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

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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 1) [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  |