DR. MELANIE HOLDEN (Orcid ID : 0000-0003-0374-2862)

DR. NATALIE J. COLLINS (Orcid ID : 0000-0001-9950-0192)

MR. JESPER BIE LARSEN (Orcid ID : 0000-0003-3077-7913)

DR. HIRAL MASTER (Orcid ID : 0000-0003-0019-3087)

MR. SØREN T THORGAARD SKOU (Orcid ID : 0000-0003-4336-7059)

DR. LOUISE M. THOMA (Orcid ID : 0000-0002-3077-0423)

DR. DANIEL KENTA WHITE (Orcid ID : 0000-0003-3792-4621)

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Title: Guidance for implementing best practice therapeutic exercise for people with knee and hip osteoarthritis: what does the current evidence base tell us?

Authors:

Melanie A Holden (PhD, BSc)

Kate Button (PhD, MSc, BSc)

Natalie J Collins (PhD, M.Sports Physio, BPhty(Hons))

Yves Henrotin (PhD, MT, PT)

Rana S Hinman (PhD, BPhysio (Hons))

Jesper B Larsen (MSc, PT)

Ben Metcalf

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Hiral Master (PhD, MPH, PT)

Søren T Skou (PhD, MSc, PT)

Louise M Thoma (DPT, PhD)

Elizabeth Wellsandt (DPT, PhD)

Daniel K White (ScD, Msc, PT)

Kim Bennell (PhD, BAppSci (physio))

Affiliations

1. Holden: Primary Care Centre Versus Arthritis, School of Primary, Community and Social Care, David Weatherall Building, Keele University, Staffordshire, ST5 5BG
2. Button: School of Healthcare Sciences, College of Biomedical and Life Sciences, Cardiff University
3. Collins: Division of Physiotherapy, School of Health and Rehabilitation Sciences, The University of Queensland, Australia
4. Henrotin: Department of Physical Therapy and Rehabilitation, Princess Paola Hospital, Belgium; Bone and Cartilage Research Unit, Institute of Pathology, University of Liège, Belgium; Center for Interdisciplinary Research on Medicines (CIRM), Institute of Pharmacy, University of Liège, Belgium.
5. Hinman: Centre for Health, Exercise & Sports Medicine, Department of Physiotherapy, University of Melbourne, Australia
6. Larsen: Translational Pain Biomarker & Sport Sciences – Performance and Technology, Department of Health Science and Technology, Aalborg University, Denmark
7. Metcalf: Centre for Health, Exercise & Sports Medicine, Department of Physiotherapy, University of Melbourne, Australia
8. Master: Department of Orthopedic Surgery and Rehab, Vanderbilt University Medical Center, Nashville, TN; Department of Physical Therapy, College of Health Sciences, University of Delaware, Newark, DE
9. Skou: Research Unit for Musculoskeletal Function and Physiotherapy, Department of Sports Science and Clinical Biomechanics, University of Southern Denmark, Denmark and Department of Physiotherapy and Occupational Therapy, Næstved-Slagelse-Ringsted Hospitals, Denmark

10. Thoma: Division of Physical Therapy, University of North Carolina at Chapel Hill, Chapel Hill, NC, USA
11. Wellsandt: Division of Physical Therapy Education, College of Allied Health Professions, University of Nebraska Medical Center, Omaha, NE, USA
12. White: Department of Physical Therapy, College of Health Sciences, University of Delaware, Newark, DE
13. Bennell: Centre for Health, Exercise & Sports Medicine, Department of Physiotherapy, University of Melbourne, Australia

Corresponding author: Melanie A Holden

Email: m.holden@keele.ac.uk

Address: Primary Care Centre Versus Arthritis, School of Primary, Community and Social Care, David Weatherall Building, Keele University, Staffordshire, ST5 5BG

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Conflict of interest

STS is associate editor of the Journal of Orthopaedic & Sports Physical Therapy, has received grants from The Lundbeck Foundation, personal fees from Munksgaard, all of which are outside the submitted work. He is co-founder of Good Life with Osteoarthritis in Denmark (GLA:D®), a not-for profit initiative hosted at University of Southern Denmark aimed at implementing clinical guidelines for osteoarthritis in clinical practice.

Abstract

Objective: Therapeutic exercise is a recommended first-line treatment for people with knee and hip osteoarthritis. However, there is little specific advice or practical resources to guide clinicians in its implementation. As the first in a series of projects by the Osteoarthritis Research Society International Rehabilitation Discussion Group to address this gap, we aim to synthesize current literature informing the implementation of therapeutic exercise for people with knee and hip osteoarthritis.

Methods: Narrative review focusing on evidence from systematic reviews and randomized controlled trials.

Results: Therapeutic exercise is safe for people with knee and hip osteoarthritis. Numerous types of therapeutic exercise (including aerobic, strengthening, neuromuscular, mind-body exercise) may be utilised at varying doses and in different settings to improve pain and function. Benefits from therapeutic exercise appear greater when dosage recommendations from general exercise guidelines for healthy adults are met. However, interim therapeutic exercise goals may also be useful, given that many barriers to achieving these dosages exist among this patient group. Theoretically-informed strategies to improve adherence to therapeutic exercise, such as patient education, goal setting, monitoring and feedback, may help maintain participation and optimise clinical benefits over the longer-term. Sedentary behaviour is also a risk factor for disability and lower quality of life in people with knee and hip osteoarthritis, although limited evidence exists regarding how best to reduce this behaviour.

Conclusion: Current evidence can be used to inform how to implement best practice therapeutic exercise, at a sufficient and appropriate dose, for people with knee and hip osteoarthritis.

Significance and Innovations.

1. Therapeutic exercise is safe for people with knee and hip osteoarthritis, and contrary to the common lay belief, does not lead to further joint damage.
2. Numerous types of therapeutic exercise (including aerobic, strength, neuromuscular and mind-body exercise) can be performed at varying dosages and in different settings, to improve pain and function in people with knee and hip osteoarthritis.

3. Benefits from therapeutic exercise appear greater when dosage recommendations from general exercise guidelines for healthy adults are met.
4. Sedentary behaviour is a risk factor for disability and lower quality of life in people with knee and hip osteoarthritis, although limited evidence exists regarding how best to reduce this behaviour.

Introduction

Osteoarthritis (OA), particularly of the knee and hip, is a common painful condition that imposes a substantial burden on individuals, healthcare systems and society [1]. Clinical guidelines recommend therapeutic exercise for the management of OA [e.g.1] irrespective of patient age, radiographic disease severity, pain intensity, functional levels and co-morbidities (Appendix 1). The World Health Organisation defines physical activity as any bodily movement produced by skeletal muscles that requires energy expenditure [2]. Exercise is a subcategory of physical activity that is planned, structured and repetitive, and can be referred to as therapeutic exercise when designed and prescribed by clinicians to achieve specific therapeutic goals. Therapeutic exercise provides multiple health benefits to people with knee and hip OA including effects on pain, functional disability, quality of life, and emotional well-being [e.g.3,4]. It can delay the need for joint replacement surgery [5], as well as having more general health benefits, including reducing the risk of comorbidities such as ischemic heart disease, diabetes and stroke [6], and contributing to weight maintenance and weight loss [7]. There is also some evidence that therapeutic exercise programs are cost-effective [e.g.8]. However, the description of therapeutic exercise programs within most clinical trials has insufficient detail to allow replication in clinical practice [9] and there is little specific advice or practical resources provided within clinical guidelines about how to implement best practice therapeutic exercise effectively [10]. As the first in a series of projects designed to address this gap by the Osteoarthritis Research Society International (OARSI) Rehabilitation Discussion Group, we aimed to synthesize current literature (focusing on systematic reviews and randomised controlled trials) relating to therapeutic exercise for patients with knee and hip OA.

What type of therapeutic exercise should be undertaken by people with knee and hip OA?

Systematic reviews suggest benefits can be gained from many types of therapeutic exercise including, but not limited to, aerobic exercise, strength training, neuromuscular exercise, and mind-body exercise such as Tai Chi and yoga [e.g.3,4]. Randomised controlled trials (RCTs) of aerobic exercise for people with knee and hip OA (aimed at improving cardiorespiratory fitness [11]) largely focus on walking, but also include cycling (e.g. stationary bike) [3,4]. Walking is often an ideal choice of therapeutic exercise, given its accessibility and the variety of surfaces (treadmill, indoors, outdoors), structures (independent versus supervised group programs), and types of walking available (e.g. Nordic walking). Strength training is recommended to combat age-related sarcopenia and muscle weakness commonly associated with knee and hip OA [11]. Strength training commonly targets the major lower limb muscle groups appropriate for the affected joint, according to individual impairments (e.g. hip flexors, extensors, abductors, adductors and rotators; knee flexors and extensors) [3,4]. Based on the individual's ability and access to equipment, resistance can be applied using body weight, resistance bands, free weights and weight machines, as similar benefits for pain and function occur with different forms of strength training [12]. Neuromuscular exercise can be used to improve sensorimotor control, proprioception, balance and functional movement [11]. There is strong evidence for the role of balance exercise in reducing falls in older adults [13], making its inclusion in a therapeutic exercise program logical when an increased falls risk is identified. Mind-body exercises such as

Tai Chi and yoga are gaining popularity and have been recommended for some patients in recent OA clinical guidelines [e.g.14], although the evidence is still relatively limited, particularly for yoga [15].

The magnitudes of benefits for pain and function from therapeutic exercise are generally small to moderate, which are similar or better than those of commonly used pain-relieving drugs [14]. However, few studies have directly compared the effects of different types of therapeutic exercise. While there is indirect evidence suggesting that the benefits may vary according to type and combination of exercise, there is a lack of agreement as to which type or combination is most beneficial. A network meta-analysis by Uthman et al [3] concluded that a combined approach to increase strength, flexibility and aerobic capacity was most likely to be effective for lower limb OA, whereas a meta-regression analysis by Juhl et al [4] concluded that single-type exercise programmes (either aerobic, resistance or performance exercise) were more effective than programmes that included different types of exercise. Both land- and water-based therapeutic exercise programs give comparable positive results for pain and function [16]. Water-based exercise (or hydrotherapy) has the additional benefit of buoyancy and decreased joint impact, and may be preferable for some, such as those with more advanced disease or when land-based exercise is too painful [14].

What dosage should be used?

Currently there is limited evidence regarding the optimal dosage, including intensity, of therapeutic exercise needed for clinical benefits in people with knee and hip OA. While it appears that benefits can be derived from both lower and higher intensity therapeutic exercise [17], there does seem to be some suggestion that benefits may be larger when sufficient and appropriate doses of are undertaken. A meta-analysis by Moseng et al [18] showed that land-based supervised therapeutic exercise in patients with hip OA significantly reduced pain only when exercise doses met the American College of Sports Medicine (ACSM) general exercise recommendations for healthy adults for cardiorespiratory fitness, muscular strength, and flexibility (shown in Appendix 2) [11]. In knee OA, a meta-analysis showed that exercise interventions following the ACSM criteria for strength training (performed with an external load above 40% of 1 repetition maximum, in 2–4 sets of 8–12 repetitions, on at least 2-3 sessions per week [11,19]) provided superior outcomes in knee extensor strength, but not in pain or disability [19]. Whilst dosages recommended in general exercise guidelines for healthy adults therefore appear appropriate for people with knee and hip OA [10], interim therapeutic exercise goals may also be useful, given that many barriers to achieving these dosages can exist among this patient group. For example, an interim target for aerobic exercise could be to obtain at least 45 minutes/week of moderate-vigorous exercise, as this dosage has been associated with maintaining or improving to a high level of physical function in individuals with knee OA [20]. While walking 10,000 steps per/ day is commonly cited as a general fitness-related step goal [21], walking 6,000 steps/day has been found to be a preliminary step goal that protects against the development of functional limitation in knee OA [22], and could therefore be an additional useful interim target in people with knee and hip OA.

How should a therapeutic exercise program be progressed or modified?

General exercise guidelines for healthy adults recommend that to achieve and maintain a sufficient dose, exercise frequency, duration and intensity should be progressed gradually over time, beginning first with duration, followed by frequency, and lastly intensity [23]. Within RCTs of therapeutic exercise for people with knee and hip OA, information about how exercise programs are tailored and progressed is often lacking, making replication within clinical practice difficult [9]. Strengthening exercise can be progressed via serial testing of maximal muscle strength to progress the resistance applied (e.g. % of true or estimated 1 repetition-maximum) [11]. An alternate approach for progression is to select the resistance that makes the last repetition in a set difficult to complete (e.g. 8 out of 10 difficulty, where 0=no effort and 10=hardest effort you can give) [11]. Similarly, aerobic exercise can be progressed to achieve target heart rates (based on individual capacity) measured during exercise bouts [11]. An alternate approach is the use of subjective reports of perceived exertion such as the Borg Rating of Perceived Exertion Scale [24]. Wearable devices such as accelerometers and pedometers or daily exercise logs may also be used to monitor and advance therapeutic exercise programs [25].

Some people with knee and hip OA report discomfort or pain during exercise, but the size of acute activity-induced pain flares has been found to decrease with an increasing number of therapeutic exercise sessions [26]. However, the role of pain in informing decisions about dosage and progression of therapeutic exercise for people with knee and hip OA remains unclear. A systematic review including data from 7 RCTs and 385 participants with chronic musculoskeletal conditions found that exercising into pain resulted in a small but significantly greater benefit for pain reduction in the short term than pain free exercise. However, in the medium and long term there was no clear superiority of one treatment over another [27]. In reality, modification of the therapeutic exercise program may be necessary if pain levels are unacceptable to the patient, which could include changes to the type, intensity, duration or frequency of the program.

Both self-reported and performance-based outcome measures have been used to assess the effects of therapeutic exercise programs in people with knee and hip OA, and these outcomes may inform progression or modification of therapeutic exercise programs. The timeframe for re-assessment varies, but generally studies have used intervals of 8 to 12 weeks [3,4], often corresponding to the length of the intervention program. Similar time frames may therefore be useful re-assessment points within clinical practice. A number of organisations have developed recommendations around core domains of measurement for people with OA. The International Consortium for Health Outcomes Measurement (ICHOM) defines a minimum "standard set" of outcome measures for hip and knee OA [28], with a focus on those outcomes that matter most to patients including pain, physical functioning and health-related quality of life. Physical performance measures have also been used to determine if the objectives of the therapeutic exercise program are being achieved, such as increases in muscle strength, joint mobility or other functional improvements. The Osteoarthritis Research Society International recommended a core set of physical performance measures for use in people with hip and knee OA [29]. This comprises the 30-second chair stand test, 40 meter fast-paced walk test and a stair climb test, with additional tests including the timed up and go (TUG) and the 6-minute walk test.

How can therapeutic exercise programs be delivered?

A variety of delivery modes can be utilised for therapeutic exercise programs including individual (one-on-one), class-based (group), home-based, or a combination. Systematic reviews have demonstrated similar benefits in terms of pain and function across different delivery modes [14].

Group programs supervised by health professionals have the advantages of incorporating social interaction, which may facilitate exercise adherence, and of lower cost delivery than individualised care.

Supervision, particularly in the initial stages of a class-based or home-based therapeutic exercise program, can help promote safe and correct exercise technique, and ensure the exercise dosage is appropriate for the patient's physical ability and program goals. In a systematic review, Juhl et al [4] found a significant relationship between the number of supervised sessions and the pain-relieving benefits of aerobic (but not resistance) exercise for people with knee OA. Supervision may also be provided remotely using e-health technologies such as telehealth, mobile health (m-health), and movement sensors (e.g. wearable technology) [30]. Qualitative research investigating patients' and clinicians' perceptions and experiences with remotely-delivered interventions reports themes such as convenience, flexibility, and empowerment to self-manage, demonstrating that this delivery method is becoming more feasible and acceptable [31]. Remote delivery may also allow for greater opportunity for people to engage with exercise practitioners, especially in regional and remote areas.

How can therapeutic exercise programs be individualised?

Clinical outcomes from therapeutic programs vary between patients, and it is now recognised that programs should be individualized rather than using a one-size-fits-all approach [10,32]. Although evidence to support individualization is scarce, there is current interest in examining whether certain patient characteristics moderate outcomes from exercise, and whether exercise that is targeted to patients in specific phenotypes or subgroups optimizes clinical effects. There is some evidence that the presence of greater muscle strength and more neutral knee joint alignment is associated with greater improvements following exercise focussed on knee stabilization training and quadriceps strengthening, respectively [33]. The presence of cardiac problems may also moderate the effects of exercise in people with knee OA, but this needs further testing [33]. A number of clinical and pain OA phenotypes have been identified, including patient and disease characteristics (e.g. pain sensitization, radiographic severity [34]), which may help in the individualization of future therapeutic exercise programs.

Given that research into targeted therapeutic exercise approaches is in its infancy, a biopsychosocial assessment incorporating the patient's values, needs, and preferences can facilitate individualization of therapeutic exercise programs [1,32]. This could include utilisation of the type of therapeutic exercise that the patient is most likely to initiate and maintain, and selection of strategies to increase adherence depending on the patient's specific barriers and facilitators (see later section). In line with clinical guidelines [32] comorbidities could also be considered, given that approximately two out of three patients with knee and hip OA have at least one other chronic condition, and that more comorbidities are associated with greater pain intensity, more painful body sites, and worse function and quality-of-life [35]. Exercise is effective in treating many chronic conditions [6]. Therefore, individualizing the therapeutic exercise program according to the patient's comorbidities may not only improve OA-related symptoms, but also symptoms of other chronic conditions and their overall health.

Is therapeutic exercise safe for people with knee and hip OA?

Therapeutic exercise is safe for people with knee and hip OA, including those with advanced disease [36-38]. A systematic review found that at the group level there was no evidence of serious adverse events, increases in pain, decreases in physical function, progression of structural OA on imaging or increased risk of total knee replacement with low impact therapeutic exercise of varying intensities [36]. Another systematic review found that low to moderate intensity therapeutic exercise was not harmful for articular cartilage in people with knee OA [37]. Even in people with end-stage knee OA, walking can be performed safely, without exacerbating pain [38]. Less research has focused on the safety of exercise in individuals with hip OA, but few minor events are reported from land-based exercise [36] . While there has been debate about whether higher impact activity, such as running, is safe for those with pre-existing OA, a large cohort study showed that self-selected running was associated with improved knee pain without worsening of structural disease progression over 48 months in people aged over 50 years with knee OA [39].

Should sedentary behaviour be targeted?

The current focus has been on promoting therapeutic exercise among people with knee and hip OA, with little attention paid to reducing sedentary behavior (such as prolonged sitting). Recent observational studies suggest that independent of time spent in general physical activity, prolonged time in sedentary behavior is associated with increased risk of functional limitation, disability and lower quality-of-life [e.g.40] in adults with knee OA. In addition, White et al. [22] found that replacing 60 minutes of sedentary activity with 60 minutes of light intensity physical activity was associated with a reduced risk of developing slow gait speed.

At present, the effect of therapeutic exercise programs in reducing sedentary behavior among people with OA is unclear given a lack of robust research. Among general older adults, a meta-analysis found that interventions that specifically targeted reduced sitting time (such as sit-stand desks) were more effective in decreasing sedentary behaviour than physical activity interventions alone [41]. Clearly, further research is needed in this area to address sedentary behaviour in people with knee and hip OA, including for example whether interventions such as sit-stand desks are acceptable, tolerated and effective among people with joint pain.

What are the barriers and facilitators to people with knee and hip OA initiating and adhering to therapeutic exercise?

The clinical benefits following a therapeutic exercise program decline over time [3,4], most likely due to lack of adherence. Maintaining a therapeutic exercise program over the long-term can be challenging. Engagement in therapeutic exercise among people with knee and hip OA is influenced by a complex interplay between physical, personal (including psychological), and social-environmental factors [42,43]. A systematic review of qualitative evidence in knee and hip OA found that facilitators for therapeutic exercise included: aiming at symptom relief and mobility; positive exercise experiences and beliefs; knowledge; a 'keep going' attitude; adjusting and prioritising therapeutic exercise; and having healthcare professionals' and social support. Barriers to therapeutic exercise included: pain and physical limitations; non-positive therapeutic exercise experiences, beliefs and information; OA-related distress; a resigned attitude; and lack of motivation, behavioural regulation, professional support and negative social comparison with co-exercisers [42]. A scoping review mapped the barriers and facilitators to therapeutic exercise to the Theoretical Domains Framework (based on behaviour change theory), as shown in Table 1[43]. The greatest number of unique barriers and facilitators mapped to the environmental context and resources domain (e.g. cost, accessibility, weather, equipment). Additionally, many barriers were related to beliefs about the consequences of therapeutic exercise [43]. This is supported by a recent qualitative study which found that once people had been "diagnosed" with "bone-on-bone" changes, many disregarded therapeutic exercise programs as they erroneously believed these would further damage their joints [44]. These barriers and facilitators are important to consider when implementing strategies to increase adherence to therapeutic exercise for people with knee and hip OA, discussed below.

What strategies and behaviour change techniques can be used to increase patient adherence to therapeutic exercise?

Various strategies to improve adherence to therapeutic exercise have been explored among people with knee and hip OA, but inconsistent results are often reported [45]. This may partially be due to a lack of standardised or robust measure of exercise adherence [45].

Patient education is recommended as a core treatment for people with knee and hip OA [1] and has been found to be an effective strategy to increase uptake of, and adherence to, therapeutic exercise [45]. For example, education about the benefits of therapeutic exercise for OA, including its low risk of harmful effects, could be used to address false beliefs about the consequences of exercising with OA [43], pain could be explained as a modifiable symptom, and treatment focus could be shifted away from a 'structural damage' model towards a 'person-centred' approach that targets modifiable biopsychosocial factors influencing pain and disability (see Appendix 3).

A strong therapeutic alliance with the clinician during treatment can facilitate adherence to therapeutic exercise in people with OA, and can improve pain outcomes in people with chronic musculoskeletal pain [46]. Characteristics of the therapeutic alliance that are predictive of exercise adherence include agreement on goals and tasks, clear communication, a sense of connectedness, positive feedback, genuine interest, individualized care plans, trust in the clinician and feeling empowered [47].

Behaviour change theory can inform strategies to maximise exercise adherence. Five particular behaviour change techniques can increase adherence to therapeutic exercise in people with persistent musculoskeletal pain [48]. These include goal setting, social support, instruction of behaviour, demonstration of behaviour and practice/rehearsal. Feedback and monitoring interventions can also positively impact exercise adherence in older adults [45]. Adults with OA believe that ongoing follow-up and review of progress, including supervision and correction of exercise technique, and longer-term follow-up (>3 months after exercise commencement) for monitoring and progression of the exercise program is important for adherence [49]. This belief is supported by evidence that "booster sessions" increase adherence to therapeutic exercise in people with OA [45].

Technology-enhanced strategies including mobile applications, wearable activity monitors, and text messaging/ email prompts have been shown to promote exercise adherence among adults with musculoskeletal problems, and promote positive physical activity behaviours in healthy adults. Meta-analyses suggest that these digital interventions increase total physical activity, moderate to vigorous activity, daily step count, and energy expenditure [e.g.50]. There is also evidence that web-based exercise programming systems can improve adherence to home exercises prescribed by a clinician for adults with musculoskeletal problems, and when delivered in conjunction with remote support achieve better adherence than paper exercise handouts [e.g.51]. Preliminary research suggests that these types of technology-enhanced adherence-enhancing strategies would be feasible to use among patients with knee and hip OA [e.g.52].

As pain is a commonly cited barrier to therapeutic exercise among people with knee and hip OA, it could be argued that pharmacological pain treatments should be delivered alongside therapeutic exercise. However, there is conflicting evidence whether pain and function outcomes are improved when therapeutic exercise is combined with pharmacological pain treatments [e.g.53]. Further research in this area is therefore required.

Summary and future directions

Therapeutic exercise is beneficial and safe for people with knee and hip OA, with no evidence of progression of structural OA, harm to articular cartilage, or increased risk of total knee replacement with therapeutic exercise of varying intensities. A range of therapeutic exercise types performed at higher and lower intensities and in different settings can improve pain and function in people with knee and hip OA. Existing general exercise guidelines provide dosage recommendations for healthy individuals, and these are applicable for people with knee and hip OA. However, interim goals may also be useful, given that barriers to achieving these dosages exist in this patient population. A biopsychosocial approach can be used to individualise the therapeutic exercise program, aiming to achieve a sufficient dose to optimise outcomes. Theoretically-informed strategies to improve adherence to therapeutic exercise may help maintain benefits over the longer-term. Although limited evidence currently exists, it may be prudent to also specifically address sedentary behaviour within clinical practice.

Whilst this review has identified a plethora of RCTs, systematic reviews and clinical guidelines that support the role of therapeutic exercise in the management of people with knee and hip OA, it has also highlighted the lack of detail and clear direction about how to implement best practice therapeutic exercise in clinical practice. This limits the strength and specificity of any recommendations for clinical practice [9]. Therapeutic exercise is a complex, multi-faceted intervention. As reporting of therapeutic exercise in most RCTs lacks detail (about its dose, how it was individualised and progressed, where and by whom it was delivered, and what training was completed to undertake therapeutic exercise delivery) the ability to replicate exercise interventions is limited. This may result in suboptimal delivery of therapeutic exercise within clinical practice [54], reducing the potential benefit of exercise for patients. To better support implementation of therapeutic exercise, researchers should fully report and describe therapeutic exercise programs tested within RCTs in accordance with best practice guidance and recommendations [55]. We will use the findings from this narrative review to inform the development of position statements and practical resources to support clinicians to implement best practice therapeutic exercise for people with knee and hip OA. Other areas for potential future research identified within this review include exploration of: the optimal dose of therapeutic exercise, including the role of pain in exercise progression; potential moderators of the effect of exercise; how to best measure and improve adherence to exercise; and the effectiveness of interventions targeting both sedentary behaviour, and pharmacological pain treatments combined with therapeutic exercise among people with knee and hip OA.

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Table 1: Barriers and facilitators to therapeutic exercise for knee and hip OA mapped to the Theoretical Domains Framework) [43]

Domain	Example Barrier	Example Facilitator
1. Knowledge	Lack of disease knowledge/education	Having undertaken OA education class
2. Skills		Higher level of physical fitness
3.Social/ Professional Identity	Self-perception of being 'inactive'	Feeling of contributing to the study which will benefit others long-term
4. Beliefs about Capabilities	Beliefs about limitations due to disability	Low level of self-reported physical limitations
5. Optimism	Fatalism regarding knee OA	Positive exercise attitude
6. Beliefs about consequences	Beliefs about disease	Perceived benefits of exercising
7. Reinforcement	Lack of improvement with exercises	Previous positive personal experience of exercise
8. Intentions	Lack of motivation	Loyalty to physical therapist
9. Goals	Short-term goal setting only	Long-term and short-term goals
10. Memory, attention and decision processes	Forgetfulness	Good quality sleep
11. Environmental context and resources	Use of a walking aid	Online programme
12 Social influences	Family commitments	Low social strain
13 Emotion	Anxiety	Improved depression with exercise
14 Behavioural regulation		Doing exercise at own pace in own time

Appendix 1: Summary of therapeutic exercise recommendations from recent OA clinical guidelines

Guidelines	**Year**	**Recommendations**
American College of Rheumatology/Arthritis Foundation Guideline for the Management of OA of the Hand, Hip, and Knee† [1]	2020	Exercise is strongly recommended. Tai Chi is strongly recommended for knee and hip OA. Balance exercises are conditionally recommended for knee and hip OA. Yoga is conditionally recommended for knee OA.
Osteoarthritis Research Society International guidelines for non-surgical management of knee, hip, and polyarticular OA† [2]	2019	Structured land-based exercise programs (Type 1 – strengthening and/or cardio and/or balance training/neuromuscular exercise OR Type 2 – Mind-body exercise including Tai Chi or yoga) strongly recommended for all patients with knee and hip OA. Aquatic exercise conditionally recommended for some patients but not for those with frailty due to potential risk of accidental injury.
European League Against Rheumatism recommendations for physical activity in people with inflammatory arthritis and OA [3]	2018	Promoting PA consistent with general PA recommendations should be an integral part of standard care throughout the course of disease All healthcare providers involved in the management of people with knee and hip OA should take responsibility for promoting PA and should cooperate, including making necessary referrals, to ensure that people receive appropriate PA-interventions. PA interventions should be delivered by healthcare providers competent in their delivery to people with OA. Healthcare providers should evaluate the type, intensity, frequency and duration of the people's actual PA by means of standardized methods to identify which of the four domains of general PA

		recommendations can be targeted for improvement (cardiorespiratory fitness, muscle strength, flexibility and neuromotor performance). General and disease-specific contraindications for PA should be identified and taken into account in the promotion of PA. PA interventions should have clear personalised aims, which should be evaluated over time, preferably by use of a combination of subjective and objective measures (including self-monitoring when appropriate). General and disease-specific barriers and facilitators related to performing PA, including knowledge, social support, symptom control and self-regulation should be identified and addressed. Where individual adaptations to general PA recommendations are needed, these should be based on a comprehensive assessment of physical, social and psychological factors including fatigue, pain, depression and disease activity. Healthcare providers should plan and deliver PA interventions that include the behavioural change techniques self-monitoring, goal setting, action planning, feedback and problem solving. Healthcare providers should consider different modes of delivery of PA (eg, supervised/not-supervised, individual/group, face-to-face/online, booster strategies) in line with people's preferences.
Royal Australian College of General Practitioners† [4]	2018	Land-based exercise is strongly recommended for both knee and hip OA. Muscle strengthening exercises, walking and Tai Chi is strongly recommended for knee OA. Stationary cycling and Hatha yoga are conditionally

		recommended for knee OA. The best land-based exercise for people with hip OA could not be determined because of limited research. Aquatic exercise is conditionally recommended for knee and hip OA.
National Institute for Health and Care Excellence. Osteoarthritis. Care and management in adults. Clinical guideline [5]	2014	Activity and exercise including local muscle strengthening and general aerobic fitness is recommended as a core treatment for all patients with OA.
European League Against Rheumatism recommendations for the non-pharmacological core management of hip and knee OA [6]	2013	All people with knee/hip OA should receive an individualised management plan (a package of care) that includes the core non-pharmacological approaches, specifically: addressing a regular individualised exercise regimen. The mode of delivery of exercise education (eg, individual 1:1 sessions, group classes, etc) and use of pools or other facilities should be selected according both to the preference of the person with hip or knee OA and local availability. Important principles of all exercise include: a. ‘small amounts often’ (pacing, as with other activities) b. linking exercise regimens to other daily activities (eg, just before morning shower or meals) so they become part of lifestyle rather than additional events c. starting with levels of exercise that are within the individual’s capability, but building up the ‘dose’ sensibly over several months People with hip and/or knee OA should be taught a regular individualised (daily) exercise regimen that

		includes: a. strengthening (sustained isometric) exercise for both legs, including the quadriceps and proximal hip girdle muscles (irrespective of site or number of large joints affected) b. aerobic activity and exercise c. adjunctive range of movement/stretching exercises * Although initial instruction is required, the aim is for people with hip or knee OA to learn to undertake these regularly on their own in their own environment

PA=physical activity. OA: Osteoarthritis

† Based on GRADE [7], a conditional recommendation is given when the quality of the evidence was low or very low and/or the balance of benefits versus harms and burdens was sufficiently close that shared decision-making between the patient and the clinician would be particularly important. Conditional recommendations are those for which the majority of informed patients would choose to follow the recommended course of action, but some would not

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Appendix 2: Summary of ACSM evidence statements recommendations for individualized exercise prescription for healthy adults (reproduced from Garber et al 2011).

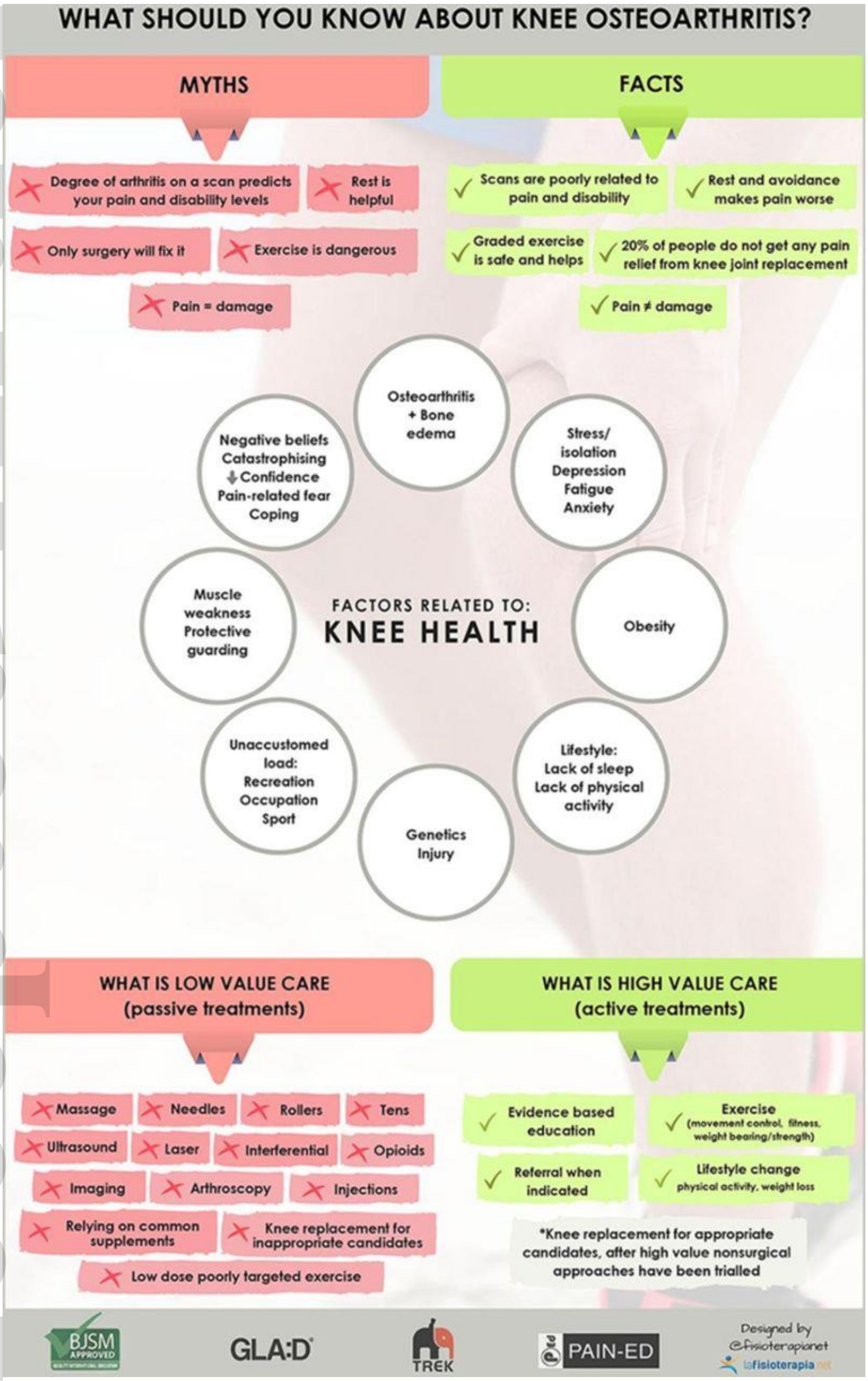
	Evidence-Based Recommendation	Evidence Category
Cardiorespiratory ("aerobic") exercise		
Frequency	$\geq$5 d·wk^{-1} of moderate exercise, or $\geq$3 d·wk^{-1} of vigorous exercise, or a combination of moderate and vigorous exercise on $\geq$3–5 d·wk^{-1} is recommended.	A
Intensity	Moderate and/or vigorous intensity is recommended for most adults.	A
	Light- to moderate-intensity exercise may be beneficial in deconditioned persons.	B
Time	30–60 min·d^{-1} (150 min·wk^{-1}) of purposeful moderate exercise, or 20–60 min·d^{-1} (75 min·wk^{-1}) of vigorous exercise, or a combination of moderate and vigorous exercise per day is recommended for most adults.	A
	$<$20 min·d^{-1} ($<$150 min·wk^{-1}) of exercise can be beneficial, especially in previously sedentary persons.	B
Type	Regular, purposeful exercise that involves major muscle groups and is continuous and rhythmic in nature is recommended.	A
Volume	A target volume of $\geq$500–1000 MET·min·wk^{-1} is recommended.	C
	Increasing pedometer step counts by $\geq$2000 steps per day to reach a daily step count $\geq$7000 steps per day is beneficial.	B
	Exercising below these volumes may still be beneficial for persons unable or unwilling to reach this amount of exercise.	C
Pattern	Exercise may be performed in one (continuous) session per day or in multiple sessions of $\geq$10 min to accumulate the desired duration and volume of exercise per day.	A
	Exercise bouts of $<$10 min may yield favorable adaptations in very deconditioned individuals.	B
	Interval training can be effective in adults.	B
Progression	A gradual progression of exercise volume by adjusting exercise duration, frequency, and/or intensity is reasonable until the desired exercise goal (maintenance) is attained.	B
	This approach may enhance adherence and reduce risks of musculoskeletal injury and adverse CHD events.	D
Resistance exercise		
Frequency	Each major muscle group should be trained on 2–3 d·wk^{-1}.	A
Intensity	60%–70% of the 1RM (moderate to hard intensity) for novice to intermediate exercisers to improve strength.	A
	$\geq$80% of the 1RM (hard to very hard intensity) for experienced strength trainers to improve strength.	A
	40%–50% of the 1RM (very light to light intensity) for older persons beginning exercise to improve strength.	A
	40%–50% of the 1RM (very light to light intensity) may be beneficial for improving strength in sedentary persons beginning a resistance training program.	D
	$<$50% of the 1RM (light to moderate intensity) to improve muscular endurance.	A
	20%–50% of the 1RM in older adults to improve power.	B
Time	No specific duration of training has been identified for effectiveness.	
Type	Resistance exercises involving each major muscle group are recommended.	A
	A variety of exercise equipment and/or body weight can be used to perform these exercises.	A
Repetitions	8–12 repetitions is recommended to improve strength and power in most adults.	A
	10–15 repetitions is effective in improving strength in middle aged and older persons starting exercise	A
	15–20 repetitions are recommended to improve muscular endurance	A
Sets	Two to four sets are the recommended for most adults to improve strength and power.	A
	A single set of resistance exercise can be effective especially among older and novice exercisers.	A
	$\leq$2 sets are effective in improving muscular endurance.	A
Pattern	Rest intervals of 2–3 min between each set of repetitions are effective.	B
	A rest of $\geq$48 h between sessions for any single muscle group is recommended.	A
Progression	A gradual progression of greater resistance, and/or more repetitions per set, and/or increasing frequency is recommended.	A
Flexibility exercise		
Frequency	$\geq$2–3 d·wk^{-1} is effective in improving joint range of motion, with the greatest gains occurring with daily exercise.	B
Intensity	Stretch to the point of feeling tightness or slight discomfort.	C
Time	Holding a static stretch for 10–30 s is recommended for most adults.	C
	In older persons, holding a stretch for 30–60 s may confer greater benefit.	C
	For PNF stretching, a 3- to 6-s contraction at 20%–75% maximum voluntary contraction followed by a 10- to 30-s assisted stretch is desirable.	B
Type	A series of flexibility exercises for each of the major muscle–tendon units is recommended.	B
	Static flexibility (active or passive), dynamic flexibility, ballistic flexibility, and PNF are each effective.	B
Volume	A reasonable target is to perform 60 s of total stretching time for each flexibility exercise.	B
Pattern	Repetition of each flexibility exercise two to four times is recommended-	B
	Flexibility exercise is most effective when the muscle is warmed through light to moderate aerobic activity or passively through external methods such as moist heat packs or hot baths.	A
Progression	Methods for optimal progression are unknown.	
Neuromotor exercise training		
Frequency	$\geq$2–3 d·wk^{-1} is recommended.	B
Intensity	An effective intensity of neuromotor exercise has not been determined.	
Time	$\geq$20–30 min·d^{-1} may be needed.	B
Type	Exercises involving motor skills (e.g., balance, agility, coordination, and gait), proprioceptive exercise training, and multifaceted activities (e.g., tai ji and yoga) are recommended for older persons to improve and maintain physical function and reduce falls in those at risk for falling.	B
	The effectiveness of neuromuscular exercise training in younger and middle-aged persons has not been established, but there is probable benefit.	D
Volume	The optimal volume (e.g., number of repetitions, intensity) is not known.	
Pattern	The optimal pattern of performing neuromotor exercise is not known.	
Progression	Methods for optimal progression are not known.	

Table evidence categories: A, randomized controlled trials (rich body of data); B, randomized controlled trials (limited body of data); C, nonrandomized trials, observational studies; D, panel consensus judgment. From the National Heart Lung and Blood Institute (263).

Reference:

Garber CE, Blissmer B, Deschenes MR, Franklin BA, Lamonte MJ, Lee IM, et al. American College of Sports Medicine position stand. Quantity and quality of exercise for developing and maintaining cardiorespiratory, musculoskeletal, and neuromotor fitness in apparently healthy adults: guidance for prescribing exercise. Med Sci Sports Exerc 2011; 43: 1334-1359.

Appendix 3: Key elements of patient education for people with knee osteoarthritis (Reproduced from Caneiro et al 2019).



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