring.

Fibromyalgia researchers and clinicians have begun to advocate an approach that is consistent with the guidelines. Rooks explored practical ways to work with individuals with fibromyalgia to increase the amount of moderate intensity physical activity, suggesting that clinicians establish a collaborative dynamic with clients in order to achieve this goal [89]. Fontaine and Haas examined a cognitive behavioral physical activity-promotion program that addressed self-monitoring, goal setting and problem solving, also helping participants find ways to integrate short bouts of moderate-intensity physical activity (termed lifestyle physical activity) into their lives [45]. Further research into physical activity programs, long-term health results and characteristics of those who are successful are needed. Development of reliable and valid measurement tools are also needed to discriminate between physical activity that does and does not meet physical activity guidelines, since the guidelines present the minimum required to accumulate (nonfibromyalgia) health benefits. We believe that this differentiation will be of benefit to individuals with fibromyalgia such that they have a clearer understanding of the issue of 'how much is enough' in terms of health benefits.

Adverse effects, attrition & adherence

Reported adverse effects are mainly associated with increases in fibromyalgia symptoms, such as muscle pain, stiffness and fatigue, but a few musculoskeletal problems were also noted. The subjects in these exercise studies are generally deconditioned at the onset, and such adverse effects are likely to occur in any population of deconditioned exercisers. Encouragingly, the adverse effects were directly linked to withdrawal from the exercise interventions in only a few papers, and no serious adverse effects were noted. Given the large number of individuals who engaged in exercise in these studies (over 1800), we are confident in stating that, with appropriate screening and monitoring, physical activity is safe for individuals with fibromyalgia.

Based on data reported at the conclusion of the intervention (or at the 12-week mark if multiple data points were available) the attrition rate across all exercise-only interventions in this group of studies was 17%. Although there were no statistically significant differences among interventions (exercise-only, composite or control groups), the mean attrition rate of the aerobic-only groups was double that of the control groups, underlining the challenges for individuals in maintaining regular exercise, even as long as 12 weeks. If one in six individuals drop out of short-term supervised protocols, we would expect the rates to be much higher in unsupported programs.

There are a number of factors that detract from adherence to an exercise program, including a person's ability to deal with stress, pain, barriers to exercise and disability (Dobkin *et al.* [90]). Motivational interviewing (a technique of behavioral counseling) and cognitive behaviour training may be useful to enhance adherence and prevent relapses to exercise

Table 4. Classification of Physical Activity Intensity (ACSM Guidelines 8th edition 2009).

Intensity classification	Relative intensity	
	$\%VO_2R$ %HRR	$\%HR_{max}$
Low*	20–39	50–63
Moderate	40–59	64–76
Vigorous‡	60–84	77–93

Data from [35].
*Low and light are both used to describe this category.
‡Vigorous and hard are both used to describe this category.
ACSM: American College of Sport Medicine; $\%HR_{max}$: Percentage of maximal heart rate; %HRR: Percentage of heart rate reserve; $\%VO_2R$: Percentage of oxygen uptake reserve.

or physical activity in individuals with fibromyalgia [91,92]. The use of these methods in conjunction with a physical activity program is consistent with the current recommendations for multidisciplinary management of fibromyalgia.

Methodological issues

For progress to be made in understanding effects of exercise and physical activity for individuals with fibromyalgia, it is vital that researchers provide complete descriptions of the exercise or physical activity protocols they intend to implement, including frequency, intensity, duration, mode and progressions. It is also critical that researchers carefully monitor, analyze and report adherence to aerobic and strength programs. While the task may seem daunting, investigators who collect heart-rate data on a regular basis could select random samples to analyze adherence to aerobic interventions. Indeed, among the 12 papers published since 2005, heart rate was monitored in six, suggesting that researchers are starting to pay attention to adherence indicators other than attendance. Monitoring adherence to strength programs would require more supervision and documentation by study personnel, however, random assessments might be a useful strategy here too. While monitoring actual adherence to home-exercise programs and lifestyle physical-activity programs appears to be even more challenging, researchers can use a combination of pedometers, accelerometers and heart-rate monitors to gain a better picture of adherence. Despite the difficulties, a more precise knowledge of adherence to physical activity interventions will contribute to a more refined understanding of the dose-response curve for fibromyalgia symptoms, which can then be used to advise and inform fibromyalgia patients undertaking exercise.

It is important that authors track adverse effects more systematically; these include flares in fibromyalgia symptoms, timing of adverse effects (e.g., where did they occur throughout the program, were they more prevalent at the start of an exercise intervention) and whether adverse effects impacted on adherence and attrition. We recommend that researchers use the framework proposed by Loke *et al.* [37]. As Loke and colleagues point out, without accurate information of adverse effects, conclusions about the benefits and harms of an intervention will be biased in favor of benefits.

In addition to improving description of the interventions, we would urge that researchers adhere to recommended procedures for randomization and allocation of subjects and implement unbiased methods of handling missing data (e.g., intention-to-treat analysis). There were problems with these procedures, especially in the early studies. Any future studies should also ensure an adequate sample size; this was another common weakness in these studies.

Several groups were under-represented in this literature. As most of these studies were restricted to women in their mid-40s, children, men and older adults are under-represented, as are those from diverse cultural and ethnic groups. Issues related to obesity were not addressed. Long-term health status of individuals with fibromyalgia has received very little attention; this area also warrants further study.

There are gaps in the literature related to intervention types – more studies are needed to explore effects of strength training, flexibility exercise and lifestyle physical activity. Studies are also needed to help determine the dose-response pattern and long-term effects on fibromyalgia symptoms, function and other health benefits.

While some studies have included a follow-up period, most have not. Since maintenance of benefits of exercise/physical activity are most likely to continue only if individuals continue such programs, further research is needed to gain a more complete understanding of characteristics of

those who successfully integrate exercise/physical activity into their lives on a long-term basis [18] and into strategies that clinicians can use to facilitate such behavior change.

Recent work by the Outcome Measures in Rheumatoid Arthritis Clinical Trials (OMERACT) group to establish a core set of domains to evaluate outcomes of treatments for fibromyalgia should help to standardize outcome measures used in future research on exercise and fibromyalgia [93]. The key outcome domains that have been identified by the OMERACT group for fibromyalgia clinical trials are: pain, patient global, depression, fatigue, health-related quality of life and sleep. The outcome constructs we have concentrated on in this review overlap with three of these. Although outcomes prioritized by individuals with fibromyalgia [4] were considered in the listing developed by OMERACT, additional variables of interest prioritized by patients that are not captured in the core set were stiffness, and difficulty moving, walking or exercising. Clinicians will also be interested in addressing these additional variables with their clients when counseling them regarding exercise and physical activity. We recommend that researchers studying exercise and fibromyalgia should use an objective measure of physical function and stiffness, in addition to the core list of outcomes developed by the OMERACT group.

Conclusion

For individuals with fibromyalgia, regular physical activity can contribute to both fibromyalgia symptom management and overall health. While research is needed to more clearly describe the dose-response curve for various types of physical activity/exercise for fibromyalgia symptoms, studies clearly support the inclusion of physical activity in the multidisciplinary management of fibromyalgia. A shift of focus from improvement in fibromyalgia symptoms to improvement in symptoms plus overall health adds to the rationale for the adoption of regular physical activity for individuals with fibromyalgia. While further study may clarify the area of long-term adherence, clinicians and individuals with fibromyalgia should work together to identify types of physical activity and strategies for implementation and maintenance of physical activity that are suited to the client's life and lifestyle.

Future perspective

In 5–10 years, there is little evidence that there will be an improved understanding of fibromyalgia [94]. If the interest in the effects of physical activity interventions for individuals with fibromyalgia continues, we do believe that we will have a clearer understanding of the benefits of exercise and physical activity for function, symptoms and health in individuals with fibromyalgia. Also, if the trend in improved description of interventions

Executive summary

Literature

- In this review, we examined 45 randomized clinical trials to determine the effect of physical activity on fibromyalgia symptoms and physical function.
- Between 1988 and 2008, over 3200 subjects participated in studies on the effects of exercise for fibromyalgia.

Outcomes of physical activity interventions

- Meta-analyses of 19 aerobic, strength, mixed, aquatic and composite interventions compared with untreated controls revealed a number of positive significant effects for global well-being, pain, physical function and depression.
- No serious adverse effects were reported, however, few improvements reached the 30% threshold for clinically important differences relative to untreated controls.

Clinical implications

- Clinicians can recommend a wide range of aquatic and land-based exercise/physical activities.
- Aquatic exercise may be of special benefit for individuals with fibromyalgia.
- Clinicians should implement standardized classifications for exercise/physical activity intensity.
- Benefits of exercise appear to be fairly resilient, lasting for several months.
- Based on the studies reviewed, attrition will be a concern clinicians must address – a client-centered approach, strategies to improve adherence and address pain, as well as a multidisciplinary approach are recommended.

Research implications

- Further investigation is required to enhance understanding of the relationship between intensity and symptom improvement and the effects of strength exercise.
- Researchers are urged to provide more detailed reporting about exercise prescribed and exercise actually performed.
- Because individuals for fibromyalgia are at risk for adverse health consequences of a sedentary lifestyle, protocols that meet current American College of Sports Medicine and American Heart Association (ACSM/AHA) guidelines for physical activity should be a goal. However, few studies in this review met the guidelines.
- Development and investigation of adherence and monitoring strategies for long-term participation in physical activity are needed.

is sustained in future research, we should have a clearer understanding of the optimal exercise types and protocols. The physical activity symptom-intensity dose-response curve, a critical factor in prescription of exercise and physical activity in this population, will be clearer. Exercise studies will include more detailed information on adverse effects, long- and short-term exercise adherence, as well as the characteristics of people with fibromyalgia who maintain participation in exercise programs. More effective adherence and monitoring strategies will be developed to support not only formal physical activity programs, but also less structured lifestyle physical activity. These lifestyle physical-activity programs will become more prevalent than exercise studies, and we will start to understand differences in adherence, symptom changes, physical function and health between formal and less-structured programs. Finally, our ability to provide evidence-based physical activity recommendations for people with fibromyalgia and clinicians who work with them will be much enhanced.

Acknowledgements

The authors wish to thank Tanis Kershaw and Julia Bidonde for their assistance.

Financial & competing interests disclosure

The authors have no relevant affiliations or financial involvement with any organization or entity with a financial interest in or financial conflict with the subject matter or materials discussed in the manuscript. This includes employment, consultancies, honoraria, stock ownership or options, expert testimony, grants or patents received or pending, or royalties.

No writing assistance was utilized in the production of this manuscript.

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Supplementary Table 1. Randomized controlled studies examining effects of exercise and physical activity interventions for individuals with fibromyalgia.

Study van Tulder internal validity score*	n (randomized) percentage female at entry	Age in years (Mean SD at entry unless otherwise noted)	Study type, Intervention groups (n analyzed), Study duration	Description of exercise intervention by group‡	Ref.
Altan *et al.* (2004) VT = 6	50 100%	43.9 (31–56)§	Aquatic mixed: • Aquatic mixed (n = 24) • Balneotherapy (n = 22) 12 weeks plus 12 weeks follow-up	Aquatic mixed (37°C): • F: Three-times per week • D: 35 min (20 min aerobic) • I: Low to moderate • M: Swimming	[76]
Assis *et al.* (2006) VT = 8	60 100%	42.2–43.4 (10.1–10.8)	Aquatic aerobic: • Aquatic aerobic (n = 30) • Land aerobic (n = 30) 15 weeks	Aquatic aerobic (28–31°C): • F: Three-times per week • D: 60 min (40 min aerobic) • I: Low to moderate • M: Flotation-assisted running Land aerobic: • F: Three-times per week • D: 40 min • I: Moderate • M: Outdoor walking	[57]
Bircan *et al.* (2008) VT = 5	30 100%	46.0 (8.5) to 48.3 (5.3)	Aerobic versus strength: • Aerobic (n = 13) • Strength (n = 13) 8 weeks	Aerobic: • F: Three-times per week • D: 20 min, progressing to 30 min • I: Low to moderate • M: Treadmill walking Strength: • F: Three-times per week • D: 40 min (30 min strength exercises) • I: Unspecified 4–5 reps, progressed to 12 reps • M: Exercises in standing, sitting and lying positions	[53]

Studies with van Tulder internal validity scores of 4 or less were excluded from analysis of outcomes.
‡Additional information on the exercise protocol provided by researchers for [70].
§Mean (range).
¶Companion studies: three pairs of reports – Hakkinen et al. [46] *and Hakkinen* et al. [103]*; Gusi* et al. [62] *and Tomas-Carus* et al. [104]*; and Tomas-Carus* et al. [63] *and Gusi* et al. [105] *– reported on a common study; although each contributed data, the two reports in each pair were treated as one study. Gowans* et al. [106] *and Mannerkorpi* et al. [79] *presented information on long-term uncontrolled follow-up of included RCTs Gowans* et al. [71] *and Mannerkorpi* et al. [52]*; thus, these reports were treated as secondary studies and were excluded from analysis.*
#Median (range)
***Additional data obtained from Redondo et al. regarding age of participants.*
D: Duration; F: Frequency; I: Intensity; M: Mode; Reps: Repetitions; RM: Repetition maximum; SD: Standard deviation; VT: van Tulder Score.

Supplementary Table 1. Randomized controlled studies examining effects of exercise and physical activity interventions for individuals with fibromyalgia.

Study van Tulder internal validity score*	n (randomized) percentage female at entry	Age in years (Mean SD at entry unless otherwise noted)	Study type, Intervention groups (n analyzed), Study duration	Description of exercise intervention by group‡	Ref.
Buckelew *et al.* (1998) VT = 6	119 91%	41.9–45.6 (8.1–9.4)	Mixed exercise: • Mixed (n = 26) • Biofeedback and mixed (aerobic and flexibility) (n = 23) • Biofeedback (n = 25) • Education and attention control (n = 27) 6 weeks plus 2 years maintenance	Active phase – mixed aerobic: • F: Three-times per week (one group, two home) • D: Group – 90 min; home – unspecified; aerobic component • I: Group – low to moderate; home – unspecified • M: Walking Actibe phase – mixed flexibility: • M: Active range of motion, details unspecified Active phase – biofeedback and mixed: • Identical to mixed aerobic Maintenance phase – mixed: • F: 1 month plus home program • D: Group – 60 min; home – unspecified • I: Unspecified • M: Unspecified	[72]
Burckhardt *et al.* (1994) VT = 5	99 100%	46.5 (8.3)	Composite • Exercise and education (n = 28) • Education (n = 28) • Control (n = 30) 12 weeks	Exercise program: • F: Group – once per week; home – approximately three-times per week • D: Group – 60 min; home – unspecified • I: Unspecified • M: Group – walking, swimming or cycling; home – mainly walking	[74]

*Studies with van Tulder internal validity scores of 4 or less were excluded from analysis of outcomes.
‡Additional information on the exercise protocol provided by researchers for [70].
§Mean (range).
¶Companion studies: three pairs of reports – Hakkinen et al. [46] and Hakkinen et al. [103]; Gusi et al. [62] and Tomas-Carus et al. [104]; and Tomas-Carus et al. [63] and Gusi et al. [105] – reported on a common study; although each contributed data, the two reports in each pair were treated as one study. Gowans et al. [106] and Mannerkorpi et al. [79] presented information on long-term uncontrolled follow-up of included RCTs Gowans et al. [71] and Mannerkorpi et al. [52]; thus, these reports were treated as secondary studies and were excluded from analysis.
#Median (range)
**Additional data obtained from Redondo et al. regarding age of participants.
D: Duration; F: Frequency; I: Intensity; M: Mode; Reps: Repetitions; RM: Repetition maximum; SD: Standard deviation; VT: van Tulder Score.

Supplementary Table 1. Randomized controlled studies examining effects of exercise and physical activity interventions for individuals with fibromyalgia.

Study van Tulder internal validity score*	n (randomized) percentage female at entry	Age in years (Mean SD at entry unless otherwise noted)	Study type, Intervention groups (n analyzed), Study duration	Description of exercise intervention by group‡	Ref.
Cedraschi *et al.* (2004) VT = 8	164 93%	48.9–49.8 (9.7–9.8)	Composite: • Multidisciplinary program (n = 84) • Control (n = 80) 6 weeks plus 6 months follow-up	Exercise program: • F: 10 total sessions (8 pool, 2 land) • D: 45 min • I: 'Find their own pace' • M: Unspecified	[56]
Da Costa *et al.* (2005) VT = 7	79 100%	49.2–52.3 (8.7–10.8)	Aerobic: • Home-based aerobic training (n = 39) • Control (n = 40) 12 weeks plus 9 months follow-up	Aerobic: • F: Unspecified • D: 60–120 min per week • I: Low to vigorous • M: Walking, swimming, dancing and/or aerobic fitness exercise Strength (carried out by about 20% subjects): • F: Three-times per week • D: Unspecified • I: Low intensity • M: Calisthenics, light weights Flexibility: • Light stretch, held for 15–30 s for most muscle groups, as tolerated	[70]

*Studies with van Tulder internal validity scores of 4 or less were excluded from analysis of outcomes.
‡Additional information on the exercise protocol provided by researchers for [70].
§Mean (range).
¶Companion studies: three pairs of reports – Hakkinen et al. [46] and Hakkinen et al. [103]; Gusi et al. [62] and Tomas-Carus et al. [104]; and Tomas-Carus et al. [63] and Gusi et al. [105] – reported on a common study; although each contributed data, the two reports in each pair were treated as one study. Gowans et al. [106] and Mannerkorpi et al. [79] presented information on long-term uncontrolled follow-up of included RCTs Gowans et al. [71] and Mannerkorpi et al. [52]; thus, these reports were treated as secondary studies and were excluded from analysis.
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D: Duration; F: Frequency; I: Intensity; M: Mode; Reps: Repetitions; RM: Repetition maximum; SD: Standard deviation; VT: van Tulder Score.

Supplementary Table 1. Randomized controlled studies examining effects of exercise and physical activity interventions for individuals with fibromyalgia.

Study van Tulder internal validity score*	n (randomized) percentage female at entry	Age in years (Mean SD at entry unless otherwise noted)	Study type, Intervention groups (n analyzed), Study duration	Description of exercise intervention by group‡	Ref.
Evcik *et al.* (2008) VT = 3	63 98%	42.8–43.8 (7.6–7.7)	Aquatic mixed and land mixed: • Aquatic mixed (n = 31) • Land mixed home exercise (n = 30) 5 week plus 19 week follow-up	Aquatic mixed (33°C): • F: Three-times per week • D: 60 min (35 min aquatic) • I: Unspecified • M: Stretches, walking, jogging and swimming Land mixed home program – aerobic, flexibility and relaxation: • F: Three-times per week • D: 60 min • I: Unspecified • M: Unspecified	[96]
Fontaine *et al.* (2007) VT = 3	48 96%	50.5 (9.1)	Aerobic/lifestyle physical activity: • Lifestyle physical activity program (n = 22) • Fibromyalgia self-help course (n = 26)	Group cognitive behavioral training to promote incorporation of physical activity into daily living: • F: One meeting every 2 weeks • D: 90 min Physical activity: • F: 5–7 days per week • D: Progressed from 10–30 min • I: Moderate	[45]

*Studies with van Tulder internal validity scores of 4 or less were excluded from analysis of outcomes.
‡Additional information on the exercise protocol provided by researchers for [70].
§Mean (range).
¶Companion studies: three pairs of reports – Hakkinen et al. [46] and Hakkinen et al. [103]; Gusi et al. [62] and Tomas-Carus et al. [104]; and Tomas-Carus et al. [63] and Gusi et al. [105] – reported on a common study; although each contributed data, the two reports in each pair were treated as one study. Gowans et al. [106] and Mannerkorpi et al. [79] presented information on long-term uncontrolled follow-up of included RCTs Gowans et al. [71] and Mannerkorpi et al. [52]; thus, these reports were treated as secondary studies and were excluded from analysis.
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D: Duration; F: Frequency; I: Intensity; M: Mode; Reps: Repetitions; RM: Repetition maximum; SD: Standard deviation; VT: van Tulder Score.

Supplementary Table 1. Randomized controlled studies examining effects of exercise and physical activity interventions for individuals with fibromyalgia.

Study van Tulder internal validity score*	n (randomized) percentage female at entry	Age in years (Mean SD at entry unless otherwise noted)	Study type, Intervention groups (n analyzed), Study duration	Description of exercise intervention by group‡	Ref.
Genc *et al.* (2002) VT = 4	32 100%	27.5–27.9 (5.6–5.4)	Mixed exercise: • Stretching and strength (n = 16) • Remedial exercise (n = 16) 3 weeks	Stretching and strength: • F: Three-times per week • D: Unspecified • I: Unspecified • M: Strength exercises Remedial exercise: • F: Three-times per week • D: Unspecified • I: Unspecified • M: Unspecified	[41]
Gowans *et al.* (1999) VT = 3	45 78%	44.3–46.6 (10.7–12.2)	Composite: • Exercise and education (n = 20) • Wait list control (n = 21) 6 weeks plus 3 months follow-up	Exercise: • F: Two-times per week • D: 40 min (20 min aerobic) • I: Low to moderate • M: Walking, jogging	[97]
Gowans *et al.* (2001)¶ VT = 5	51 88%	44.6–49.8 (8.7–7.3)	Aerobic: • Aerobic (n = 27) • Untreated control (n = 23) 23 weeks	Aerobic: • F: Three-times per week • D: 30 min (20 min aerobic) • I: Low to moderate • M: Water ('warm') walking/running progressing to land walking/running	[71]
Gusi *et al.* (2006)¶ VT = 7	35 100%	51–51 (9–10)	Aquatic mixed: • Aquatic mixed (n = 17) • Control (n = 17) 12 weeks plus 12 week follow-up	Aquatic mixed (33°C): • F: Three-times per week • D: 60 min (2 × 10 min aerobic, 20 min strength) • I: Moderate • M: Aerobic – unspecified; strength – low extremity exercises	[62]

**Studies with van Tulder internal validity scores of 4 or less were excluded from analysis of outcomes.*
‡Additional information on the exercise protocol provided by researchers for [70].
§Mean (range).
¶Companion studies: three pairs of reports – Hakkinen et al. [46] *and Hakkinen* et al. [103]*; Gusi* et al. [62] *and Tomas-Carus* et al. [104]*; and Tomas-Carus* et al. [63] *and Gusi* et al. [105] *– reported on a common study; although each contributed data, the two reports in each pair were treated as one study. Gowans* et al. [106] *and Mannerkorpi* et al. [79] *presented information on long-term uncontrolled follow-up of included RCTs Gowans* et al. [71] *and Mannerkorpi* et al. [52]*; thus, these reports were treated as secondary studies and were excluded from analysis.*
#Median (range)
***Additional data obtained from Redondo et al. regarding age of participants.*
D: Duration; F: Frequency; I: Intensity; M: Mode; Reps: Repetitions; RM: Repetition maximum; SD: Standard deviation; VT: van Tulder Score.

Supplementary Table 1. Randomized controlled studies examining effects of exercise and physical activity interventions for individuals with fibromyalgia.

Study van Tulder internal validity score*	n (randomized) percentage female at entry	Age in years (Mean SD at entry unless otherwise noted)	Study type, Intervention groups (n analyzed), Study duration	Description of exercise intervention by group‡	Ref.
Hakkinen *et al.* (2001)¶ VT = 4	21 100%	37–39 (5–6)	Strength: • Strength (n = 11) • Control (n = 10) 4 weeks control (all groups) plus 21 weeks intervention	Strength: • F: Two-times per week • I: 15–20 reps at 40–60% of 1 RM, progressing to 5–10 reps at 70–80% of 1 RM; from week 7 onward – 30% of leg exercise performed rapidly with 40–60% RM • M: 6–8 dynamic exercises (upper extremity, lower extremity and trunk) versus resistance	[46]
Hammond *et al.* (2006) VT = 7	133 Gender not specified	48.4–48.7 (10.91–10.95)	Composite: • Cognitive behavior training, including mixed exercise (n = 71) • Weekly relaxation training (n = 62) 10 weeks plus 4 months follow-up	Mixed: • F: Once per week • D: 15 min progressing to 45 min • I: Self-paced • M: Tai Chi, stretching and strength Home program: • F: Five-times per week • D: Increasing to 30 min • I: Low to moderate • M: Walking, swimming and cycling	[44]

Studies with van Tulder internal validity scores of 4 or less were excluded from analysis of outcomes.
‡*Additional information on the exercise protocol provided by researchers for* [70].
§*Mean (range).*
¶*Companion studies: three pairs of reports – Hakkinen* et al. [46] *and Hakkinen* et al. [103]*; Gusi* et al. [62] *and Tomas-Carus* et al. [104]*; and Tomas-Carus* et al. [63] *and Gusi* et al. [105] *– reported on a common study; although each contributed data, the two reports in each pair were treated as one study. Gowans* et al. [106] *and Mannerkorpi* et al. [79] *presented information on long-term uncontrolled follow-up of included RCTs Gowans* et al. [71] *and Mannerkorpi* et al. [52]*; thus, these reports were treated as secondary studies and were excluded from analysis.*
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Supplementary Table 1. Randomized controlled studies examining effects of exercise and physical activity interventions for individuals with fibromyalgia.

Study van Tulder internal validity score*	n (randomized) percentage female at entry	Age in years (Mean SD at entry unless otherwise noted)	Study type, Intervention groups (n analyzed), Study duration	Description of exercise intervention by group‡	Ref.
Isomeri *et al.* (1993) VT = 3	51 87%	43.7 (24–55)	Aerobic and composite: • Aerobic (n = 15) • Stretching and medication (n = 16) • Aerobic and medication (n = 14) 15 weeks	Light stretching (aerobic): • F: Unspecified • D: Unspecified • M: Unspecified Cardiovascular fitness training (stretching, aerobic and medication): • F: Unspecified • D: Unspecified • I: Unspecified • M: Unspecified Referred to as aerobic in Cochrane review	[98]
Jentoft *et al.* (2001) VT = 5	44 100%	39.4–42.9 (8.8–8.6)	Aquatic mixed and land mixed: • Aquatic mixed (aerobic, strength) (n = 18) • Land-based mixed (aerobic, strength) (n = 16) 20 weeks plus 6 months follow up	Aquatic (34°C water) and land based: • F: Two-times per week • D: Total – 60 min; aerobic – 22 min • I: Low to vigorous • M: Aerobic dance Strength for thighs and trunk: • D: 15 min • M: Dynamic • I: 3–4 sets of 8–12 reps	[47]

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§Mean (range).
¶Companion studies: three pairs of reports – Hakkinen et al. [46] *and Hakkinen* et al. [103]*; Gusi* et al. [62] *and Tomas-Carus* et al. [104]*; and Tomas-Carus* et al. [63] *and Gusi* et al. [105] *– reported on a common study; although each contributed data, the two reports in each pair were treated as one study. Gowans* et al. [106] *and Mannerkorpi* et al. [79] *presented information on long-term uncontrolled follow-up of included RCTs Gowans* et al. [71] *and Mannerkorpi* et al. [52]*; thus, these reports were treated as secondary studies and were excluded from analysis.*
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Supplementary Table 1. Randomized controlled studies examining effects of exercise and physical activity interventions for individuals with fibromyalgia.

Study van Tulder internal validity score*	n (randomized) percentage female at entry	Age in years (Mean SD at entry unless otherwise noted)	Study type, Intervention groups (n analyzed), Study duration	Description of exercise intervention by group‡	Ref.
Jones *et al.* (2002) VT = 5	68 100%	46.4–49.2 (8.6–6.4)	Strength and flexibility: • Strength (n = 28) • Flexibility (n = 28) 12 weeks	Strength and flexibility: • F: Two-times per week • D: 60 min Strength for lower and upper limbs and trunk: • I: Progressed from 4–12 reps • M: Dynamic (eccentric work minimized) Flexibility for lower limbs and trunk: • M: Static stretches	[51]
Jones *et al.* (2008) VT = 6	165 97%	49.5 (8.1)	Composite and mixed: • Mixed plus pyridostigmine (n = 40) • Diet recall plus pyridostigmine (n = 36) • Mixed plus placebo medication (n = 39) • Control (diet recall plus placebo medication) (n = 39) 6 months	Mixed plus pyridostigmine and control: • F: Three-times per week • D: 60 min classes Aerobic: • D: 30 min • I: Low to moderate • M: Low impact aerobics Strength: • D: 10 min • I: Progressive resistance training • M: Dynamic exercise using light weights and theraband (overhead and eccentric work minimized) Flexibility: • D: 5 min • M: Dynamic and static movements	[60]

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‡Additional information on the exercise protocol provided by researchers for [70].
§Mean (range).
¶Companion studies: three pairs of reports – Hakkinen et al. [46] and Hakkinen et al. [103]; Gusi et al. [62] and Tomas-Carus et al. [104]; and Tomas-Carus et al. [63] and Gusi et al. [105] – reported on a common study; although each contributed data, the two reports in each pair were treated as one study. Gowans et al. [106] and Mannerkorpi et al. [79] presented information on long-term uncontrolled follow-up of included RCTs Gowans et al. [71] and Mannerkorpi et al. [52]; thus, these reports were treated as secondary studies and were excluded from analysis.
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Supplementary Table 1. Randomized controlled studies examining effects of exercise and physical activity interventions for individuals with fibromyalgia.

Study van Tulder internal validity score*	n (randomized) percentage female at entry	Age in years (Mean SD at entry unless otherwise noted)	Study type, Intervention groups (n analyzed), Study duration	Description of exercise intervention by group‡	Ref.
Keel *et al.* (1998) VT = 6	32 89%	49 (no SD or range available)	Composite: • Self-management training, including mixed with home program (aerobic, flexibility) (n = 14) • Relaxation training (n = 13) 15 weeks plus 4 months follow up	Mixed self-management training: • F: Once per week • D: 20–30 min Other details unspecified	[95]
King *et al.* (2002) VT = 7	152 100%	44.9–47.4 (10.0–9.0)	Aerobic and composite: • Aerobic only (n = 42) • Education (n = 41) • Aerobic and education (n = 35) • Control (n = 34) 12 weeks plus 3 months follow up	Aerobic: • F: Three-times per week • D: Progressed from 10–40 min • I: Low to moderate • M: Walking, aquasize or low impact aerobics	[68]
Lemstra *et al.* (2005) VT = 9	79 85%	49.1–49.7 (13.4–9.6)	Composite: • Multidisciplinary management including mixed (n = 43) • Wait List (n = 36) 6 weeks with 15 months follow up	Multidisciplinary management: • F: 18 sessions over 6 weeks Aerobic: • D: Progressed from 5–20 min • I: Moderate • M: Treadmill walking Flexibility: • D: 10 min for upper and lower extremities Strength for lower limb and upper limbs: • I: 2 sets × 15 reps • M: Dynamic	[66]

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§Mean (range).
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Supplementary Table 1. Randomized controlled studies examining effects of exercise and physical activity interventions for individuals with fibromyalgia.

Study van Tulder internal validity score*	n (randomized) percentage female at entry	Age in years (Mean SD at entry unless otherwise noted)	Study type, Intervention groups (n analyzed), Study duration	Description of exercise intervention by group‡	Ref.
Mannerkorpi *et al.* (2000)¶ VT = 5	69 100%	45 (8.0) to 47 (11.6)	Composite: • Aquatic mixed and education (n = 28) • Control (n = 29) 24 weeks	Aquatic mixed and education: • F: Once per week • D: 35 min Exercise included aerobic and flexibility at self-selected intensities below pain and fatigue threshold in temperate pool	[52]
Martin *et al.* (1996) VT = 6	60 97%	43.9–45.7 (9.7–9.9)	Mixed: • Mixed (n = 18) • Relaxation (n = 20) 6 weeks	Mixed: • F: Three-times per week • D: 60 min Aerobic: • D: 20 min • I: Low to vigorous Strength for upper, low extremities and trunk: • I: Progressive resistance • M: Dynamic Flexibility – unspecified	[77]

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‡Additional information on the exercise protocol provided by researchers for [70].
§Mean (range).
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Supplementary Table 1. Randomized controlled studies examining effects of exercise and physical activity interventions for individuals with fibromyalgia.

Study van Tulder internal validity score*	n (randomized) percentage female at entry	Age in years (Mean SD at entry unless otherwise noted)	Study type, Intervention groups (n analyzed), Study duration	Description of exercise intervention by group‡	Ref.
McCain *et al.* (1988) VT = 6	42 Gender not specified	38.5–45.9 (11.1–8.2)	Aerobic and flexibility: • Aerobic (n = 18) • Flexibility (n = 20) 20 weeks	Aerobic and flexibility: • F: Three-times per week • D: 60 min Aerobic: • D: 50 min • I: Vigorous • M: Cycle ergometry Flexibility: • I: Performed at heart rate below 115 beats/min • M: Details unspecified	[42]
Mengshoel *et al.* (1992) VT = 3	35 100%	33.5–34 (21–42) to (25–38)#	Aerobic: • Aerobic (n = 11) • Control (n = 14) 20 weeks	Aerobic: • F: Two-times per week • D: 60 min aerobic • I: Moderate to vigorous • M: Aerobic dance	[99]
Meyer *et al.* (2000) VT = 1	21 100%	49.5 (6.3)	Aerobic: • Low-intensity walking (n = 8) • High-intensity walking (n = 8) • Control (n = 5) 24 weeks	High- and low-intensity walking: • F: Three-times per week • D: Progressed from 12 to 30 min Low intensity: • I: Progressed from low to moderate • M: Walking High intensity: • I: Moderate to vigorous • M: Walking	[43]

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Munguia-Izquierdo *et al.* (2007) VT = 6	60 100%	46–50 (8–7)	Aquatic mixed: • Aquatic mixed (n = 35) • Fibromyalgia control (n = 25) • Healthy control (n = 25) 16 weeks	32°C water: • F: Three-times per week Aerobic: • D: 20–30 min • I: Low to vigorous in chest-deep water Strength for all major muscle groups: • D: 10–20 min • M: Exercise in chest-deep water, resistance from water and aquatic materials	[73]
Nichols *et al.* (1994) VT = 2	24 92%	47.8–50.8 (11.1–11.8)	Aerobic: • Aerobics (n = 10) • Control (n = 9) 8 weeks	Aerobic: • F: Three-times per week • D: 20 min • I: Low to moderate • M: Walking	[100]
Norregaard *et al.* (1997) VT = 4	38 Gender not specified	44–55 (8–10)	Aerobic: • Aerobic (n = 5) • Therapeutic exercise (n = 11) • Hot packs (n = 7) 12 weeks	Aerobic: • F: Three-times per week • D: 40 min • I: Moderate • M: Aerobic dance	[55]

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§*Mean (range).*
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Study van Tulder internal validity score*	n (randomized) percentage female at entry	Age in years (Mean SD at entry unless otherwise noted)	Study type, Intervention groups (n analyzed), Study duration	Description of exercise intervention by group‡	Ref.
Ramsay *et al.* (2000) VT = 3	74 Gender not specified	Unspecified	Aerobic: • Single supervised instructional session plus aerobic home program (n = 35) • Multiple supervised circuit aerobic plus aerobic home program (n = 15) 12 weeks	Aerobic single session: • F: One supervised session with instructions for aerobic home program; home program details unspecified Aerobic multiple session: • F: Once per week • D: 60 min • I: Unspecified • M: Circuit aerobic program plus aerobic home program, details unspecified	[101]
Redondo *et al.* (2004)** VT = 5	40 100%	52.5 (8.8)	Mixed: • Mixed (n = 19) • Cognitive behavioral therapy (n = 21) 8 weeks plus 6 months and 12 months follow-up	Mixed (flexibility, aerobic, strength): • F: Total – five-times per week • D: 45 min Aerobic: • F: Twice per week • I: Low to vigorous • M: Cycle ergometry Flexibility and muscle strength /endurance: • F: Twice per week (flexibility) • M: Gravity and free weight resisted concentric and eccentric exercise, static stretching exercise Aquatic: • F: Once per week in warm water	[81]

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Richards *et al.* (2002) VT = 8	136 93%	45–48 (38–52) to (38–56)#	Aerobic and composite • Aerobic (n = 69) • Relaxation and flexibility (n = 67) 12 weeks plus 1 year follow-up	Aerobic: • F: Twice per week • D: 2 × 6 min to 2 × 25 min • I: Moderate • M: Treadmill, cycle ergometer Flexibility: • F: Twice per week • D: 60 min • M: Upper and lower limb stretches	[54]
Rooks *et al.* (2007) VT = 6	207 100%	48–51 (11–12)	Mixed and composite: • Mixed (aerobic, flexibility) (n = 35) • Mixed (strength, aerobic, flexibility) (n = 35) • Mixed (strength, aerobic, flexibility) plus fibromyalgia self-help course (n = 38) • Fibromyalgia self-help course (n = 27) 16 weeks	Mixed (aerobic, flexibility): • F: Twice per week • D: 60 min • I: Self-determined moderate • M: Treadmill, flexibility for primary body movements Mixed (strength, aerobic, flexibility [plus fibromyalgia]): • F: Twice per week • D: 60 min • I: Progressed from one set of six reps to two sets of 10–12 reps • M: Treadmill, resisted exercise, flexibility for primary body movements	[49]

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Schachter *et al.* (2003) VT = 7	143 100%	41.3–42.5 (8.7–6.7)	Aerobic: • Aerobic short bouts (n = 56) • Aerobic long bout (n = 51) • Control (n = 36) 16 weeks	Short bout aerobic: • F: Three- to five-times per week • D: 5 min progressed to 15 min, twice per day • I: Moderate to vigorous • M: Videotaped low impact aerobics Long bout aerobic: • F: Three- to five-times per week • D: 10 min progressed 30 min, once per day • I: Low to vigorous • M: Videotaped low impact aerobics	[59]
Sencan *et al.* (2004) VT = 6	60 100%	32.7–35.5 (9.4–7.9)	Aerobic: • Aerobic (n = 20) • Paroxetine (n = 20) • Placebo transcutaneous electrical stimulation (n = 20) 6 weeks plus 6 week follow-up	Aerobic: • F: Three-times per week • D: 40 min • I: Unspecified intensity • M: Cycle ergometry	[69]
Tomas-Carus *et al.* (2008)¶ VT = 7	33 100%	50.7–50.9 (10.6–6.7)	Aquatic mixed: • Aquatic mixed (n = 15) • Fibromyalgia control (n = 15) 8 months	Mixed Aquatic (aerobic, strength, flexibility): • F: Three-times per week • D: Total – 60 min in waist-deep warm water (33°C); aerobic – 20 min • I: Low to moderate • M: Walking; strength and flexibility • D: 20 min • I: 4 × 10 reps for each exercise • M: Lower extremity against water resistance, raising arms with light loads and elastic bands	[63]

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Valim *et al.* (2003) VT = 4	76 100%	44–47 (11–10)	Aerobic and flexibility: • Aerobic (n = 32) • Stretching (n = 28) 20 weeks	Aerobic: • F: Three-times per week • D: 45 min • I: Moderate • M: Walking Flexibility: • F: Three-times per week • D: 45 min • I: Hold for up to 30 s • M: Two sets of 17 static stretches for cervical and thoracic spine and extremities	[102]
Valkeinen *et al.* (2004) VT = 5	26 100%	59.1–60.2 (3.5–2.5)	Strength: • Strength training (fibromyalgia) (n = 13) • Strength training (healthy individuals) (n = 10) • Control (fibromyalgia) (n = 13) 21 weeks	Strength training: • F: Twice per week; strength for major muscle groups • D: 80% strength, 20% power • I: Progressive resistance from three sets of 15–20 reps at 40–60% of 1 RM to 3–5 sets of 5–10 reps at 70–80% of 1 RM; for power (legs only), two sets of 8–12 reps at 40–50% of 1 RM • M: Dynamic exercise versus resistance	[48]

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§Mean (range).
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Study van Tulder internal validity score*	n (randomized) percentage female at entry	Age in years (Mean SD at entry unless otherwise noted)	Study type, Intervention groups (n analyzed), Study duration	Description of exercise intervention by group‡	Ref.
Valkeinen *et al.* (2008) VT = 5	26 100%	58–59 (3–3)	Mixed: • Mixed (aerobic, strength) (n = 13) • Control (n = 11) 21 weeks	Mixed (aerobic, strength) aerobic: • F: Alternately once or twice per week • D: 30–60 min • I: Low to vigorous • M: Walking and cycling Strength: • F: Alternately once or twice per week • D: 60–90 min • I: Progression from 2–4 sets at 40–60% of 1 RM to 2–6 sets at 70–80% of 1 RM • M: Dynamic exercise for major muscle groups versus resistance	[50]
van Santen *et al.* (2002) VT = 7	129 100%	42.8–46.2 (26–59) to (26–59)§	Mixed: • Mixed (n = 44) • Biofeedback (n = 38) • Treatment as usual control (n = 27) 24 weeks	Mixed self-selected intensity (aerobic, strength, flexibility): • F: two supervised plus one unsupervised session per week • D: Total – 50 min (30 min aerobic/flexibility, 10 min strength) • I: Self selected • M: not specified	[64]

*Studies with van Tulder internal validity scores of 4 or less were excluded from analysis of outcomes.
‡Additional information on the exercise protocol provided by researchers for [70].
§Mean (range).
¶Companion studies: three pairs of reports – Hakkinen et al. [46] and Hakkinen et al. [103]; Gusi et al. [62] and Tomas-Carus et al. [104]; and Tomas-Carus et al. [63] and Gusi et al. [105] – reported on a common study; although each contributed data, the two reports in each pair were treated as one study. Gowans et al. [106] and Mannerkorpi et al. [79] presented information on long-term uncontrolled follow-up of included RCTs Gowans et al. [71] and Mannerkorpi et al. [52]; thus, these reports were treated as secondary studies and were excluded from analysis.
#Median (range)
**Additional data obtained from Redondo et al. regarding age of participants.
D: Duration; F: Frequency; I: Intensity; M: Mode; Reps: Repetitions; RM: Repetition maximum; SD: Standard deviation; VT: van Tulder Score.

Supplementary Table 1. Randomized controlled studies examining effects of exercise and physical activity interventions for individuals with fibromyalgia.

Study van Tulder internal validity score*	n (randomized) percentage female at entry	Age in years (Mean SD at entry unless otherwise noted)	Study type, Intervention groups (n analyzed), Study duration	Description of exercise intervention by group‡	Ref.
van Santen *et al.* (2002) VT = 8	37 100%	39–45 (20–54) to (25–58)§	Mixed and aerobic: • Low-intensity training (n = 13) • High-intensity training (n = 17) 23 weeks	Mixed self-selected low intensity (aerobic, strength, flexibility): • F: Two supervised plus one unsupervised session per week • D Total – 50 min (30 min aerobic/flexibility, 10 min strength) • I: Self selected • M: Not specified Aerobic high intensity: • F: Three-times per week • D: 60 min • I: Moderate to vigorous • M: Cycle ergometer	[75]
Verstappen *et al.* (1997) VT = 4	87 100%	42.8–46.6 (8.4–8.3)	Mixed: • Mixed (n = 45) • Control (n = 27) 6 months	Mixed (aerobic, flexibility, strength): • F: Two-times per week supervised and one- to two-times per week unsupervised • D: 40 min • I: Self selected • M: Running or cycling, nautilus	[65]
Wigers *et al.* (1996) VT = 9	60 92%	44 (10)	Aerobic: • Aerobic (n = 16) • Stress management (n = 17) • Treatment as usual (n = 17) 14 weeks plus 4.5 year follow-up	Aerobic: • F: Three-times per week • D: 45 min • I: Low to moderate intensity • M: Low impact aerobic dance and aerobic games	[58]

*Studies with van Tulder internal validity scores of 4 or less were excluded from analysis of outcomes.
‡Additional information on the exercise protocol provided by researchers for [70].
§Mean (range).
¶Companion studies: three pairs of reports – Hakkinen et al. [46] and Hakkinen et al. [103]; Gusi et al. [62] and Tomas-Carus et al. [104]; and Tomas-Carus et al. [63] and Gusi et al. [105] – reported on a common study; although each contributed data, the two reports in each pair were treated as one study. Gowans et al. [106] and Mannerkorpi et al. [79] presented information on long-term uncontrolled follow-up of included RCTs Gowans et al. [71] and Mannerkorpi et al. [52]; thus, these reports were treated as secondary studies and were excluded from analysis.
#Median (range)
**Additional data obtained from Redondo et al. regarding age of participants.
D: Duration; F: Frequency; I: Intensity; M: Mode; Reps: Repetitions; RM: Repetition maximum; SD: Standard deviation; VT: van Tulder Score.

Supplementary Table 1. Randomized controlled studies examining effects of exercise and physical activity interventions for individuals with fibromyalgia.

Study van Tulder internal validity score*	n (randomized) percentage female at entry	Age in years (Mean SD at entry unless otherwise noted)	Study type, Intervention groups (n analyzed), Study duration	Description of exercise intervention by group‡	Ref.
Zijlstra *et al.* (2005) VT = 4	134 96%	47–48 (24–64) to (22–64)#	Composite: • Composite (Spa intervention): thalassotherapy, exercise, education, recreation) (n = 58) • Treatment as usual (n = 76) 2.5 weeks plus 12 months follow-up	Aerobic composite: • F: Seven sessions per 2.5 weeks • D: 60 min • I: Moderate intensity aerobic exercise • M: Treadmill, walking, swimming, cycling, light stretching	[61]

**Studies with van Tulder internal validity scores of 4 or less were excluded from analysis of outcomes.*
‡Additional information on the exercise protocol provided by researchers for [70].
§Mean (range).
¶Companion studies: three pairs of reports – Hakkinen et al. [46] *and Hakkinen* et al. [103]*; Gusi* et al. [62] *and Tomas-Carus* et al. [104]*; and Tomas-Carus* et al. [63] *and Gusi* et al. [105] *– reported on a common study; although each contributed data, the two reports in each pair were treated as one study. Gowans* et al. [106] *and Mannerkorpi* et al. [79] *presented information on long-term uncontrolled follow-up of included RCTs Gowans* et al. [71] *and Mannerkorpi* et al. [52]*; thus, these reports were treated as secondary studies and were excluded from analysis.*
#Median (range)
***Additional data obtained from Redondo et al. regarding age of participants.*
D: Duration; F: Frequency; I: Intensity; M: Mode; Reps: Repetitions; RM: Repetition maximum; SD: Standard deviation; VT: van Tulder Score.