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Osteoarthritis and Therapeutic Exercise

ABSTRACT

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Osteoarthritis (OA) is the most common cause of locomotor dysfunction and disabling joint pain in the United States. It is also the most common rheumatic disease.[1] The disease affects 33% of individuals over the age of 65 yrs. The rapid increase in the percentage of people older than 55 yrs of age in Western countries means that OA is becoming a major public health problem, affecting approximately 40 million people.[2] The most frequently affected joints are the hand, knee, and hip. The typical presentation includes joint pain, limited motion, and occasional swelling. These signs and symptoms can significantly limit activities of daily living such as walking. The American College of Rheumatology has developed guidelines for nonpharmacological therapy for hip and knee OA to include patient education, weight loss if overweight, physical therapy, orthotics, occupational therapy, and aerobic exercise programs.[3] Regular exercise is now routinely recommended to patients with OA. However, there has been relatively little study of specific exercise programs.

Individuals with OA range widely in age, disease severity and type (primary and secondary), impairments, functional goals, and interests. Some are interested in, and capable of, performing independent exercise programs with a goal of improving physical fitness. Some patterns with OA may need individualized exercise instruction and support to be able to participate in rehabilitation programs. Others may not be candidates for rigorous training programs but can be educated and encouraged to adopt appropriate daily activity habits to improve or maintain health, improve function, and reduce their risk of inactivity-related illness. It is important when initiating a new exercise regimen that patients are given positive feedback regarding their ability to exercise successfully and safely.[4]

Many people with OA can also succeed in community-based exercise programs with a knowledgeable and experienced instructor on site. For others, professional consultation with a knowledgeable health professional can be a crucial first step in the development and adoption of a safe and effective exercise habit. Patient outcomes can be optimized by combining medical knowledge of the disease and its pharmacological management, rehabilitation, kinesiology and biomechanics, exercise physiology, and exercise behavior in an accessible,

CME Objectives:
On completion of this article, the reader should be able to: (1) recognize the literature to support the efficacy of stretching and strengthening exercises in the treatment of osteoarthritis of the knee, (2) prescribe an appropriate rehabilitation program for patients with osteoarthritis, and (3) educate patients on the role of various nonpharmacological treatments such as strengthening, flexibility, and aerobic exercise that can improve pain and function.

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enjoyable, and affordable setting. Such collaboration provides a supportive environment in which the person with OA can experience success and learn to maintain self-directed regular exercise and appropriate physical activity.[4]

The definition of an effective rehabilitation program has not been universally agreed upon; however, there is some evidence supporting some rehabilitation approaches for OA. Hurley et al.[5] go so far as to say that “failure to recommend exercise to our patients is professional negligence.”

The primary goals in the rehabilitation of patients with OA are to (1) educate patients on the disease process and joint preservation to prevent or decrease pain, (2) improve flexibility, and (3) increase static and dynamic muscle strength. These therapeutic interventions are designed to alter the detrimental and inefficient biomechanics throughout the entire kinetic chain, including the ankle, knee, and hip joints. Therefore, this review will focus on the evidence supporting or refuting therapeutic exercises that impact this lower-limb kinetic chain for patients with OA. The majority of the evidence focuses on the knee; consequently, paper will discuss more on the knee joint because less literature is available on therapeutic exercises for the hip and ankle. The exercises reviewed include range of motion (ROM), strengthening, gait training, aerobic exercise, and multimodal rehabilitation exercise. The exercises reviewed are not intended to be comprehensive but to highlight some suggested therapeutic exercises in each category.

Overview of Comprehensive Exercise

Generally speaking, a comprehensive exercise program should involve exercises that improve functional capacity first, with a secondary focus on physical fitness so that the patient may engage in activities of daily living without undue pain or fatigue. Exercises should progress from flexibility of the affected joints to prevent joint contracture, to strengthening exercises focusing on functional tasks that enhance muscle endurance and contraction speed, to aerobic exercises, either weight bearing or non–weight bearing, such as aquatic exercise. Initially, the exercise program should progress more conservatively to monitor symptom exacerbation indicating adaptability to increased physical demand, and also to encourage exercise compliance.[6]

Warm-Up Exercise Phase

An exercise program should include periods of warm-up, aerobic exercise, and cool-down that include individualized, therapeutic exercises to improve or maintain flexibility, ROM, muscle strength and endurance, and cardiovascular fitness and health. The warm-up period prepares the body for more vigorous activity. The warm-up routine can be designed to involve ROM, stretching of the affected joints, and strengthening of various muscle groups.The aerobic exercise component provides the stimulus for adaptation and training of cardiovascular efficiency, aerobic endurance, and activity tolerance. This should include exercise activities that have demonstrated safety and effectiveness in OA, including limiting repetitive weight-bearing exercises and using aquatic aerobic exercise, and stationary cycling. Once a person is able to perform 10 mins or more of aerobic activity at an intensity of 70% or more of age-predicted maximal heart rate (moderate intensity), a 3- to 5-min active cool-down is recommended.[6] As with the warm-up period, low-intensity cool-down activities can be designed and used in a daily program that provides general as well as therapeutic benefit. In general, warm-up aerobic exercises can make soft tissue more pliable by centrally heating the body, thereby preparing the body for flexibility exercises. Each of the therapeutic exercise components of flexibility, strengthening, and aerobic exercise, as well as mixed programs, will be discussed individually.

Flexibility Exercises

Increasing ROM has been shown to improve discomfort and result in an increase in function.[7] Flexibility limitations contribute to mobility deficits for patients with OA at some point during the course of the disease process. These deficits result from a combination of shortened muscles and joint restrictions, which result in inflexibility. Additionally, ROM in one joint of the lower limbs is associated with an alteration in ROM in other joints along that kinetic chain. For example, when OA is present in the knee, adaptive changes of the ankle and hip (often decreased ROM) occur. These limitations result in a reduction in overall kinematics of movement such as seen during gait,[8] resulting in an overall reduction in gait velocity. Flexibility exercises involve stretching of shortened musculotendinous structures, thereby increasing joint ROM as long as the joint is not obstructed by calcifications or OA-related bony changes. There are capsular patterns of loss of ROM at the hip that usually begin first with loss of rotation, most often internal rotation, and are later followed by a decrease in abduction and hip flexion.[9] Muscular tightness is then superimposed onto these joint-capsule restrictions. Exercises should be chosen to specifically address these patterns of inflexibility.

There are several principles to consider when implementing ROM and stretching exercises to improve flexibility in the treatment of patients with OA. First, all affected joints should move through their full available ROM at least once per day, although it has also been suggested that flexibility exercises should be performed as many as three to five times a day. Second, all major muscle groups that cross the affected joint(s) should be stretched daily.[6] Forcing a joint through its ROM should be avoided.

Independent or home flexibility exercises for the hip may include hip abduction in sitting to squatting from a stance position to increase abduction and external rotation. Increases in abduction could be promoted through "V" sitting or "long sitting" with the legs separated. Patients are asked to reach between their legs, gradually stretching the adductors and avoiding stretching the upper back by leaning with the trunk forward, without curving the spine. Patients should avoid bouncing to stretch and instead slowly move to a slightly uncomfortable point in the ROM. They should hold that position for at least 30 secs and repeat it three times daily.[7] Severe discomfort should be avoided. For the knee, it is critical to stretch the hamstrings and the quadriceps. This can be accomplished through hanging the affected leg over the edge of a bed with the knee flexed. The patient should attempt to pull the lower leg into greater knee flexion by activating the hamstrings. This may result in reciprocal inhibition of the quadriceps, allowing for greater stretching of the quadriceps. The patient should simultaneously attempt to press the back of the thigh into the surface toward hip extension, thus enabling stretching of the quadriceps across the anterior hip region. This maneuver also encourages increased hip extension by stretching the rectus femoris across the hip.

To stretch the hamstrings, the patient should lie in a supine position with a towel wrapped around the foot. The leg is fully extended at the knee and then is lifted up from the resting position until the stretch is felt behind the knee.

Strengthening Exercises

Optimal ROM is needed for functional performance so that strengthening can be optimized throughout the greatest available motion. Therefore, it is important to perform flexibility exercises before or in conjunction with strengthening exercises. Research focusing on resistance exercises has shown that patients with OA have dramatic improvements in muscle strength, muscle endurance, and contraction speed of the muscles surrounding the arthritic joint.[6,10] Several studies have evaluated deficits in quadriceps strength, which is associated with knee OA.[11–13] Slemenda et al.[14] studied the relationship of quadriceps strength and obesity with the risk for the development of knee OA in 342 elderly community dwellers. Strength was measured by isokinetic dynamometry, and muscle mass was measured by dual-energy x-ray absorptiometry to adjust for muscle-mass differences across subjects. After accounting for body weight, there was an 18% reduction in quadriceps strength for those individuals who later developed radiographic evidence of knee OA, which occurred approximately 2.5 yrs later in women. However, when accounting for muscle mass, quadriceps strength was only 15% lower in the women who later developed knee OA, and this relationship was no longer significant. There was a strong negative correlation of obesity and a reduction in quadriceps strength in a subset of the women ($r = -0.74$). This was in contrast to men, in whom increased muscle strength correlated positively with increased obesity, although this was a more modest correlation. The authors concluded that weak quadriceps in combination with obesity may be a risk factor for the development of knee OA in women.

Although quadriceps weakness has been widely reported in patients with knee OA, there is some disagreement as to whether muscle weakness is the cause of OA and/or the cause of its progression. Brandt et al.[15] explored the relationship between lower-limb weakness and the progression of established radiographic changes of knee OA when definite unilateral radiographic changes were present. Mean peak strength of women with progressive OA, measured by isokinetic dynamometry (controlling for muscle mass measured by dual-energy x-ray absorptiometry), was about 9% lower than in those with stable radiographic changes, but this difference was not statistically significant. This decrease in quadriceps strength in women with progressive OA did not seem to be attributable to knee pain or knee strength at baseline compared with those with radiographically stable OA. These results suggest that factors other than quadriceps weakness are important determinants of OA progression.

Weakness of the quadriceps has also been reported to be associated with pain.[16] The weakness of the quadriceps has been suggested to be either the result of disuse atrophy secondary to knee pain and muscle inhibition from the knee or from the primary joint pain dysfunction leading to inactivity and functional weakness from disuse atrophy. Regardless of its origin, weakness can put a patient at risk for further pain, progression of joint damage, and, if left untreated, disability.[7]

There are fewer studies on the effect of exercise therapies for hip OA compared with studies for knee OA. In addition, few studies have evaluated the long-term effects of such programs for hip OA. Tak et al.[17] evaluated the effect of and 8-wk exercise program for 109 people with clinical symptoms of hip OA who were randomized into a group exercise program focused on improving the symptoms of hip OA or into a standard care group. Exercises were implemented once a week and included strengthening using fitness equipment such as pulleys, a bowflex, and a treadmill. Using the Harris Hip Score, there was a greater reduction in pain sustained at the 3-mo follow-up (average Harris Hip Score was 3.8 at baseline, 3.6 after the exercise training program, and 3.5 at the 3-mo follow-up) in the exercise group compared with the standard care group (average Harris Hip Score was 4.2 at baseline, 4.1 after the exercise training program, and 5.1 at the 3-mo follow-up). Using the Sickness Impact Profile (physical activity subscale), there was a reduction of the impact of OA on disability at follow-up (7.2 to 5.1, respectively). Using the Groningen Activity Restriction Scale, there was a trend of decreased self-report disability noted at the 3-mo follow-up. Using the timed Up & Go test, the exercise group was significantly better than the control group at follow-up, with a tendency (nonsignificant) to have an improved walking speed (average timed Up & Go was 10.4 secs at baseline, 10.1 secs after the exercise training program, and 9.4 secs at the 3-mo follow-up). The results of this study provide evidence of the benefit of exercise on pain reduction and hip function, which are important factors in the onset or maintenance of disability.

van Baar et al.[18] studied the effectiveness of exercise in patients with hip or knee OA. Their primary outcome measures were pain during the past week using a visual analog scale (VAS), use of nonsteroidal antiinflammatory drugs, and observed disability measured by video reviews of standardized timed tasks. The patients in the exercise group were given exercise treatment individually by a physiotherapist. The treatment included exercises for muscle strength and flexibility, mobility, and locomotion. Sessions ranged from one to three times a week, depending on the pain level, and lasted approximately 30 mins for up to 12 wks, with a follow-up at 24 wks. Patients in the control group were provided education and medication if necessary. Patients were instructed to use as little medication as possible. A brochure was provided for patient education, covering diagnosis, prognosis, advice about rest, daily activities and diet, the use of aids, and medical treatment. No advice about exercise was included. Results from this study indicated that there were beneficial effects of exercise on pain during the past week at 12 wks, but that these effects had declined at 3 mos, indicating a small to moderate statistical effect size (0.58 after treatment to 0.36 at 3-mo follow-up). No effects were found for nonsteroidal antiinflammatory drug use and observed disability. At 9 mos, there was no significant difference found between the groups. Furthermore, a prognostic analysis of patient characteristics at baseline compared with at 3- and 6-mo follow-up determined that there was a benefit of exercise for patients who were overweight at baseline. Patients who had a body mass index of 30 or greater at baseline compared with at the follow-up periods benefited more from exercise than those who were not obese. Similarly, patients who reported a lower level of pain-coping strategy at baseline compared with at the follow-up periods improved in pain levels more than those who did not report problems with pain-coping strategies. Although there was a 66% level of exercise compliance (measured during the therapy period, not during long-term follow-up), there was no relationship to long-term beneficial outcome or reduced pain and disability as a result of exercise after treatment. The authors conclude that their results support the usefulness of exercise in patients with OA of the hip or knee but that the effect of reduced pain and disability is diminished over time. The authors suggest future research to evaluate the benefits of intermittent exercise booster sessions that take into account optimal content of the exercise program, such as type and dosing of each component of the exercise program. Additionally, the authors suggest that the timing of an interim booster session and of short- and long-term follow-ups to enhance the retention of these positive findings warrant further study.

Deficits in sensorimotor function and knee-joint proprioception have been observed in patients with unilateral OA and have also been reported to be associated with quadriceps weakness. A reduction in quadriceps motor neuron excitability compared with that of healthy controls resulted in reduced quadriceps activation and strength and also joint position sense (JPS).[19,20] This weakness and reduced proprioception was correlated with a reduction in self-report and objective functional performance measures, such as the "get up and go" test. JPS was measured using an electrogoniometer. The participant was asked to match the knee position to that identified by the investigator previously with the participant's eyes closed to determine the error between the tester's knee-joint angle *vs.* the participant's matched knee-joint angle. The authors suggested a potential for reduced postural stability and functional performance in patients with OA and with loss of sensorimotor function and knee proprioception. Hurley and Scott[10] later reported improvements in knee JPS and position sense after an exercise program emphasizing isometric exercises to the quadriceps, bicycle riding to increase knee ROM, concentric/eccentric knee contractions using elastic bands to increase dynamic control, and functional activities such as sit-to-stand exercises, twice weekly for 5 wks.

Bennell et al.[21] evaluated the relationship of sensorimotor function with knee-joint kinematics during gait. The authors measured knee-joint proprioception or JPS using kinematic markers on the hip, knee, and ankle. The authors found a weak but significant association with knee JPS and knee kinematics during gait. The authors suggest that this finding may be attributable to prepositioning of the knee in extension just before the loading response to maintain the knee in a stable position during the stance phase of gait, because of the lack of proprioception. Riskowski et al.[22] also found that individuals with greater knee extension just before initial contact of the foot during gait had both a higher rate of loading and poorer proprioception. These studies underscore the importance of the evaluation of joint proprioception in OA and of designing treatments to enhance proprioceptive feedback during functional tasks such as ambulation.

Strengthening techniques should focus initially on the quadriceps and hamstrings, but ultimately, a strengthening program that incorporates the entire kinetic chain is needed. Early on in the rehabilitation process, gentle isometric exercises, such as "quad sets," can help minimize pain and improve confidence. Quad sets involve isometric contraction of the quadriceps muscles against a fixed surface that can be flat or wedged with a towel roll or rigid foam wedge to accommodate flexion contractures. These can be progressed to straight-leg raises and "wall sits." Straight-leg raises are performed in the supine position with the opposite knee bent to protect the back from excessive lordosis and discomfort. The leg is raised with the knee straight by activating the quadriceps muscles, particularly the rectus femoris, which generates hip flexion when the knee is extended. Wall sits are controlled isometric squat exercises in which body weight and gravity are used as the resistive forces at a particular point in the ROM. The wall provides support for balance and assumes a portion of the body weight. Patients can gradually increase the depth of the "wall sit" as quadriceps strength and knee ROM improves. Care should be taken to avoid valgus and varus stresses by using foot wedging to counteract the medial and lateral forces. A close monitoring of the pain response must be maintained before progressing the level of difficulty.

The exercise regimen should then be progressed to isotonic exercises such as knee-flexion and -extension exercises with increasing resistance to fatigue. Ultimately, strength training should progress to closed kinetic chain exercises because they involve multiple muscle groups of multiple joints of the lower limb and replicate how these muscles are used in daily activities such as getting up from a chair or climbing up stairs. These exercises include squats and wall slides that can be progressed to lunges if isometrics are tolerated well.

Fisher[6] emphasized contraction speed as another aspect of muscle training that is often overlooked but that should be added to the progression of exercises. The author points out that muscle-contraction speed is important for high-speed functional tasks such as crossing a street with a traffic light, and for fall prevention. These exercises should be performed in a cautious manner to protect the arthritic joint. This could be accomplished through isokinetic devices by which the speed of the motion is preset, or simply by asking the patient to perform contractions through the available ROM as quickly as possible.

The Ottawa Panel reported evidence-based clinical practice guidelines for therapeutic exercises and manual therapy in the management of OA.[23] Using the Cochrane methodology, the Ottawa methods group synthesized evidence from randomized controlled trials and then asked stakeholders to nominate representatives to serve as panels of experts. This panel agreed on grading criteria to evaluate the evidence. Of 609 potential studies, 26 randomized controlled trials and controlled clinical trials were reviewed. The panel identified 16 positive recommendations for therapeutic exercises, especially strengthening and general physical activity for the management of pain and for the improvement of functional capacity. Manual therapy combined with exercises was also recommended. Limitations reported by the panel in their review included the need for more precise descriptions of the characteristics of the therapeutic application such as dose, type and frequency of exercise employed, and the intensity of its application.

Aerobic Exercise

Once the muscles' strength, endurance, and contraction speed have been improved sufficiently and can be used without exacerbation of symptoms, aerobic exercises can be added to the progression of exercises. Previous research has shown that patients with OA can benefit from aerobic exercises, including cycle ergometry.[24] Aerobic fitness exercise training programs have been shown to reduce pain and morning stiffness and improve walking speed and balance over an extended period. Minor et al.[25] studied a group of 120 patients with either rheumatoid arthritis or OA who were randomly assigned to either an aerobic or nonaerobic exercise program for 12 wks. The aerobic group that participated in walking and aquatics showed significant improvement in the 50-ft walking time, exercise aerobic capacity, and other quality-of-life measures. There were no significant differences in flexibility, number of clinically active joints, or duration of morning stiffness, but the authors point to the feasibility and tolerance to the aerobic program (83% retention) for patients with OA. Minor[4] later reported walking as a safe, effective, and accessible form of cardiovascular exercise for people with knee, hip, and spinal OA.

Coleman et al.[26] studied the effect of aerobic exercise in patients with knee OA. The authors examined 100 people between the ages of 68 and 85, about half of whom reported mild to moderate OA and who received 6 mos of resistance and/or aerobic exercise and found improved strength and endurance. Joint symptoms fluctuated similarly in those with and without arthritis. The rate of musculoskeletal injuries that required reduction or discontinuation of exercise for at least 1 wk was less than 0.5% underscoring the notion that properly performed conditioning exercise does not necessarily exacerbate joint symptoms in OA and may reflect a normal fluctuation of joint discomfort over time. It was also noted that although there may have been aerobic benefits, such as an increases in peak oxygen consumption, there was not as much improvement in muscle strength or endurance.[26] Others have reported that improvements in aerobic capacity are associated with decreases in pain.[27,28] Fisher[6] points out that prescribed aerobic activity be selected based on patient preference. For example, a patient may not be compliant with aquatic exercises if he or she is uncomfortable wearing a bathing suit in public. Generally speaking, aerobic exercises should be implemented at the lower target heart rate ranges and then progress to the cardiovascular training ranges (70–85% maximal heart rate).

Brosseau et al.[29] completed a meta-analysis on the efficacy of aerobic exercises for OA using the Cochrane Collaboration methodology. Twelve trials were identified that included 1363 patients undergoing aerobic physical activities, including walking aquatics (walking in water) and Tai Chi. The current debate that stimulated the need for this review is not whether therapeutic exercises benefit patients with OA, but, rather, what are the most effective exercises for each stage of the disease, and what are the best strategies to motivate patients for lifelong regular physical activity. The review focused on aerobic exercises, although some studies combined aerobic exercises with strengthening and ROM exercises. In general, aerobic exercises such as walking or jogging in water were found to have beneficial effects on pain, joint tenderness, functional status, and respiratory capacity for patients with OA. When strengthening and aerobic exercise were compared, strengthening seemed to provide a superior benefit to short-term outcomes that improved impairments such as pain, whereas aerobic exercise had a greater benefit in long-term functional outcomes. Still, the most efficacious exercise program has yet to be determined because only 12 studies were reviewed and the exercise interventions consisted of various forms. However, the authors indicate that patients with OA should consider strengthening and aerobic exercise depending on their symptoms and functional deficits. The studies reviewed did not report significant improvements at follow-up, but the results could have indicated that patients did not continue to maintain their exercise program. The authors of this review and others suggest that continuation of exercise is essential to maintain improved mobility and quality of life.

Walking Exercise and Gait

Earlier notions that weight bearing (e.g., walking) is harmful, whereas non–weight-bearing and isometric exercises are "safe," have been revised. Approximately 20 yrs ago, prescriptions for rehabilitation avoided any activities that would increase joint loading. It is now clear that joint movement and loading are essential for proper nutrition of cartilage.[30] Studies of patients with knee effusion have shown that synovial blood flow increases with dynamic exercise, both walking and cycling.[31] When properly chosen, exercise has not been shown to cause excessive force generation across joints. For example, one study of hip-joint contact pressures show that free speed walking produces minimal pressures that are much lower than those generated by isometric or standing dynamic hip exercises.[32]

It is important to note that faster walking speeds will increase the biomechanical forces on the knee joint. In the presence of abnormal alignment, these forces may be undesirable. Schnitzer et al. reported that faster walking speeds produce increased loads on the joint, especially when pain is reduced after using a nonsteroidal drug. Fast walking may not be desirable if attention is not paid to lower-limb biomechanics as part of a treatment program. This walking program may also include prescription of supportive footwear with viscoelastic materials inserted, rigid or semirigid orthotics, wedged insoles, use of a cane in the contralateral hand, and/or strengthening of the muscles controlling the knee.

Investigators have studied the differences in gait between unimpaired individuals and patients with knee OA.[33–36] The general conclusions were that patients with knee OA have altered temporal–spatial variables such as a decreased walking speed, shorter stride length, and a longer stance phase compared with control groups. Patients with knee OA also have differences in kinetic patterns, including reduced peak vertical ground reaction force, as measured by force plates during gait analysis compared with control groups. There was also a reduction in plantar flexor power but an increase in hip-extension power, or contraction force of the extensors per unit of time. The increase in hip-extension power is related to the need to generate femoral extension without contraction of the quadriceps, which would increase the knee articular pressure and, consequently, knee pain.

Multi-Modal Rehabilitation Programs

Bennell et al.[37] studied the efficacy of physiotherapy using a randomized, double-blind, placebo-controlled trial involving 119 patients with knee-joint OA. The patients were blinded to group assignment, with the ultrasound delivering a sham treatment and patients from the two groups not receiving treatments concurrently. The examiner was also blinded to group assignment, as were the statisticians who evaluated what group patients nominated as their possible group upon completion of the trial. The authors studied the effect of a 12-wk supervised intervention, three times a week for 4 wks, and once a week thereafter. This was followed by a 12-wk period of unsupervised exercise. Therapy included exercise, massage, taping, and mobilization for the experimental group, whereas the control group received sham ultrasound and an application of a nontherapeutic gel. There was no difference in pain reduction and global improvement at 12 wks between the two groups. The authors attributed these results to nonspecific treatment effects, known as placebo effects. Placebo effects have been reported for sham knee OA treatment.[38,39] They specifically attributed the placebo effect to the attention provided by the physiotherapist, patient expectation of the treatment effects, the impressiveness of the intervention, or the intense monitoring during the study. This study did not use traditional strengthening; instead, it used a new exercise regimen involving motor control and function of the hip and pelvis, which may be another explanation for the nonspecific group differences reported by the authors.

Conversely, a study by Deyle et al.[40] found significant benefits with a 4-wk multimodal physiotherapy program of manual therapy that was individually tailored. For example, if the examination revealed that symptoms were reduced with a squatting exercise, then squatting was included as a component of the exercise in the treatment group. Conversely, if squatting increased symptoms, then the ROM at the onset of pain was noted as a baseline measure from which to compare treatment outcomes. The treatment group had their manual therapy program tailored to their initial assessment and consisted of physiologic and accessory movement mobilization and soft-tissue mobilization around the knee region. These techniques were also applied to the spine, hip, and ankle regions if the examination revealed pain or restrictions in ROM. This manual therapy program was accompanied by a supervised exercise program that consisted of stretching, active ROM exercises for the knee, muscle-strengthening exercises for the hip and knee, muscle stretching for the lower limbs, and riding a stationary bike. All of the activities were mutually reinforcing, with repeated gentle challenges to the end ranges of movement. Progress was measured through the use of the Western Ontario McMasters University Arthritis Index, a multidimensional outcome measure validated for patients with knee and hip OA. The distance covered in the 6-min walk test was also used to determine the efficacy of the intervention studied. Results from the treatment group were compared with those of the control group, who had received sham treatments consisting of ultrasound at subtherapeutic intensities. The results of this study may highlight the importance of tailoring the exercise program to the needs of the patient and the importance of strengthening exercises for the reduction of pain in the treatment of knee OA.

More recently, Deyle et al.[41] compared a home-based physical therapy program and a clinically based physical therapy program in 134 subjects with knee OA. Subjects in the clinic treatment group received supervised exercise, individualized manual therapy, and a home exercise program for a 4-wk period. Subjects in the home exercise group received the same exercise program initially, reinforced at a clinic visit 2 wks later. Both groups showed significant improvements in 6-min walk distances (approximately 10%) and Western Ontario McMasters University Arthritis Index scores at 4 wks (particularly in the pain, stiffness, and function subscales) and at 8 wks. The subjects in the clinic treatment group improved 52%, and the home exercise group improved only 26% in Western Ontario McMasters University Arthritis Index scores at 4 wks. By 1 yr, there was no difference between the groups, presumably because they were both completing the same home exercise program. The subjects in the clinic treatment group were also less likely to be taking medications for their arthritis (48 *vs.* 68% in the home exercise group, which just was nearly statistically significant [$P = -0.05$]) and were more satisfied with the overall outcome of their rehabilitative treatment, which was statistically significant, The authors concluded that a home exercise program provides important benefits and that adding approximately six additional clinical visits for the application of manual therapy and supervised exercise resulted in greater symptomatic relief. This research continues to support a multimodal approach including home exercises with some personalized treatments, including manual therapy.

Huang et al.[42] studied the effect of integrated therapy for patients with knee OA. The authors randomly assigned 140 patients with bilateral knee OA into either isokinetic exercises or isokinetic exercise and ultrasound, or isokinetic exercise, ultrasound, and hyaluronan therapy compared with a control group for 8 wks of treatment and a 1-yr follow-up. Treatment efficacy was determined by the Lequesne's index, knee ROM, knee-flexion and -extension isokinetic peak muscle torques, ambulation speed, and a visual analog scale of pain ratings. All treatment groups exhibited increased muscle peak torques and significantly reduced pain and disability after treatment and at follow-up. However, the isokinetic groups with either ultrasound or with ultrasound and the hyaluronan therapy showed significant improvements in ROM, peak torque, and ambulation speed after treatment. Interestingly, the group that received the isokinetic exercise with ultrasound and hyaluronan therapy showed the greatest increase in walking speed and peak torque associated with maximal strength and decrease in disability after treatment and at follow-up. The authors suggest an integrated therapy dealing with the extra- and intraarticular progressive pathologic changes in the rehabilitation management of OA.

Exercise Adherence

Marks and Allegrante[43] conducted a review of the literature on factors associated with exercise adherence of patients with chronic OA. The authors noted that patients with OA are often asked to adhere to prescribed exercise regimens that must be undertaken in the presence of pain and other disease-related symptoms. Unfortunately, almost all studies reviewed on the topic of exercise adherence among people with OA were short term and did not use validated measures of adherence. Poor adherence was the most compelling reason for the declining impact of the benefits of exercise over time. The authors concluded that interventions to enhance self-efficacy, social support, and skills in long-term monitoring of progress are necessary to foster exercise adherence among patients with OA. Future studies should focus on both the short- and long-term factors associated with exercise adherence.

CONCLUSION

To maximize the functional capacity of patients with OA, comprehensive exercise programs that emphasize stretching, strengthening and conditioning and education and that are individualized to disease severity and patients' individual musculoskeletal abnormalities are recommended. More specifically, exercise programs should begin with a "warm-up" phase to prepare the body for flexibility, strengthening, aerobic, or combination therapies. Flexibility exercises are essential to improve or maintain ROM and to reduce pain and stiffness associated with the disease process and activities of daily living. Because of quadriceps weakness in persons with knee OA, strengthening exercises have been demonstrated to benefit static and dynamic muscle strength and also functional performance during gait and stair climbing. In general, strengthening exercises improve the ability to control the forces at the joint during dynamic movements, thus potentially reducing the effects of loading and ensuing pain. The ability to improve the speed of contraction is also an important consideration to enhance functional capabilities. Additionally, aerobic exercise can improve pain and functional capacity (e.g., walking speed and balance) and quality of life. Finally, the maintenance of physical activity such as walking programs maintains gains from therapeutic exercise programs.

Therapeutic exercises must be progressed according to the patient's symptoms. For example, non–weight-bearing exercises such as cycling or aquatic therapy might be the initial modes of exercise. The rehabilitation program should be progressed to the most functional type of exercises, possibly including closed kinetic chain strengthening and proprioceptive training to restore sensorimotor input, functional strength, and balance.

Many patients will require a combination of pharmacological and nonpharmacological approaches for optimal outcomes. Additionally, combined nonpharmacological approaches such as exercise combined with modalities to reduce pain and swelling will result in the most beneficial effects, although more research is needed to tease out the additive effects of these adjuvant therapies.

Finally, patients with OA should be given support and education to build confidence that exercise is a reasonable and important lifestyle change. The continuation of exercise must be emphasized to help prevent potential secondary effects of inactivity such as weight gain, which can lead to increased pain, further inactivity, atrophy, weakness, pain, further immobility, and depression. Patients with OA must be educated as to multiple options for exercise environments, such as home or community programs, so that activity will become part of their everyday routines.

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