

Exercise for osteoarthritis of the hip and knee

Howe, Tracey

Published in:
Annual Review of Gerontology and Geriatrics

DOI:
[10.1891/0198-8794.36.155](https://doi.org/10.1891/0198-8794.36.155)

Publication date:
2016

Document Version
Author accepted manuscript

[Link to publication in ResearchOnline](#)

Citation for published version (Harvard):
Howe, T 2016, 'Exercise for osteoarthritis of the hip and knee', *Annual Review of Gerontology and Geriatrics*, vol. 36, pp. 155-168. <https://doi.org/10.1891/0198-8794.36.155>

General rights

Copyright and moral rights for the publications made accessible in the public portal are retained by the authors and/or other copyright owners and it is a condition of accessing publications that users recognise and abide by the legal requirements associated with these rights.

Take down policy

If you believe that this document breaches copyright please view our takedown policy at <https://edshare.gcu.ac.uk/id/eprint/5179> for details of how to contact us.

CHAPTER 6

Exercise for Osteoarthritis of the Hip and Knee

Tracey E. Howe

ABSTRACT

Osteoarthritis (OA) is the most common form of arthritis and is a painful, chronically disabling joint disease that often significantly compromises function and independence. With the generalized rise in the age of the global population, the number of people suffering from musculoskeletal disorders throughout the world will increase dramatically over the coming decades. International clinical guidelines recommend exercise for the treatment of OA. Given the current and predicted future global burden of OA of the hip and knee, the aim of this chapter is to summarize the evidence from recent systematic reviews published in English on the effectiveness of land- and water-based exercise programs for people with OA of the hip and knee. The primary outcomes considered, based on the recommendations of the OMERACT III conference, are pain and function. Recent systematic reviews have examined the effectiveness of exercise on pain and function compared with controls: land- versus water-based exercise, individual versus group exercise, and exercise prior to surgery for people with OA of the hip, the knee, and lower limb (hip and knee combined). Generally, most forms of exercise have been demonstrated to have significant positive effects on pain and function at the end of the exercise program, but unless participants continue the program, the sustainability of these effects in the longer term are questionable.

AQ1

1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
16
17
18
19
20
21
22
23
24
25
26
27
28
29
30
31
32
33
34
35
36
37
38
39
40
41

1 However, exercise appears to be a safe intervention, with few adverse effects
2 reported. A number of considerations relating to the design and reporting of
3 primary research in this area are discussed.

4 5 6 INTRODUCTION

7 Osteoarthritis (OA) is the most common form of arthritis and is a painful,
8 chronically disabling joint disease that often significantly compromises func-
9 tion and independence. OA can present in the spine and hands, but the most
10 frequently affected joints are the main load-bearing joints, the hips and knees.
11 Approximately one in four people may develop symptomatic hip OA in their
12 lifetime (Murphy et al., 2010); the lifetime prevalence for hip OA is estimated to
13 be 25.3% but it is much higher for knee OA, 44.7% (Murphy et al., 2008). The
14 global age-standardized point prevalence for hip and knee OA in 2010 was 3.8%
15 (95% uncertainty interval 3.6 to 4.1) and was higher in females peaking at age
16 50 years (March et al., 2014).

17 The symptoms of OA include pain, joint stiffness, muscle weakness and
18 atrophy, altered proprioception, and limitations in functional activities and social
19 participation. Joint malalignment may be present in progressive disease states
20 and this can result in bone-on-bone joint pain. Hip and knee OA accounts for
21 about 10.5% of the total disability burden in terms of years lived, with disabili-
22 ties for all musculoskeletal diseases combined.

23 With the generalized rise in the age of the global population, the number
24 of people suffering from musculoskeletal disorders throughout the world will
25 increase dramatically over the coming decades. For example in the United States,
26 the number of adults with arthritis is projected to increase from 47.8 million in
27 2005 to 67 million in 2030 (Hootman & Helmick, 2006). This will result in an
28 exponential increase in the global burden of disability from OA hip and knee;
29 therefore, finding cost-effective and safe treatment to minimize the symptoms for
30 people with OA hip and knee is imperative.

31 Traditionally, treatment of OA involves pharmacological interventions
32 such as paracetamol/acetaminophen, nonsteroidal anti-inflammatory drugs,
33 and intra-articular steroids. Nonpharmacological interventions include exercise,
34 education, weight reduction, appliances, heat and cold therapy, transcutaneous
35 electrical nerve stimulation, pulsed electromagnetic field, and laser and galvanic
36 stimulation; joint replacement is the most common surgical intervention.

37 38 THE ROLE OF PHYSICAL ACTIVITY AND EXERCISE

AQ2

39 It is well documented that regular moderate-intensity physical activity—such as
40 walking, cycling, or participating in sports—has been shown to have significant
41

benefits for general health of populations, such as reducing the risk of cardiovascular diseases, diabetes, colon and breast cancer, and depression; decreasing the risk of a hip or vertebral fracture; and helping control weight. Indeed, global recommendations on physical activity for health for adults are participation in moderate physical activity, for example, walking, cycling, and household chores for at least 30 minutes per session, five times per week, or vigorous activity for at least 25 minutes per session, three times per week (WHO, 2010a). It can be postulated then that participation in regular physical activity may be sufficient to protect against the development of OA or relieve symptoms of OA hip and knee. However, it has been reported that only 27.8% of individuals with arthritis engage in physical activity to a level that is sufficient to experience these benefits (Hootman, Macera, Ham, Helmick, & Sniezek, 2003). The terms *physical activity* and *exercise* are often used interchangeably. Physical activity in daily life can be categorized into occupational, sports, conditioning, household, or other activities. Exercise is a subset of physical activity that is planned, structured, and repetitive and has the objective of improvement or maintenance of physical fitness or a desired therapeutic effect (Caspersen, Powell, & Christenson, 1985). Exercise has been demonstrated to be effective in a number of groups, for example, improving balance in older people (Howe, Rochester, Neil, Skelton, & Ballinger, 2011) and preventing and managing osteoporosis in postmenopausal women (Howe et al., 2011).

AQ3 International clinical guidelines such as Osteoarthritis Research Society International (OARSI) guidelines for the nonsurgical management of knee OA (McAlindon et al., 2014; Roddy et al., 2006) recommend exercise as a low-cost safe intervention with few reported adverse effects. The aim of therapeutic exercise programs is to relieve the symptoms of OA of the hip or knee including pain, joint stiffness, muscle weakness, and subsequent reduction in function. Therapeutic exercise programs for OA hip and knee frequently include land- or water-based exercise designed to improve muscle strength, range of movement in the joint, or aerobic capacity, or combinations of these. These exercise programs are typically designed and supervised by health professionals but may also be undertaken at home as part of self-management strategies.

Outcome measurement in clinical studies requires the use of valid, reliable, and responsive measurement procedures that adequately capture important aspects of the condition. In 1997, participants at the OMERACT III conference agreed ($\geq 90\%$) on a core set of four domains for outcome measurement in future Phase III clinical studies of hip, knee, and hand OA. The four domains identified were pain, physical function, patient global assessment, and, for studies of at least 1 year, joint imaging (Bellamy et al., 1997). This has been further confirmed by Paskins, Sanders, and Hassell (2014) in their systematic review comparing

1 patient experiences of the OA consultation with general practitioner (GP) atti-
 2 tudes and beliefs about OA. The authors found that pain management and fear of
 3 disability were consultation priorities for patients. Patients seem keen to explore
 4 nonpharmacological interventions, whereas GPs reported frustration and lack of
 5 knowledge about issues to do with lifestyle changes.

6 Functioning and disability, according to the International Classification of
 7 Functioning, Disability and Health (ICF) (WHO, 2010b), are viewed as a com-
 8 plex interaction between the health condition of the individual and the contex-
 9 tual factors of the environment as well as personal factors. The ICF focuses on
 10 impact, creating a foundation and a common framework allowing all conditions
 11 to be compared using a common metric—the impact on the functioning of the
 12 individual “in his or her world.”

13 Recognizing the global burden of OA of the hip and knee, this chapter
 14 summarizes the evidence from recent systematic reviews on the effectiveness of
 15 exercise programs for OA of the hip and knee on pain and function.

16 **Exercise and OA of the Hip**

17 Three systematic reviews have examined the effects of exercise on OA of the hip
 18 (Fransen, McConnell, Hernandez-Molina, & Reichenbach, 2014; Hernández-
 19 Molina, Reichenbach, Zhang, Lavalley, & Felson, 2008; Romeo, Parazza, Boschi,
 20 Nava, & Vanti, 2013).

21 A recently updated Cochrane review, search updated to Feb 2013, (Fransen
 22 et al., 2014) included 10 studies (549 participants), 7 of which were judged as
 23 having a low risk of bias. The studies included participants with mostly mild-
 24 to-moderate symptomatic hip OA, alone or with knee OA. Except for one study
 25 where participants enrolled in a tai chi program, all other participants underwent
 26 land-based exercise programs consisting of traditional muscle strengthening, func-
 27 tional training, and aerobic fitness programs, supervised either individually or as
 28 part of a group. Participants in the control groups did not exercise. Meta-analysis
 29 of high-quality evidence from nine studies (549 participants) demonstrated that
 30 exercise reduced pain (standardized mean difference [SMD] -0.38 , 95% CI -0.55
 31 to -0.20) equivalent to 8 points on a scale 0–100 (95% CI 4 to 11 points; number
 32 needed to treat for an additional beneficial outcome [NNTB] = 6). Physical func-
 33 tion also improved (SMD -0.38 , 95% CI -0.54 to -0.05) equivalent to 7 points
 34 on a 0–100 scale (95% CI 1 to 12 points; NNTB = 6). Only three small studies
 35 (183 participants) evaluated quality of life and they demonstrated no benefit from
 36 exercise for participants' quality of life (SMD -0.07 , 95% CI -0.23 to -0.36).

37 These findings are consistent with a previous high-quality meta-analysis of
 38 nine studies (1,234 participants) comparing exercise programs of durations lon-
 39 ger than 4 weeks with control (Hernández-Molina et al., 2008). Results indicate
 40
 41

beneficial effect of exercise on pain with an effect size (ES) of -0.38 (95% CI -0.68 to -0.08 ; $p = 0.01$), but there was high heterogeneity ($I^2 = 75\%$) among studies. The heterogeneity was caused by one trial consisting of an exercise intervention that was not administered in person. When the authors removed this study leaving eight studies (493 participants) with a similar exercise strategy (specialized hands-on exercise training, all of which included at least some element of muscle strengthening), exercise demonstrated a benefit on pain with an ES of -0.46 (95% CI -0.64 to -0.28 ; $p < 0.0001$).

In contrast, a descriptive review involving 10 Studies, 2 of which involved manual therapy (Romeo et al., 2013), concluded that at mid- and long-term follow-up land-based exercises showed insufficient evidence of effectiveness with respect to pain and quality of life, but positive results were found for physical function. The authors also concluded that water-based exercises significantly reduced fall risk when combined with functional exercises. They stated that programs containing progressive and gradual exposure to difficult activities, education, and exercises promoted better outcomes, higher adherence to home program, and increased amount of physical activity, especially walking.

Exercise and OA of the Knee

Eight reviews examined studies investigating the effects of exercise on OA of the knee (Devos-Comby, Cronan, & Roesch, 2006; Focht, 2006; Fransen et al., 2015; Jansen, Viechtbauer, Lenssen, Hendriks, & de Bie, 2011; Juhl, Christensen, Roos, Zhang, & Lund, 2014; Petrella, 2000; Roddy, Zhang, & Doherty, 2005; Tanaka, Ozawa, Kito, & Moriyama, 2013).

A recently updated Cochrane review (Fransen et al., 2015), search updated to May 2013, undertook meta-analysis of data immediately after completion of exercise programs, compared with controls. They defined exercise as any land-based nonoperative therapeutic exercise regimen aimed at relieving the symptoms of OA, regardless of content, duration, frequency, or intensity. High-quality evidence from 44 studies (3,537 participants) indicated that pain was reduced (SMD -0.49 , 95% CI -0.39 to -0.59), equivalent to 12 points (95% CI 10 to 15 points) on a scale of 0–100 points. Moderate-quality evidence from 44 studies (3,913 participants) showed that exercise improved physical function (SMD -0.52 , 95% CI -0.39 to -0.64), equivalent to 10 points (95% CI 8 to 13 points) on a scale of 0–100 points. Furthermore, high-quality evidence from 13 studies (1,073 participants) revealed that exercise improved quality of life (SMD 0.28 , 95% CI 0.15 to 0.40) equivalent to 4 points (95% CI 2 to 5 points) on a scale of 0–100 points.

Encouragingly, Fransen et al. (2015) reported a sustained treatment effect at 2–6 months after intervention. Evidence from 12 studies (1,468 participants)

1 indicated reduction in pain (SMD -0.24 , 95% CI -0.35 to -0.14), equivalent to
2 6 (3–9) points on a scale of 0–100 points. Ten studies (1,279 participants) indi-
3 cated sustainability of effect on physical function (SMD -0.15 , 95% CI -0.26 to
4 -0.04), equivalent to improvement of 3 (1–5) points on a scale of 0–100-points.
5 This confirmed the large significant ES (SMD -0.94 , 95% CI -1.31 to -0.57) of
6 exercise on knee pain reported by Tanaka et al. (2013) based on eight studies
7 (unclear number of participants).

8 In a review comparing exercise with control in 12 studies (808 participants),
9 Devos-Comby et al. (2006) concluded that exercise had only a small-to-moderate
10 effect on physical outcomes as assessed by self-report and direct measures with
11 ES = 0.29 (95% CI 0.23 to 0.36); a small positive effect was seen on direct mea-
12 sures of impairment in 11 studies (740 participants) with a mean ES = 0.15 (95%
13 CI 0.08 to 0.23). This is supported by the findings of two descriptive reviews
14 (Focht, 2006; Petrella, 2000). Focht (2006) reported significant differences in
15 pain between exercise and control interventions with small (0.25) to large (2.75)
16 ESs based on 18 studies (2,320 participants). Petrella (2000) found small-to-
17 moderate beneficial effects of exercise treatment for pain, small beneficial effects
18 on disability, and moderate-to-great beneficial effects were observed according to
19 patient global assessment of effect.

20 In a review of 12 studies (unknown number of participants) comparing three
21 types of exercise interventions, Jansen et al. (2011) reported that the ES on pain
22 for strength training was ES = 0.38 (95% CI 0.23 to 0.54), for exercise, it was ES
23 = 0.34 (95% CI 0.19 to 0.49), and the ES on pain for exercise plus manual mobi-
24 lization was ES = 0.69 (95% CI 0.42 to 0.96). Furthermore, each intervention also
25 improved physical function significantly. However, metaregression indicated that
26 exercise plus manual mobilizations improved pain significantly more than exer-
27 cise alone ($p = 0.03$). Subgroup analyses by Tanaka et al. (2013) showed a larger
28 effect for non-weight-bearing strengthening exercise (SMD -1.42 , 95% CI -2.09 to
29 -0.75) compared with weight-bearing strengthening exercise (SMD -0.70 , 95% CI
30 -1.05 to -0.35) and aerobic exercise (SMD -0.45 , 95% CI -0.77 to -0.13).

31 Juhl et al. (2014) examined the effects of different types of exercise pro-
32 grams on pain in 47 studies (4,028 participants). Positive effects on pain relief
33 were found for aerobic, resistance, and performance exercise (SMD 0.67, 0.62,
34 and 0.48, respectively; $p = 0.733$). Single-type exercise programs were more effi-
35 cacious than programs that included different exercise types (SMD 0.61 versus
36 0.16; $p < 0.001$). The effect of aerobic exercise on pain relief increased with an
37 increased number of supervised sessions (slope 0.022, 95% CI 0.002 to 0.043).
38 More pain reduction occurred with quadriceps-specific exercise than with gen-
39 eral lower limb exercise (SMD 0.85 versus 0.39; $p = 0.005$) and when super-
40 vised exercise was performed at least three times a week (SMD 0.68 versus 0.41;
41

$p = 0.017$). No impact of intensity, duration of individual sessions, or patient characteristics was found. Similar results were found by Roddy et al. (2005) in 13 studies. Pooled ESs for pain were 0.52 for aerobic walking and 0.39 for quadriceps strengthening, and for self-reported disability, ES was 0.46 for aerobic walking and 0.32 for quadriceps strengthening.

Exercise for OA of the Lower Limb

Ten reviews included studies involving participants with OA of either their hip or knee (Bartels et al., 2007; Brosseau et al., 2004; Daly Iversen, 2010; Pelland et al., 2004; Pisters et al., 2007; Tiffreau et al., 2007; Uthman et al., 2014; van Baar, Assendelft, Dekker, Oostendorp, & Bijlsma, 1999; Waller et al., 2014; Wallis & Taylor, 2011)

Uthman et al. (2014) in an analysis of 60 studies (44 knee, two hip, 14 mixed with 2,118 participants) reported that for pain relief, several types of exercise programs were significantly more effective than control. These included (a) strengthening, (b) flexibility plus strengthening, (c) flexibility plus strengthening plus aerobic, (d) aquatic strengthening, and (e) aquatic strengthening plus flexibility. Furthermore, a combined intervention of strengthening, flexibility, and aerobic exercise was also significantly more effective than the no-exercise control for improving limitation in function (SMD -0.63 , 95% credible interval -1.16 to -0.10).

ESs from 11 studies, 10 on the knee and 1 on the hip (van Baar et al., 1999) indicated small-to-moderate beneficial effects of exercise therapy on pain, small beneficial effects on both disability outcome measures, and moderate-to-great beneficial effects according to the patient's global assessment of effect. However, only two studies had an acceptable validity score as well as sufficient power and another two studies had an acceptable validity score, but low power.

In a best-evidence synthesis of 11 studies (5 high and 6 low quality) (Pisters et al., 2007), strong evidence was found for no long-term effectiveness on pain and self-reported physical function, moderate evidence for long-term effectiveness on patient global assessment of effectiveness, and conflicting evidence for observed physical function. For exercise programs with additional booster sessions, moderate evidence was found for long-term effectiveness on pain, self-reported physical function, and observed physical function.

This is further confirmed by descriptive reviews of 12 studies (1,363 participants) (Brosseau et al., 2004) and 18 studies (1 hip, 6 hip and knee, 11 knee) (Daly Iversen, 2010) that indicated that various forms of aerobic exercise, such as a walking program, jogging in water, yoga, and tai chi can have statistically significant effects on pain, joint tenderness, functional status, and respiratory capacity for patients with OA.

1 A review of 22 studies (2,325 participants) concluded that strengthening
2 exercises alone have some effects on improving pain and functional outcomes
3 (Pelland et al., 2004). However, in order to maximize their effectiveness, it is
4 necessary to combine them with a more complete exercise program including
5 range of motion (ROM), stretching, functional balance, and aerobic exercises.
6

7 **Individual Versus Group Exercise**

8 The effectiveness of individual or collective group exercise programs for knee
9 or hip OA was examined in 29 studies (21 knee, 1 hip, and 7 knee and hip)
10 (Tiffreau et al., 2007). The authors reported that the benefit of individual and
11 group exercise programs is low-to-moderate for pain, strength, and ability to
12 walk, and that there is no evidence of the superiority of one modality over the
13 other. However, they observed that effectiveness is not maintained over time if
14 the exercise program is not continued.
15

16 **Aquatic Versus Land-Based Exercise**

17 The effects of aquatic based exercise were examined by Waller et al. (2014).
18 They included 11 studies (6 knee and hip, 3 knee only, 1 hip only, and 1 any
19 lower limb OA in a total of 1,092 participants). Effects directly after intervention
20 revealed a small but significant effect from aquatic exercise on pain (SMD 0.26,
21 95% CI 0.11 to 0.41), stiffness (SMD 0.20, 95% CI 0.03 to 0.36), self-reported
22 and objectively measured physical functioning (SMD 0.30, 95% CI 0.18 to 0.43;
23 and SMD 0.22, 95% CI 0.07 to 0.38, respectively), physical functioning at activ-
24 ity level (SMD 0.22, 95% CI 0.01 to 0.42), ROM (SMD 0.56, 95% CI 0.14 to
25 0.99), and quality of life (SMD 0.24, 95% CI 0.04 to 0.45). Only two studies
26 examined effects at 3- and 6-month follow-up, but the effects had been lost at
27 both follow-up measurement points.

28 An earlier meta-analysis comparing aquatic with land-based exercise at
29 the end of treatment for combined knee and hip OA revealed that there was a
30 small-to-moderate effect on function (SMD 0.26, 95% CI 0.11 to 0.42) and a
31 small-to-moderate effect on quality of life (SMD 0.32, 95% CI 0.03 to 0.61). A
32 minor effect of a 3% absolute reduction (0.6 fewer points on a 0–20 scale) and
33 6.6% relative reduction from baseline was found for pain. There was no evidence
34 of effect on walking ability or stiffness immediately after the end of treatment
35 (Bartels et al., 2007). From the one trial including participants with hip OA alone,
36 which compared aquatic exercise with land-based exercise, no evidence of effect
37 on pain, function, or quality of life was observed. However, for the one study
38 including participants with knee OA, there was a large effect on pain (SMD 0.86,
39 95% CI 0.25 to 1.47; 22% relative percent improvement), immediately after the
40 treatment program but no evidence of effect on stiffness or walking ability.
41

Positive effects of exercise programs involving aquatic strengthening and aquatic strengthening plus flexibility on pain were also confirmed by Uthman et al. (2014).

Exercise Prior to Surgery

Only one review (Wallis & Taylor, 2011) has examined the effects of exercise prior to joint replacement surgery. They included 23 studies (1,461 participants) and found moderate-quality evidence that preoperative exercise interventions for knee OA reduced pain prior to knee replacement surgery (SMD 0.43, 95% CI 0.13 to 0.73). Meta-analyses provided evidence of low-to-moderate quality that exercise interventions for hip OA reduced pain (SMD 0.52, 95% CI 0.04 to 1.01) and improved activity (SMD 0.47, 95% CI 0.11 to 0.83) prior to hip replacement surgery. Meta-analyses provided low-quality evidence that exercise with education programs improved activity after hip replacement with reduced time to reach functional milestones during hospital stay, for example (SMD 0.50, 95% CI 0.10 to 0.90), for first-day walking.

Is Exercise Safe?

Adverse events attributed to exercise programs have been reported but these are typically small numbers (Fransen et al., 2014; Fransen et al., 2015; Waller et al., 2014), and were all related to increased pain and specifically in the knee or back (Fransen et al., 2015).

Considerations

There are many common deficiencies in the reports of the primary studies included in the reviews considered in this chapter, many of which are detailed in the extension to the Consolidated Standards of Reporting Trials (CONSORT) statement for randomized controlled trials of nonpharmacological interventions (Boutron et al., 2008). This includes the complexity of the intervention, difficulties of blinding, and the influence of care providers' expertise and volume of care of centers on treatment effect.

Many studies do not include sufficient detail to allow subsequent comparison of the exercise interventions. This information should include the dose of interventions such as duration, frequency, and intensity. Furthermore, many self-management strategies include exercise but also include other interventions such as pain management, weight reduction, education, and generalized physical activity. This makes it difficult to unpack any potential effects of exercise.

Other areas of consideration include level of supervision if any, type of supervisor, environment in which the intervention is delivered, adherence to the intervention, and method by which this is monitored, calculated, and reported.

1 Blinding is also a particular issue for exercise interventions but not impossible,
2 and authors should explain how they attempted to blind participants and thera-
3 pists. This is of course closely related to sham therapy, again difficult but not
4 impossible to achieve for exercise interventions. This could, for example, include AQ5
5 the use of generalized stretching programs and attention only activities.

6 The choice of appropriate, valid, and reliable outcome measures is an area
7 that should receive attention. The conclusions of a recent systematic review sug-
8 gest that further good-quality research investigating measurement properties of
9 performance (function) measures including responsiveness and interpretability
10 in people with hip and/or knee OA is needed (Dobson et al., 2012).

11 Other issues relate to the duration of surveillance. This is often inadequate;
12 typically, data ends on completion of the intervention with no follow-up or at
13 best short-term follow-up data. It has been demonstrated that initial compliance
14 with exercise programs is high because of loyalty to the therapist (Campbell et al.,
15 2001). However, reasons underpinning continued compliance is more complex,
16 involving willingness and ability to accommodate exercises within everyday life,
17 the perceived severity of symptoms, attitudes toward arthritis and comorbidity,
18 and previous experiences of OA. A necessary precondition for continued compli-
19 ance was the perception that the exercise was effective in ameliorating unpleasant
20 symptoms. A Cochrane review (Jordan, Holden, Mason, & Foster, 2010) con-
21 cluded that interventions such as supervised or individualized exercise therapy
22 and self-management techniques might enhance exercise adherence for chronic
23 musculoskeletal pain in adults.

24 Many studies of exercise lack power; the sample size should be adequate to
25 provide a high probability of detecting as significant an ES of a given magnitude
26 if such an effect actually exists. Furthermore, the severity of OA of participants
27 is frequently not quantified by the authors of studies. This could have impor-
28 tant implications on the data obtained and conclusions drawn from these studies.
29 Future studies should include this information, as this would allow future reviews
30 to undertake subgroup analysis in which the intervention effect is evaluated in a
31 defined subset of the participants by severity of symptoms. Finally, adverse event
32 reporting is often inadequate; this can mislead by introducing a bias favoring the
33 intervention. The emphasis on treatment benefit, together with lack of informa-
34 tion on harmful effects, creates difficulties for people who are trying to make
35 balanced decisions (Cochrane Adverse Effects Methods Group, 2015).

36 37 38 CONCLUSIONS

39 This chapter has summarized the findings of recent systematic reviews that have
40 examined the effectiveness of exercise on pain and function compared with
41

controls: land- versus water-based exercise, individual versus group exercise, and exercise prior to surgery for people with OA of the hip, the knee, and lower limb (hip and knee combined). Generally, most forms of exercise have been demonstrated to have significant positive effects on pain and function at the end of the exercise program, but unless participants continue the program, the sustainability of these effects in the longer term is questionable. However, exercise appears to be a safe intervention with few adverse effects reported.

There are a number of important considerations relating to the design and reporting of primary research in this area. Future studies are needed to determine the optimum dose of exercise programs (intensity, duration, and frequency) and to determine methods to optimize compliance with the aim of integrating exercise into people's lifestyle. It is important, however, that any further studies should be cognizant of the reporting guidelines of the CONSORT statement.

REFERENCES

- Bartels, E. M., Lund, H., Hagen, K. B., Dagfinrud, H., Christensen, R., & Danneskiold-Samsøe, B. (2007). Aquatic exercise for the treatment of knee and hip osteoarthritis. *Cochrane Database of Systematic Reviews*, (4), CD005523. doi:10.1002/14651858.CD005523.pub2
- Bellamy, N., Kirwan, J., Boers, M., Brooks, P., Strand, V., Tugwell, P., et al. (1997). Recommendations for a core set of outcome measures for future phase III clinical trials in knee, hip, and hand osteoarthritis. Consensus development at OMERACT III. *The Journal of Rheumatology*, 24(4), 799–802.
- Boutron, I., Moher, D., Altman, D. G., Schulz, K., Ravaud, P., & CONSORT group. (2008). Extending the CONSORT Statement to randomized trials of nonpharmacologic treatment: Explanation and elaboration. *Annals of Internal Medicine*, 148(4), 295–309.
- Brosseau, L., Pelland, L., Wells, G., Macleay, L., Lamothe, C., Michaud, G., et al. (2004). Efficacy of aerobic exercises for osteoarthritis (part II): A meta-analysis. *Physical Therapy Reviews*, 9(3), 125–145.
- Campbell, R., Evans, M., Tucker, M., Quilty, B., Dieppe, P., & Donovan, J. L. (2001). Why don't patients do their exercises? Understanding non-compliance with physiotherapy in patients with osteoarthritis of the knee. *Journal of Epidemiology Community Health*, 55(2), 132–138. doi:10.1136/jech.55.2.132
- Caspersen, C. J., Powell, K. E., & Christenson, G. M. (1985). Physical activity, exercise, and physical fitness: Definitions and distinctions for health-related research. *Public Health Reports*, 100(2), 126–131.
- Cochrane Adverse Effects Methods Group. (2015). More about us. Retrieved from <http://aemg.cochrane.org/more-about-us>
- Daly Iversen, M. (2010). Managing hip and knee osteoarthritis with exercise: What is the best prescription? *Therapeutic Advances in Musculoskeletal Disease*, 2(5), 279–290.

- 1 Devos-Comby, L., Cronan, T., & Roesch, S. (2006). Do exercise and self-management
2 interventions benefit patients with osteoarthritis of the knee? A metaanalytic
3 review. *The Journal of Rheumatology*, 33, 744–756.
- 4 Dobson, F., Hinman, R. S., Hall, M., Terwee, C. B., Roos, E. M., & Bennell, K. L. (2012). AQ6
5 Measurement properties of performance-based measures to assess physical func-
6 tion in hip and knee osteoarthritis: A systematic review. *Osteoarthritis Cartilage*,
7 20(12), 1548–1562. doi:10.1016/j.joca.2012.08.015
- 8 Focht, B. C. (2006). Effectiveness of exercise interventions in reducing pain symptoms
9 among older adults with knee osteoarthritis: A review. *Journal of Aging and Physical*
10 *Activity*, 14(2), 212–235.
- 11 Fransen, M., McConnell, S., Harmer, A., Van der Esch, M., Simic, M., & Bennell Kim,
12 L. (2015). Exercise for osteoarthritis of the knee. *Cochrane Database of Systematic*
13 *Reviews*, (1), CD004376. doi:10.1002/14651858.CD004376.pub3
- 14 Fransen, M., McConnell, S., Hernandez-Molina, G., & Reichenbach, S. (2014). Exercise
15 for osteoarthritis of the hip. *Cochrane Database of Systematic Reviews*, (4), CD007912.
16 doi:10.1002/14651858.CD007912.pub2
- 17 Hernández-Molina, G., Reichenbach, S., Zhang, B., Lavalley, M., & Felson, D. (2008).
18 Effect of therapeutic exercise for hip osteoarthritis pain: Results of a meta-analysis.
19 *Arthritis and Rheumatism*, 59(9), 1221–1228.
- 20 Hootman, J., & Helmick, C. (2006). Projections of US prevalence of arthritis and associ-
21 ated activity limitations. *Arthritis and Rheumatism*, 54, 226–229.
- 22 Hootman, J., Macera, C., Ham, S., Helmick, C., & Sniezek, J. (2003). Physical activ-
23 ity levels among the general US adult population and in adults with and without
24 arthritis. *Arthritis Rheumatism*, 49, 129–135.
- 25 Howe, T. E., Rochester, L., Neil, F., Skelton, D. A., & Ballinger, C. (2011). Exercise for
26 improving balance in older people. *Cochrane Database of Systematic Reviews*, (11),
27 CD004963. doi: 10.1002/14651858.CD004963.pub3
- 28 Howe, T. E., Shea, B., Dawson, L. J., Downie, F., Murray, A., Ross, C., et al. (2011).
29 Exercise for preventing and treating osteoporosis in postmenopausal women.
30 *Cochrane Database of Systematic Reviews*, (7), CD000333. doi: 10.1002/14651858.
31 CD000333.pub2
- 32 Iwamoto, J., Sato, Y., Takeda, T., & Matsumoto, H. (2011). Effectiveness of exercise for AQ7
33 osteoarthritis of the knee: A review of the literature. *World Journal of Orthopedics*,
34 2(5), 37–42. doi:10.5312/wjo.v2.i5.37
- 35 Jamtvedt, G., Dahm, K. T., Christie, A., Moe, R. H., Haavardsholm, E., Holm, I., & AQ8
36 Hagen, K. B. (2008). Physical therapy interventions for patients with osteoarthritis
37 of the knee: An overview of systematic reviews. *Physical Therapy*, 88(1), 123–136.
- 38 Jansen, M. J., Viechtbauer, W., Lenssen, A. F., Hendriks, E. J. M., & de Bie, R. A. (2011).
39 Strength training alone, exercise therapy alone, and exercise therapy with passive
40 manual mobilization each reduce pain and disability in people with knee osteo-
41 arthritis: A systematic review. *Journal of Physiotherapy*, 57(1), 11–20. doi: http://
dx.doi.org/10.1016/S1836-9553(11)70002-9

- Jordan, J., Holden, M A., Mason, E., & Foster, N. (2010). Interventions to improve adherence to exercise for chronic musculoskeletal pain in adults. *Cochrane Database of Systematic Reviews*, (1), CD005956. doi:10.1002/14651858.CD005956.pub2
- Juhl, C., Christensen, R., Roos, E., Zhang, W., & Lund, H. (2014). Impact of exercise type and dose on pain and disability in knee osteoarthritis: A systematic review and meta-regression analysis of randomized controlled trials. *Arthritis and Rheumatology*, 66(3), 622–636. doi:10.1002/art.38290
- March, L., Smith, E. U., Hoy, D. G., Cross, M. J., Sanchez-Riera, L., Blyth, F., et al. (2014). Burden of disability due to musculoskeletal (MSK) disorders. *Best Practice & Research. Clinical Rheumatology*, 28(3), 353–366. doi:10.1016/j.berh.2014.08.002
- McAlindon, T., Bannuru, R., Sullivan, M., Arden, N., Berenbaum, F., Bierma-Zeinstra, S., et al. (2014). OARSI guidelines for the non-surgical management of knee osteoarthritis. *Osteoarthritis and Cartilage*, 22(3), 363–388. doi:10.1016/j.joca.2014.01.003
- Murphy, L. B., Helmick, C. G., Schwartz, T. A., Renner, J. B., Tudor, G., Koch, G., et al. (2010). One in four people may develop symptomatic hip osteoarthritis in his or her lifetime. *Osteoarthritis and Cartilage*, 18(11), 1372–1379.
- Murphy, L. B., Schwartz, T. A., Helmick, C. G., Renner, J. B., Tudor, G., Koch, G., et al. (2008). Lifetime risk of symptomatic knee osteoarthritis. *Arthritis and Rheumatism*, 59, 1207–1213.
- Paskins, Z., Sanders, T., & Hassell, A. (2014). Comparison of patient experiences of the osteoarthritis consultation with GP attitudes and beliefs to OA: A narrative review. *BMC Family Practice*, 15, 46.
- Pelland, L., Brosseau, L., Wells, G., MacLeay, L., Lambert, J., Lamothe, C., et al. Tugwell, P. (2004). Efficacy of strengthening exercises for osteoarthritis (part 1): A meta-analysis. *Physical Therapy Reviews*, 9(2), 77–108.
- Petrella, R. J. (2000). Is exercise effective treatment for osteoarthritis of the knee? *British Journal of Sports Medicine*, 34(5), 326–331. doi:10.1136/bjism.34.5.326
- Pisters, M. F., Veenhof, C., Meeteren, N. L., Ostelo, R. W., Bakker, D. H., Schellevis, F. G., & Dekker, J. (2007). Long-term effectiveness of exercise therapy in patients with osteoarthritis of the hip or knee: A systematic review. *Arthritis and Rheumatism*, 57(7), 1245–1253.
- Roddy, E., Zhang, W., & Doherty, M. (2005). Aerobic walking or strengthening exercise for osteoarthritis of the knee: A systematic review. *Annals of the Rheumatic Diseases*, 64(4), 544–548.
- Roddy, E., Zhang, W., Doherty, M., Arden, N. K., Barlow, J., Birrell, F., et al. (2006). Evidence-based clinical guidelines: A new system to better determine true strength of recommendation. *Journal of Evaluation in Clinical Practice*, 12(3), 347–352.
- Romeo, A., Parazza, S., Boschi, M., Nava, T., & Vanti, C. (2013). Manual therapy and therapeutic exercise in the treatment of osteoarthritis of the hip: A systematic review. *Reumatismo*, 65(2), 63–74. doi:10.4081/reumatismo.2013.63

- 1 Tanaka, R., Ozawa, J., Kito, N., & Moriyama, H. (2013). Efficacy of strengthening or aer-
2 obic exercise on pain relief in people with knee osteoarthritis: A systematic review
3 and meta-analysis of randomized controlled trials. *Clinical Rehabilitation*, 27(12),
4 1059–1071.
- 5 Tiffreau, V., Mulleman, D., Coudeyre, E., Lefevre-Colau, M. M., Revel, M., & Rannou,
6 F. (2007). The value of individual or collective group exercise programs for knee
7 or hip osteoarthritis: Elaboration of French clinical practice guidelines. *Annales de*
8 *Readaptation et de Medecine Physique*, 50(9), 741–746.
- 9 Uthman, O. A., van der Windt, D. A., Jordan, J. L., Dziedzic, K. S., Healey, E. L., Peat,
10 G. M., & Foster, N. E. (2014). Exercise for lower limb osteoarthritis: Systematic
11 review incorporating trial sequential analysis and network meta-analysis. *British*
12 *Journal of Sports Medicine*, 48(21), 1579.
- 13 van Baar, M., Assendelft, W., Dekker, J., Oostendorp, R., & Bijlsma, J. (1999). Effectiveness
14 of exercise therapy in patients with osteoarthritis of the hip or knee: A systematic
15 review of randomized clinical trials. *Arthritis and Rheumatism*, 42(7), 1361–1369.
- 16 Waller, B., Ogonowska-Slodownik, A., Vitor, M., Lambeck, J., Daly, D., Kujala, U. M.,
17 & Heinonen, A. (2014). Effect of therapeutic aquatic exercise on symptoms and
18 function associated with lower limb osteoarthritis: A systematic review with meta-
19 analysis. *Physical Therapy*, 94(10), 1383–1395. doi:10.2522/ptj.20130417
- 20 Wallis, J. A., & Taylor, N. F. (2011). Pre-operative interventions (non-surgical and
21 non-pharmacological) for patients with hip or knee osteoarthritis awaiting joint
22 replacement surgery--a systematic review and meta-analysis. *Osteoarthritis and*
23 *Cartilage / OARS, Osteoarthritis Research Society*, 19(12), 1381–1395. doi:10.1016/j.
24 joca.2011.09.001
- 25 Walsh, N. E., Mitchell, H. L., Reeves, B. C., & Hurley, M. V. (2006). Integrated exercise AQ9
26 and self-management programmes in osteoarthritis of the hip and knee: A system-
27 atic review of effectiveness. *Physical Therapy Reviews*, 11(4), 289–297.
- 28 WHO. (2010a). *Global recommendations on physical activity for health*. Retrieved from AQ10
29 http://apps.who.int/iris/bitstream/10665/44399/1/9789241599979_eng.pdf
- 30 WHO. (2010b). *International classification of functioning, disability and health (ICF)*.
31 Retrieved from <http://www.who.int/classifications/icf/en/>
32
33
34
35
36
37
38
39
40
41

QUERIES:

- AQ1: Please clarify if OMERACT needs spelling out at first instance. Also, please check if the edits in the subsequent sentence are OK.
- AQ2: Please check whether the headings and subheadings are identified correctly.
- AQ3: Please confirm expansion of OARSI.
- AQ4: Please confirm expansion of SMD.
- AQ5: The phrase “attention only activities” is not clear and may need rewording.
- AQ6: The doi number has been changed to match the details from <http://www.ncbi.nlm.nih.gov/pubmed/22944525>; is this okay?
- AQ7: Please cite the Iwamoto et al. 2011 reference in the text or delete it from the reference list.
- AQ8: Please cite the Jamtvedt et al. 2008 reference in the text or delete it from the reference list.
- AQ9: Please cite the Walsh et al. 2006 reference in the text or delete it from the reference list.
- AQ10: Please confirm that the URL inserted for the WHO 2010a reference is correct.