SPECIAL ARTICLE

Exercise Prescription for Older Adults With Osteoarthritis Pain: Consensus Practice Recommendations

A Supplement to the AGS Clinical Practice Guidelines on the Management of Chronic Pain in Older Adults

American Geriatrics Society Panel on Exercise and Osteoarthritis

INTRODUCTION

In response to mounting evidence that a program of increased physical activity is a useful component in the management of osteoarthritis (OA) in older adults, the Board of Directors of the American Geriatrics Society (AGS), along with a multidisciplinary panel of experts, recommended that the AGS take the lead in promoting exercise prescription for OA patients in the primary care setting. This project, culminating in the publication of these practice recommendations, parallels the Society's clinical practice guidelines on the management of chronic pain in older persons.[1]

The purpose of this document is to provide an evidenced-based review that explains why a physically active life style benefits older adults with OA and to provide practical strategies and exercise guidelines for this expanding patient population. These practice recommendations are derived from the existing literature and by consensus among a panel of experts from many disciplines: geriatrics, internal medicine, orthopedics, physical therapy and rehabilitation, exercise physiology, nursing, and pharmacy. A literature search involving a full-text computer search of *Index Medicus* and MEDLINE using the terms *osteoarthritis*, *exercise*, and *aging* was first conducted. An extensive manual search using the bibliographies of the publications located through the computer search was also undertaken. A study was included in this review if the publication made an implicit or explicit claim regarding osteoarthritis or research designed to evaluate the effects of exercise on physiologic or functional parameters in older adults. Members of the multidisciplinary panel reviewed successive drafts of the report summarizing their findings, and the final draft was submitted for review and comment by experts routinely involved in the care of older adults.

Americans 65 years or older represent an expanding proportion of the United States (U.S.) population, and their numbers will increase rapidly as the baby-boom generation ages.[2,3] Although the majority of older people in the U.S. are healthy and physically active, others suffer with chronic illnesses and require some assistance (family, friends, and public support systems) to manage their everyday lives.[4,5] Approximately one quarter of all patients seen by primary care physicians present with musculoskeletal conditions[6] and, among those age 65 years and older, the most prevalent articular disease is OA.[7] Addressing the health care needs of this rapidly expanding population is a national priority.

The conspicuous presence of OA in the older population has many believing that chronic pain and functional difficulties are immutable consequences of aging. OA, the most common form of arthritis, is associated with considerable disability.[8] Symptomatic OA causes pain, limits daily activities, and reduces quality of life.[8,9] The majority of those burdened with OA are elderly; in fact, about half of all persons age 65 and over are affected by OA.[10] The fallacy that undercuts the mistaken belief that symptomatic OA is caused by aging is revealed in the following anecdote. An older man visits his doctor complaining of difficulty with getting out of a chair and walking because of persistent pain in one of his knees. The doctor replies, "Well you're 75, this is just part of growing old." The astute patient replies, "My other knee is just as old and it doesn't hurt."[11]

An emerging body of evidence shows that light- to moderate-intensity physical activity may play a preventive and possibly a restorative role in combating declines in health and functional capacity caused by chronic diseases such as OA.[12–17] Regular physical activity modifies risk factors for chronic diseases prevalent in the older population,[18,19] improves psychologic health,[10] and promotes functional independence.[20–33] Physical inactivity is recognized as a risk factor for many diseases prevalent in the older population (coronary artery disease, diabetes mellitus, and obesity), and increasing physical activity in sedentary OA patients may reduce morbidity and mortality.[34–38] Evidence indicates that quadriceps muscle weakness is a risk factor for knee OA, which is often the consequence of inactivity.[35] Furthermore, inactivity may contribute to the morbidity associated with a variety of other chronic diseases, most notably diabetes mellitus, cerebrovascular disease, coronary artery disease, congestive heart failure, osteoporosis, and depression. The superimposition of any of these

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conditions on several age-related changes only compounds the negative effects of OA on the older person's functional independence. Encouraging regular exercise may reduce the physical impairments and the burden of comorbidities, and thus improve the OA patient's quality of life.[36]

Comprehensive management of the patient with OA should involve non-pharmacological interventions in combination with medications. Medications such as analgesics and nonsteroidal anti-inflammatory drugs (NSAIDs) should not be used alone as the primary therapy but instead should be used in conjunction with non-pharmacologic measures.[11,39,40] These include education about joint protection, weight-loss counseling for obese people, development of pain-coping skills, enhancement of social support, application of heat or cold to painful joints, exercises that strengthen muscles, and the use of a cane or a walker. Developing an exercise program aimed at alleviating pain and improving overall physical fitness is especially important, because the primary concern for many OA patients is maintenance of functional independence.[12,41,42]

OA RISK FACTORS, INCIDENCE, AND PREVALENCE: IMPLICATIONS FOR TREATMENT

Osteoarthritis is a major cause of chronic pain and disability in the older population. Even though there is much that we still do not understand about the pathophysiology of OA, our current understanding is sufficient to direct therapeutic interventions. Research in the underlying mechanisms of OA have identified several risk factors. The data suggest that, as with atherosclerotic heart disease, the risk of developing symptomatic OA is influenced by the presence of multiple risk factors. Reducing or eliminating these risk factors may reduce the symptoms and disability associated with OA. Table 1 lists the major risk factors of knee OA in older adults.[11] Some factors, such as age, gender, and inheritance are immutable, but others are modifiable. Obesity, muscle weakness, joint laxity, and altered biomechanics are some risk factors potentially amenable to nonpharmacologic measures. An understanding of the ways these risk factors affect the course of OA provides clinicians with the rationale for targeting their interventions for OA patients and increases the likelihood that these patients will improve.

The incidence and prevalence of OA at different anatomic regions vary, depending on whether this condition is defined by clinical symptoms, radiologic findings, or a combination of the two.[43–46] Although all peripheral joints may be affected, OA of the knee has been the focus of many epidemiologic studies.[9,47–55]

Age is the most consistent risk factor for both radiographic and symptomatic OA at all articular sites.[46] The prevalence of OA increases after the age of 40 in women and 50 in men.[55,56] OA affects about 50% of persons age 65 and older, and this prevalence increases to 85% in the group age 75 and older.[57,58] In the Framingham Osteoarthritis Study, Felson and colleagues[56] found that 27% of the people age 63 to 70 years had knee OA diagnosed radiographically, and among those 80 years or older, the prevalence increased to 44%. In 1997, researchers found that nearly 12% of people age 65 years and older said that their activities were limited because of arthritis.[1] This number is likely to grow proportionally as elderly people comprise an increasingly greater share of the U.S. population in the decades to come.

Gender also influences the prevalence and incidence of OA. Isolated hand and knee OA are common in women, whereas the prevalence of hip disease is higher in men.[44,45,49,50,54] Prospective, longitudinal studies have examined the relationship between body weight and OA. Data from the Framingham Knee Osteoarthritis Study, which followed 1,420 persons for more than 30 years, indicate that overweight men and women are at higher risk for developing symptomatic and radiographic OA than those less obese.[53,59] Similarly, both the Baltimore Longitudinal Study of Aging and the Swedish study demonstrated that obesity increased the risk for developing OA.[60,61] Felson and colleagues also reported that weight reduction reduces pain, further supporting the relationship between obesity and OA.[62] Although the exact mechanisms remain unclear, several investigators speculate that excessive body weight increases the biomechanical stresses across weight-bearing joints, which eventually results in cartilage damage.[63–65] Although some data support this teleologic hypothesis, a direct relationship between weight loss and reduced OA morbidity is less convincing. A small limited number of randomized clinical trials provide preliminary data suggesting that a reduction in OA symptoms is correlated more strongly with reduced body fat mass than with reduced total body weight.[56,66] Slemenda and colleagues[67,68] reported that reduced strength, relative to body weight, may play a role in the development of OA. These preliminary data could indicate that reduced total body fat and increased muscle strength may be relevant to the development of OA. These data suggest that interventions designed to strengthen the muscles and reduce total body fat may be effective methods for reducing pain and improving function in patients suffering with OA.

A history of joint trauma, the presence of bony deformities, or joint instability are also risk factors for OA.[9] Evidence from a variety of cross-sectional and longitudinal studies suggests that major trauma to a joint increases the risk for developing OA.[69–73] Consistently, the evidence suggests a strong relationship between joint damage and the development of OA later in life.

Table 1. Major Risk Factors for Osteoarthritis

Modifiable	Potentially Modifiable	Immutable
Obesity	Trauma	Age
Muscle weakness	Reduced Proprioception	Fender female > male
Heavy physical activity	Poor joint biomechanics (i.e., joint laxity)	Inheritance
Inactivity		Congenital (i.e., malformations)

Recent studies report that muscle weakness and reduced joint proprioception are risk factors for developing OA. In patients with knee OA, quadriceps weakness is common. Because of decreased joint stability and shock-absorbing capacity, muscle weakness contributes to disability.[74] Until recently, this disuse muscle atrophy was thought to develop because patients avoid loading painful joints. Slemenda and colleagues[67] examined this relationship between muscle strength and knee OA in a population of randomly selected community-dwelling older adults age 65 years and older. They reported that in those without a history of knee pain, isolated quadriceps weakness was strongly associated with radiographic knee OA. The findings from subsequent studies[68,75,76] suggest that quadriceps weakness may be a risk factor for knee OA.

Although proprioception declines with age, several reports demonstrate that diminished position sense contributes to the development of OA.[77–80] Pai and colleagues showed that knee proprioception was significantly diminished in older adults with knee OA when compared with their counterparts without OA.[77] Whether reduced proprioception causes or is a consequence of OA remains unknown. Highlighting the importance of these factors are the findings from several studies that demonstrated strengthening and aerobic exercise programs designed to improve muscle strength and joint proprioception reduce pain and improve mobility in patients with OA.[75,76,81–83]

The relationship between levels of physical activity and the risk of OA has been well studied. In general, moderate amounts of recreational physical activity do not increase the risk of OA.[84–86] However, participation in occupations requiring strenuous physical activity or intense competitive sports activity throughout life may contribute to the development of OA.[59,87–89] Nevertheless, the results of many studies suggest that older adults, even those with OA, can reduce their morbidity by regularly participating in moderate physical activity.

BENEFITS OF PHYSICAL ACTIVITY FOR OA PATIENTS

Published reviews outline the effects of exercise training in the OA population.[90,91] The details of selected randomized, controlled studies are presented in Table 2,[42] which also lists many of the benefits of increased physical activity for OA patients. Although many researchers who have studied this question conclude that exercise training does not impact the pathological process of arthritis,[30–32,60,76,82,92–95] a notable and consistent finding across the OA literature is that exercise training does not exacerbate pain or disease progression and is effective in decreasing pain and improving function. Moreover, the evidence from well-controlled clinical trials suggests that regular physical activity can provide older OA patients with the same physical, psychologic, and functional benefits observed in the general population. Chief among the functional benefits produced by increasing physical activity is improved postural and gait stability, which may reduce falls in this at-risk population.[76,96–100] These findings are significant because emerging research data implicate muscle weakness as a risk factor for OA[67,68,101] and suggest that physical inactivity exacerbates disability in OA patients.[102]

Short-term studies show that aerobic exercise[82,103] and strength-training programs[17,83,100] effectively improve important physiologic parameters related to functional capacity in older adults with OA. More recent randomized, controlled long-term trials confirm these earlier findings.[75,74,102,104] Given the positive health and functional benefits associated with exercise and the fact that inactivity contributes to disability,[102] it is evident that promoting physical activity should be an integral component of the management of OA.

MANAGEMENT OF SYMPTOMATIC OA

To date, no definitive treatment or cure for OA has been identified. The management of OA includes patient education, therapeutic modalities, exercise, and medications in parallel. Treatment goals include pain control, maximizing functional independence and improving quality of life within the constraints imposed by both OA and comorbidities.[40,105]

Patient Education and OA

Patient education is an important component of effective arthritis rehabilitation. Counseling programs have been found to be effective in reducing the pain and disability associated with OA.[106–110] Formal community-based programs to which the primary practitioner can refer OA patients are also available in many locations. In addition, the Arthritis Foundation publishes educational brochures and videotapes for patients and, in many communities, offers courses that teach practical techniques to reduce pain and improve function and general health. The Arthritis Foundation maintains a Web site (http://www.arthritis.org) and can be reached at 1-800-283-7800.

Therapeutic Modalities

Modalities, such as heat, cold, sound, and electricity are adjunctive interventions that are used with exercise and medications. While little scientific data demonstrate the efficacy of any specific modality in OA treatment, topical applications of heat and cold have been used for thousands of years. The physiologic effects of thermal modalities include muscle relaxation and decreased pain. However, because adverse effects can occur with the application of heat and cold, a comprehensive medical evaluation is necessary prior to using these modalities. The physiologic effects and general precautions of these modalities are outlined in Table 3.

EXERCISE ASSESSMENT AND PRESCRIPTION

Pain, swelling, limited range of motion, muscle weakness, postural or gait instability, and poor cardiovascular fitness are significant physical impairments associated with OA. Interestingly, sedentary people without arthritis have many of these same problems, which suggests that physical inactivity plays an important role in the symptoms and signs associated with OA. A potential barrier to recommending regular physical activity to patients with OA is the belief that exercise will exacerbate joint symptoms. The results of randomized, controlled clinical trials, however, indicate that increased physical activity does not produce or exacerbate joint symptoms and, in fact, confers significant health benefits.[30,32,52,54,59,60,111]

Patient Screening

A comprehensive evaluation is the initial step in designing a physical activity program individualized for the patient with OA. The information obtained provides the founda-

Table 2. Effects of Exercise Training in Osteoarthritis Patients: Randomized, Controlled Trials

Author, Year	Exercises (Modes, Volume, Frequency, Intensity)	Sample Population (Groups/Subjects [n], Age [yr], Disease Classification)	Outcome Measures (Physiologic, Psychological, Functional, Disease Activity)	Results
Minor, 1989[82]	Aerobic walking and aquatic exercise 12 wk, 3/wk, 30-min sessions, HR_{MAX} 60%–80%)	Walking, aquatic/n = 49 Control/n = 19 Age: 63.8 ± 8.6 Age range: 36–83	Physio: VO_2max trunk flexibility	↑ In exercisers ($P \leq 0.01$) ↑ In aerobic exercisers ($P \leq 0.01$)
			FXN: 50-ft walk test	↑ In aerobic exercisers ≈ 12% ($P \leq 0.01$)
			Psych—AIMS: phys activity, pain anxiety, depression	↓ In aerobic group ($P \leq 0.01$) in aerobic group ($P \leq 0.05$)
			Dz: swollen joints, morning stiffness	↓ No. swollen joints in aerobic group ($P \leq 0.01$)
Kovar, 1992[83]	Supervised walking program 8 wk, 3/wk, 30-min sessions, intensity: NR	Walkers/n = 47 Age: 70.4 ± 9.1 Control/n = 45 Age: 68.5 ± 11.3	Fxn: 6-min walk	↑ Distance 70 m in exercise group but 17 m in control group ($P \leq 0.001$)
			Psych—AIMS: phys act'y disability pain medication	↓ in exercisers ($P < 0.001$) ↓ in exercisers ($P < 0.003$) Slight ↓ in exercisers ($P = 0.08$)
Ettinger, 1997[77]	Aerobic training: 3-mo supervised walking then 15-mo home walking, 3/wk, 1-hr sessions; $HR_{reserve}$: 50%–70%	Aerobic training/n = 144 Age: 69 ± 6 Resistance training/n = 146 Age: 68 ± 6	Physio: Isokinetic strength of knee flexion at 30°/sec	Significant ↑ both exercise groups in comparison with controls
			V_{o2}max	Significant ↑ aerobic exercisers in comparison with controls
	Resistance training: 3-mo supervised the 15-mo home program, 9 exercises of UE and LE muscle groups, 2 sets of 12 repeats 3 d/wk; intensity: NR		Psych: self-report of phys disability	Both exercise groups reported less disability than controls
			Fxn: 4 timed performance tests	Both exercise groups did better than controls
			Dz: knee radiographs	No difference in severity of OA among 3 groups
			Knee pain scale	Both exercise groups reported significantly less pain than controls
	Control: health education program	Control/n = 149 Age: 69 ± 6		
Rogind, 1998[84]	General fitness: LE & low back exercises—ROM, balance, coordination, and muscle strengthening (hip abductors, adductors; quadriceps, hamstrings; gluteal, erector spinae), 3-mo supervised by PT 2 d/wk plus 4 d/wk home program	Knee OA exercise/n = 11 Age: 69.3 ± 8.2 Knee OA control/n = 12 Age: 73.0 ± 6.5	Physio: Quadriceps isokinetic strength 30° thru 180°/sec	Significant ↑ (20%) extension strength in exercise groups least affected knee at 30°/sec at 3 mos ($P < 0.05$)
			Isometric with knee at 90°	↑ (21%) extension strength in exercise groups least affected knee at 3 mos ($P = 0.06$)
			Postural sway	No difference between groups

(*continued*)

Table 2. Continued

Author, Year	Exercises (Modes, Volume, Frequency, Intensity)	Sample Population (Groups/Subjects [*n*], Age [*yr*], Disease Classification)	Outcome Measures (Physiologic, Psychological, Functional, Disease Activity)	Results
			Fxn: 20-m walk test	Significant ↑ walk velocity in exercise group at 1 yr ($P < 0.05$)
			Timed balance test	No difference between groups
			AFI score	Significant ↓ in exercise group at 3 mos and 1 yr ($P < 0.05$); no change in control group
			Dz: knee effusions	Significant ↑ in exercise group at 1 yr (compared with control); significant ↓ in control group at 1 yr (compared with exercisers)
			Pain scale	Significant ↓ night pain in exercise group at 1 yr ($P < 0.01$)
van Baar, 1998[76]	Individualized PT exercise program, 12 wk, 1–3/wk, 30-min sessions; intensity: individual	Exercise/$n = 93$ Age: 68.3 ± 8.4 Control $n = 98$ Age: 67.7 ± 9.2	Physio: isometric hip strength	↑ Hip strength in exercise group ($P = 0.03$)
			Fxn: disability analyzed on videotapes of performance of specific tasks)	↓ Disability in exercise group ($P = 0.04$)
			Dz: Pain (visual analog scale)	↓ Pain in exercise group during last wk and last mo ($P < 0.01$ for both)
			No. of medications	↓ Use of paracetamol in exercise group ($P = 0.02$)

NOTE: ↓ = decreased; ↑ = increased; AFI = Algofunctional Index; AIMS = Arthritis Impact Measurement Scales; Dz = disease activity; Fxn = functional measures; HR max = age-predicted heart rate maximum; LE = lower extremities; NR = not reported; OA = osteoarthritis; PT = physical therapy; ROM = range of motion; UE = upper extremities; VO_2max = maximal aerobic capacity (measurement of aerobic fitness).
d = day; wk = week; mos = months
SOURCE: Adapted with permission from O'Grady M, Fletcher J, Ortiz S. Therapeutic and physical fitness exercise prescription for older adults with joint disease: an evidence based approach. Rheum Dis Clin North Am 2000;26: 617–646.

Table 3. Thermal Modalities: General Physiologic Effects & Precautions

	Heat	Cold
Physiologic Effects		
Hemodynamic	Vasodilation	Vasoconstriction
Neuromuscular		
Nerve Conduction Velocity	Increased	Decreased
Connective Tissue		
Collagenase Activity	Increased	Decreased
Tendon Extensibility	Increased	Decreased
Clinical Effects		
Pain	Decreased	Decreased
Hemodynamics		
Bleeding	Increased	Decreased
Edema	Increased	Decreased
Inflammation		
Acute	Increased	Decreased
Chronic	Increased	Decreased
Neuromuscular		
Muscle Relaxation	Increased	Increased
Connective Tissue		
Joint Stiffness	Decreased	Increased
Precautions		
Acute Trauma & Inflammation	Contraindicated	Indicated
Impaired Circulation	Contraindicated	Contraindicated
Impaired Sensation	Contraindicated	Contraindicated
Cognitive Impairment	Contraindicated	Contraindicated

tion for developing an appropriate exercise prescription for each patient. Assessment objectives can be divided into two broad categories: arthritis-related factors (current medications, joint pain, inflammation, stability, and range of motion) and impairments associated with inactivity (altered body composition, muscle weakness, and poor cardiovascular fitness). The assessment should include a search for any subclinical or undetected health problems or conditions that could be exacerbated by exercise. In addition, reviewing the patient's expectations along with his or her financial and social resources may improve long-term adherence.[112–116] When all these factors are considered, an exercise prescription can be offered that accommodates to the specific needs and circumstances of the patient.

The Need For Graded Exercise Testing

As many older adults may have cardiovascular disease, a complete history and physical examination are needed before prescribing increased physical activity. Contraindications to exercise are presented in Table 4; in general, they are not different from those applicable to younger, healthier adults.[117] Opinions differ regarding the need for a physician-supervised exercise stress test. Cardiovascular response to exercise should be considered for patients with significant risk factors. Such testing assesses cardiac response to exercise and helps to establish an individual's initial aerobic exercise prescription.[118] False positives do occur with exercise stress testing, and there are no consensus recommendations concerning the need to obtain this costly and inconvenient test in older adults who do not have significant cardiovascular disease risk factors. In a review of 14 studies (11 different training protocols) examining the effects of high-intensity strength training in older adults, only three included exercise stress test as part of their screening procedures.[10,14,16,28,29,119–127] In the largest of these studies, 70 subjects were screened with exercise stress testing; five subjects were excluded because of a resting blood pressure $> 160/100$, and eight were excluded because of positive exercise stress test results.[28,29]

Although serious cardiovascular events can occur with physical exertion, these usually occur during high-intensity activities. This risk should be considered in light of the fact that regular physical activity of moderate intensity lowers the risk of mortality from cardiovascular disease and can be safely implemented in patients with a low risk for such events.

How to Start

The first step in designing an exercise program for the OA patient is to understand which functional problems are most important to the patient. Once disabilities have been

Table 4. Contraindications to Exercise by the Osteoarthritis Patient

Absolute	Relative
Uncontrolled arrhythmias	Cardiomyopathy
Third degree heart block	Valvular heart disease
Recent electrocardiographic changes	Poorly controlled blood pressure
Unstable angina	Uncontrolled metabolic disease
Acute myocardial infarction	
Acute congestive heart failure	

inventoried and prioritized, the patient and clinician can set specific short- and long-term goals, which will determine the exercises to be prescribed. Involving the patient in the process enhances long-term adherence.[112–116]

Initially, the program should involve exercises that address the impairments (pain, limited joint range of motion, or muscle weakness) contributing to functional problems. As soon as these impairments begin to improve, a generalized fitness program designed to improve health and functional capacity should begin. Shortly after therapeutic exercise is initiated, fitness training can begin and continue in parallel. The clinician should reinforce the goals and benefits of exercise and familiarize the patient with the specifics of the exercise prescription (intensity, volume, and frequency) and precautions. The latter might include, for example, warnings that physical performance and disease activity can vary from day to day, and that signs of excessive exercise stress include joint pain during activity, pain lasting more than 1 to 2 hours after exercise, swelling, fatigue, and weakness. Patients who are aware of their body's response to exercise and equipped to adjust their training program to avoid immobility may have better long-term adherence with a physical activity program.

Basic Exercise Principles and Prescription Components

The basic components for any physical activity program are exercises to improve flexibility, strength, and endurance. Table 5 presents basic recommendations. The training parameters should be individualized for each patient, but all programs are based on general guidelines, as follows.

All exercise prescriptions aimed at improving joint flexibility, muscle strength, or endurance are based on the overload principle: when musculoskeletal tissues are subjected to unaccustomed physiologic stresses, they will adapt and increase their capacity. Overload can be accomplished by increasing the exercise intensity, volume, or frequency, or a combination of these factors.[42]

To be most useful and clear, each exercise prescription specifies exercise intensity, volume, frequency, and progression (Table 5).

- *Intensity* defines the amount of muscular effort or exertion put forth during the activity. The intensity of an activity is typically expressed as a percentage of the individual's maximal capacity. Traditionally, the intensity specified in an exercise program is submaximal (i.e., at levels below the individual's full capacity).
- *Volume* describes how long the exercise is to be performed. For endurance training, volume may be expressed as the amount of time (in number of minutes per exercise session or accumulated minutes per week) the person is engaged in aerobic exercises. For resistance training, volume may be expressed as the number of sets and number of repetitions per set to be performed.
- *Frequency* may be expressed as the number of exercise sessions per week.
- *Progression*, or the gradual application of the overload principle as adaptation occurs, depends on the individual's response to exercise. Although the initial time needed for adaptation to the stress of exercise has not been identified, the range may be 2 to 3 months for most older arthritic adults with reduced physiologic reserve. Progression can be manipulated by changing the intensity, volume, or frequency of training.

The greatest amount of force that a muscle or group of muscles can generate defines strength. A variety of methods have been developed to measure strength. The most commonly used strength measurement is the one repetition maximum or 1RM, defined as the maximum amount of resistance that can be lifted through a full range of motion only once. Typically, the intensity of a strength training program is expressed as a percentage of 1RM. The amount of strength gain depends on the individual's initial level of

Table 5. Training Parameters: General Guidelines

Exercise	Intensity	Volume	Frequency
Flexibility: static stretching			
Initial	Stretch to subjective sensation of resistance	1 stretch/key muscle group; hold position 5–15 sec	Once daily
Goal	Stretch to full range of motion	3–5 stretches/key muscle group; hold position 20–30 sec	3–5/wk
Strength: resistance			
Isometric	Low–moderate: 40%–60% MCV	1–10 submaximal contractions involving key muscle group; hold contraction 1–6 sec	Daily
Isotonic	Low: 40% 1 RM Mod: 40%–60% 1 RM High: > 60% 1 RM	10–15 repetitions 8–10 repetitions 6–8 repetitions	2–3/wk
Endurance: aerobic	Low–Mod: 40%–60% of VO_2max/HR_{max} RPE: 12–14 = 60%–65% VO_2max Talk test	Accumulation of 20–30 min/day	3–5/wk

NOTE: 1 RM = one repetition maximum (measurement of isotonic or dynamic strength); MCV = maximal voluntary contraction (measurement of isometric strength); RPE = rating of perceived exertion; HR max = age-predicted heart rate maximum; VO_2max = maximal aerobic capacity (measurement of aerobic fitness).

strength and potential and on the training intensity, frequency, and volume.[128,129]

The type of muscle contraction, static or dynamic, differentiates training techniques. A *static* or *isometric* contraction does not change muscle length or move a joint. Isometric strength training occurs when the force of the muscle cannot overcome the applied external resistance (i.e., holding a heavy tray). Strength increases occur primarily at the angle where the muscle was trained, with less improvement at other angles. This drawback limits the usefulness of isometric exercise as the sole form of strength training.

Dynamic training is more useful for the person with OA. A *dynamic* contraction both changes muscle length and moves the joint. Dynamic contractions are further classified as isotonic or isokinetic. *Isokinetic* muscle contractions are performed on sophisticated machines that apply variable resistance throughout the range of motion. Isokinetic training, which has been studied in OA patients,[130–132] shows no significant advantages over isotonic strengthening programs. Therefore, from a practical standpoint, isotonic is the recommended form of dynamic strength training for OA patients. An *isotonic* muscle contraction is characterized by variable joint speed exerted against a constant resistance (i.e., free-weight bench press exercise). Isotonic exercise closely corresponds to everyday activities, and strengthening isotonic muscle contractions therefore are recommended for OA patients.

All exercise sessions should have three phases, each of which is essential for reducing the potential for injury and maximizing benefit. The first phase is a warm-up period involving repetitive low-intensity range-of-motion exercises; warm-up lasts 5 to 10 minutes. This phase is important because a proper warm-up prepares the body for more vigorous activity. The second phase is the training period, which provides the overload stimulus to increase joint range of motion, muscle strength, or aerobic capacity, or a combination of these. The final phase, cool-down, lasts 5 minutes and typically involves static stretching of the muscles.

Exercise and other non-pharmacologic interventions are used in parallel with medications to reduce pain and improve function in the older OA patient. The management of symptomatic OA should be adjusted to the needs of the individual patient; an algorithmic approach, though limited, nonetheless helps to organize this complex process into a series of steps (Figure 1). The algorithm highlights the importance of modifiable risk factors in the design of treatment plans that accommodate the heterogeneity of the older OA population and yet facilitates simultaneous implementation of several therapeutic interventions. Such an approach helps to reduce the latency for reducing pain and improving function in older symptomatic OA patients.

FLEXIBILITY (RANGE-OF-MOTION) EXERCISES

General Principles

Joint mobility is important to health and to maximal joint range of motion, enhanced muscle performance,[95] reduced risk for injury,[95,133] and improved cartilage nutrition.[134] Flexibility exercises, typically the first step when beginning an exercise program,[34,104] increase the length and elasticity of muscles and periarticular tissues.[135] For the OA patient, the objectives of such exercises are to decrease stiffness, increase joint mobility, and prevent soft-tissue contractures. Flexibility exercises are often done during the warm-up period or in conjunction with resistance or aerobic activities.

To improve joint range of motion in the OA patient, static stretching is recommended. This stretching technique moves muscles, joints, and periarticular tissues through a range of motion that is comfortable for the patient but that produces some resistances to further movement. Joints, especially those that are painful, should not be over stretched (i.e., stretched to a point that elicits pain), as this may compromise stability. All movement should be through the fullest possible pain-free range. The application of heat prior to stretching may help reduce pain and increase motion.

According to the American College of Sports and Medicine (ACSM), a flexibility program can begin with one stretching exercise per muscle group and should be performed at least 3 times per week.[136] With improvement, the number of repetitions per muscle group can be gradually increased to 4 to 10 repetitions.[137] This general static stretching program should involve the major muscle and tendon groups in the upper and lower extremities (Table 6).

Static Stretching Exercise: General Recommendations

- Exercise daily when pain and stiffness are minimal (i.e., prior to bedtime).
- Exercises can be preceded by a warm shower or by application of superficial moist heat.
- Relax before beginning stretching exercises.
- Perform movements slowly and extend the range of motion that is both comfortable and produces a slight subjective sensation of resistance. Breathe during each stretch.
- Hold this terminal stretch position for 10 to 30 seconds before slowly returning the joint or muscle group to the resting length.
- Modify the stretching exercises to avoid pain or when the joint is inflamed (decrease the extent of joint range of motion or the duration of holding the static position).

STRENGTH TRAINING

General Principles

Strength, an important factor in the performance of daily activities, is an important part of a comprehensive rehabilitation program for the older adult with OA. The aging process, burdens of chronic disease, malnutrition, and inactivity due to OA pain[138] all contribute to reduced muscle mass (sarcopenia) and weakness.[90,139] Studies have shown that resistance training reverses many age-related physiologic changes and can improve function.[94,140–142] The objectives of strength training are to increase the strength of muscles that support the affected joints. The strength training of the individual OA patient should be based on the following principles:

- Specific exercises should be selected on the basis of the patient's joint stability and degree of pain and inflammation.
- Muscles should not be exercised to fatigue.
- Exercise resistance must be submaximal.

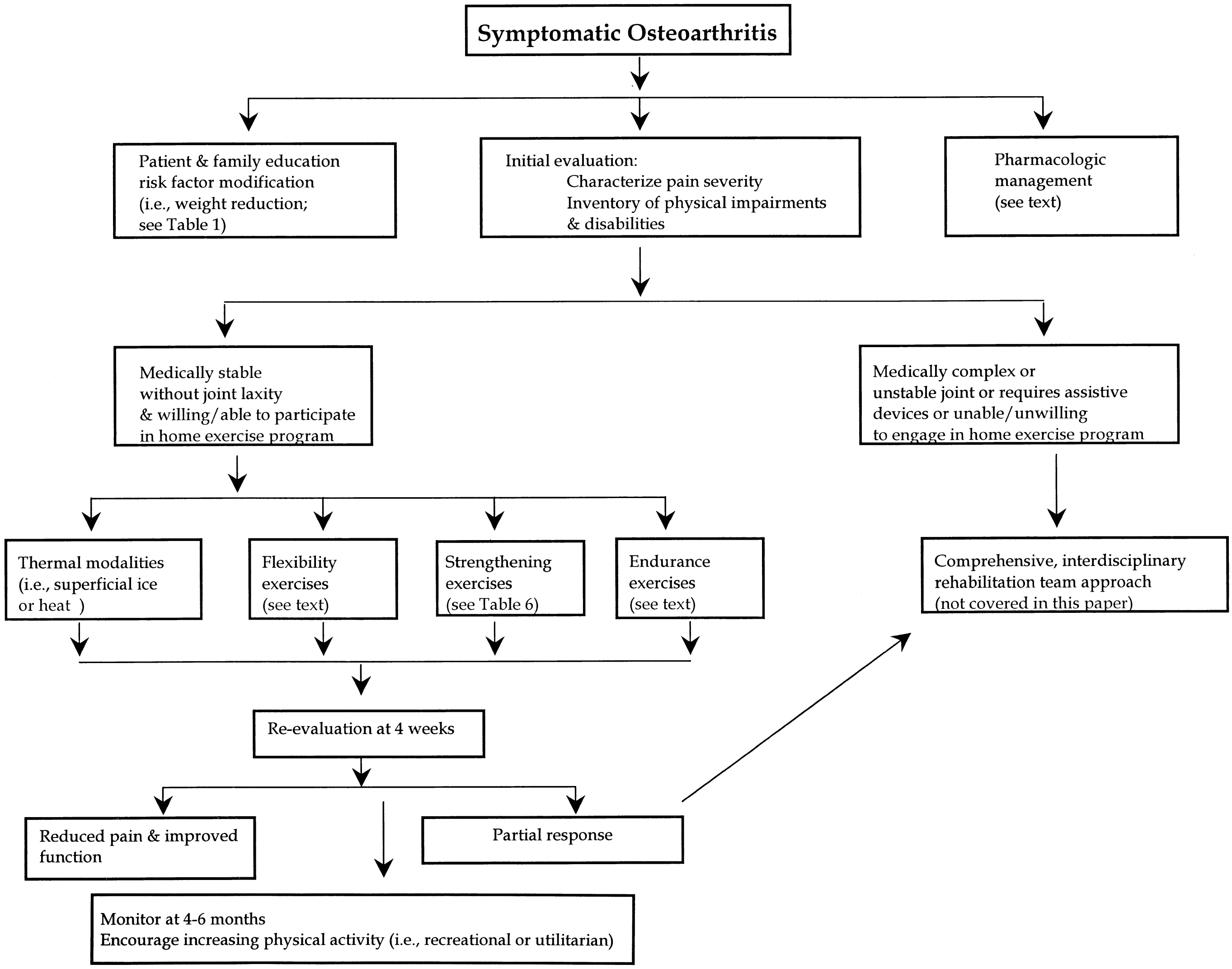

Figure 1. Steps in managing osteoarthritis in the older patient.

- Inflamed joints should be isometrically strengthened and involved in only a few repetitions; movements should not be resisted.
- Joint pain lasting 1 hour after exercise and joint swelling indicate excessive activity.

Isometric Strengthening

General Principles

Isometric strengthening is indicated when joints are acutely inflamed or unstable. Isometric contractions produce low articular pressures[83] and are well tolerated by OA patients with swollen, painful joints. These exercises can improve muscle strength and static endurance. They prepare the joint for more dynamic movements and are, therefore, typical starting points for most strengthening programs.

Data indicate that strength increases occur when isometric contractions are performed at the muscles' resting length.[143,144] Strength improvements occur primarily at the angle the muscle was trained, with less improvement at different angles[145–147] which hinders the usefulness of this exercise form if the goal is to improve overall function. As joint instability and pain decrease, the patient's exercise program should gradually shift to dynamic (isotonic) training, as these muscle contractions are used during the performance of activities of daily living.

Isometric Strength Training Recommendations

- *Exercises:* Include exercises that involve the major muscle groups presented in Table 6.
- *Intensity:* Introductory, isometric contractions should be performed at low intensity. To establish the exercise intensity, ask the patient to maximally contract the muscles targeted for strengthening.[42,129] This is the patient's maximal voluntary contraction and initial training intensity should begin at approximately 30% of this maximal effort. As tolerated by the patient, the intensity should gradually increase to 75% of the maximal voluntary contraction.
- *Volume:* The contraction should be held for no longer that 6 seconds. Initially, one contraction per muscle group should be performed, and the number of repetitions should be gradually increased to eight to 10, as tolerated by the patient.

Table 6. Key Muscle Groups Targeted for Stretching and Strengthening Exercises

Head, neck	Extensors, flexors
Shoulder	Forward flexion, extension, abduction, adduction
	External and internal rotators
	Scapular retractors and depressors
Elbow	Extensors, flexors
Forearm, wrist	Pronators, supinators
	Wrist extension, flexors
Hand	Finger flexor, extensors
	Thumb adductor, abductors
Trunk, low back	Forward flexion, extension, side bending, rotation
Hips	Forward flexion, extension, abduction, adduction
	External rotation, internal rotation
Knees	Extensors, flexors
Ankle, foot	Dorsiflexors, plantar flexors
	Inverters, everter
	Toe flexors, extensors

- The patient should be instructed to breathe during each contraction. Twenty seconds of rest between contractions is suggested.[67,127,143]
- *Frequency:* Exercises should be performed twice daily during acute inflammatory periods. The number of these exercises should be gradually increased to five to 10 times per day, as tolerated by the patient.
- *Progression:* Initially, contractions should be performed at muscle lengths tolerable to the patient. As pain and inflammation decrease, contractions should be performed at different muscle lengths and joint angles.[145] As strength develops, resistance may be added (i.e., contractions against an immovable weight).
- *Precaution:* Contraction > 10 seconds can increase blood pressure.[148]

Isotonic Training

General Principles

Isotonic muscle contractions are used to perform activities of daily living. Isotonic strength training has been shown to produce positive effects on energy metabolism,[139] insulin action,[111] bone density,[18] and functional status[18,20,21,141] in healthy older adults. In the absence of inflammation and joint instability, this exercise form is well tolerated by OA patients. Recently, the ACSM published isotonic strength training guidelines. Their recommendations, based on scientific research, are the basis of the exercise recommendations for OA patients outlined below.

OA Isotonic Exercise Recommendations

Because older OA sufferers with a sedentary lifestyle are likely to have diminished physiologic reserve these exercises should *not* proceed to muscle fatigue.

- *Exercises:* Resistance training should involve eight to 10 exercises involving the major muscle groups.
- *Intensity:* Resistance should begin at 40% of the patient's 1RM. Maximum resistance should be 80% 1RM.
- *Volume:* The beginner should complete one set of four to six repetitions. Exercisers should avoid muscle fatigue.
- *Frequency:* The frequency of training should be a maximum of 2 days per week.
- *Progression:* The progression of resistance training intensity and volume should be gradual to allow time for adaptation. A 5% to 10% increase per week in the amount of resistance used for training seems appropriate.

Strength Training for Symptomatic Knee OA: An Example

For the medically stable or robust older adult with symptomatic knee OA, some basic exercises aimed at improving quadriceps strength are outlined in Table 7. For those patients with a number of medical problems, the clinician should consider referral to an experienced therapist.

AEROBIC TRAINING

General Principles

Aerobic exercise has numerous physiologic benefits that alleviate the deteriorations of aging. These include improved maximal aerobic capacity (measurement of aerobic fitness),[14,15,126,149] insulin action,[150] body composition,[151] and plasma lipoprotein lipid profiles.[75,76,152] Regular aerobic exercise also reduces blood pressure.[153] Meredith and colleagues[138] showed that moderate-intensity training (70% of maximal heart rate), performed 45 minutes per day, 3 days per week for 3 months produced similar aerobic gains in both sedentary young and older adults. The mechanisms for adaptation to aerobic conditioning differ between young and old adults, but improvement in skeletal muscle oxidative capacity and glycogen store are more prominent in the older adult.

The ACSM has set forth standards for the quantity and quality of exercises for developing and improving cardiovascular fitness in an older population.[137] The overload principle is applied to improve an individual's aerobic fitness (VO_2max). (This principle states that the intensity, frequency, and volume of aerobic exercise must be greater than normal daily activities.) The ACSM recommends that aerobic activities should involve dynamic repetitive movements of large muscle groups.

Aerobic Exercise Recommendations

- *Exercises:* Activity selection depends on several factors: the patient's current disease activity, joint stability, and resources and interests. The patient should choose a variety of exercise options, to prevent overuse of specific joints and to avoid exercise boredom. Examples of aerobic exercise are bicycling, swimming, low-impact aerobics (i.e., walking, dance, or Tai Chi), or exercising on equipment such as treadmills or rowing machines. Other more utilitarian activities, such as walking the dog, mowing the lawn, raking leaves, or playing golf, are also considered aerobic exercise and should be encouraged. Aquatic exercise is a good choice for OA pa-

Table 7. Home-Based Exercises Designed to Improve Knee Extensor Strength

Exercise	Purpose	Position	Action	Volume and Frequency
Gluteal squeezes	Strengthen buttocks muscles	Lying, sitting, standing	Squeeze buttocks muscles tightly; hold squeeze for 6–7 sec, then slowly relax; rest 2–3 sec between squeezes	Perform 5–7 squeezes 3–5 times a day (before getting out of bed, before climbing stairs, and before going to sleep at night)
Quad set	Strengthen thigh muscles	Lying or standing with legs straight	Squeeze the muscles on top of thigh (this forces the knee cap to move toward the hip); hold squeeze for 6–7 sec, then slowly relax; rest 2–3 sec between squeezes	Perform 5–7 squeezes 3–5 times a day
Short-arc quad set	Strengthen thigh muscle nearest the knee cap	Lying	Place a firm pillow under the knee so that knee is bent; slowly lift foot until leg is straight; hold leg straight for 6–7 sec, then slowly lower leg; rest 2–3 sec between motions	Perform motion 5–7 times 3–5 times a day
Long-arc quad set	Strengthen entire thigh muscle	Sitting	Squeeze muscles on top of thigh to lift foot and straighten leg; hold leg straight for 6–7 sec, then slowly lower leg; rest 2–3 sec between motions	Perform motion 5–7 times 3–5 times a day
Closed-chain, short-arc knee extension	Strengthen hip and thigh muscle	Standing and holding onto a solid object (eg, kitchen counter) for balance	Keeping the back straight, slowly bend knees to 30 degrees, then slowly push back up, extending knees; rest 2–3 sec between motions; as strength improves, increase speed of the motion and depth of knee bend	Perform motion 5–7 times 3–5 times a day

NOTE: Never hold breath during any exercises.

tients; pool exercises performed in warm water (86 °F) provide analgesia for painful muscles and joints. Moreover, the buoyancy of the aquatic environment reduces joint loading, enhances pain-free motion, and provides resistance for strengthening muscle groups around arthritic joints. In addition, pool therapy is commonly a group activity that may help reduce a patient's depression and feelings of isolation. High-impact aerobic training involves rapid application of loads across joint structures and should be avoided, as recent research suggests that the magnitude of joint loading may not be as important in producing pain or damage as the rate of joint loading.[42]

- *Intensity:* Several valid tools are useful for selecting an appropriate exercise intensity, the gold-standard being maximal aerobic power (VO_{2MAX}). However, establishing a patient's VO_2max is costly and sometimes difficult to obtain. Practical tools that can be helpful in determining appropriate exercise intensity include maximal heart rate (HR_{MAX}: 220 − (minus sign) age in years), rating of perceived exertion (RPE: a 15-point ordinal scale, 6 to 20), or the "talk test" (whether an exerciser can converse comfortably during the activity without getting short of breath).[154,155] Exercise intensity is considered low to moderate when 1) HR_{MAX} is between 50% and 75% (i.e. an 80yr old's HR_{MAX} would be 220–80 or 140 with 50–75% being 70–105), 2) an RPE between 10 and 13, and 3) a positive "talk test." The aerobic exercise intensity should then range between HR_{MAX} 50% to 60%, RPE 10 and 12, or positive on the "talk test." For many OA patients, especially those taking medications that control heart rate, the "talk test" or RPE is the simplest method for determining an exercise intensity.
- *Volume:* The recommended volume for the beginner is a minimum of 20 to 30 minutes per day. Some older, sedentary adults are unable to complete 20 to 30 minutes of continuous aerobic activity at low to moderate intensity. An acceptable alternative is four to five shorter exercise bouts (each, a minimum of 5 minutes) performed at slightly higher intensities (i.e., 55% to 60% HR_{MAX}) throughout the day.[156,157] Accumulating between 60 and 90 minutes of moderate level physical activity over the course of a week has been included in recent recommendations from the ACSM. As fitness improves, exercise bouts can be lengthened gradually to 20 to 30 minutes of continuous aerobic activity.
- *Frequency:* The initial frequency of training should be at least 3 days but no more than 4 days per week. Frequency of five times per week is not recommended because of increased risk for injury.
- *Progression:* The progression of aerobic training intensity and volume should be gradual to allow time for adaptation (i.e., 2 to 3 months). Following this initial phase of aerobic training, a 2.5% increase per week in the intensity or volume may be compatible with the reduced physiologic reserve associated with older arthritis patients.
- *Precautions:* Musculoskeletal injuries are preventable. More often than not, injuries can be avoided if the patient gradually works up to the desired activity level and avoids excessive amounts of activity.

Pharmacologic Therapy

Most authorities agree that the treatment for OA pain should be comprehensive, including both non-pharmacologic and, when necessary, pharmacologic approaches.[1] They also agree that non-pharmacologic therapy should be considered the initial treatment and that pharmacologic agents, such as analgesics and NSAIDs, should be used as adjunctive therapy.[158] Drug therapy for the treatment of OA pain is most effective when used in conjunction with a coordinated program encompassing appropriate non-pharmacologic strategies.[1] Primary physicians who are prescribing exercise for OA patients are encouraged to regularly review the literature on pain management for up-to-date information on the pharmacologic management of pain.

Acetaminophen should be considered the preferred first-line pharmacologic treatment for mild to moderate pain of OA.[1,159–161] Acetaminophen has been shown to provide pain relief comparable to that achieved with NSAIDs,[162,163] without the potential for the gastrointestinal (GI) side effects associated with the use of NSAIDs.[164,165] The daily dosage of acetaminophen should not exceed 4 grams per day.

As an alternative to acetaminophen, a trial of an NSAID (available over the counter [OTC] or by prescription) might be of benefit.[166–171] There is also considerable risk of drug-drug interactions and drug-disease interactions (e.g., congestive heart failure, hypertension, and hepatic and renal disease) with the NSAIDs. Physicians treating OA patients therefore need to take detailed medication histories, including questions about OTC medication use, in order to provide optimal care and recommendations. It has been reported that adverse events with nonselective NSAIDs are more frequent than with any other drug class.[172] It is important to remember that elderly persons are at high risk for side effects of NSAIDs, including GI, platelet, and nephrotoxic effects. Accordingly, NSAIDs should not be used in high doses for long periods of time.[1]

If a patient has a history of gastroduodenal ulcers or of GI bleeding, or develops GI symptoms, one of the new cyclooxygenase (COX-2) inhibitors or selective NSAIDs should be considered.[173,174] The new COX-2 inhibitors have been demonstrated to be as effective as traditional NSAIDs in the management of OA pain. The two currently available COX-2 inhibitors, celecoxib and rofecoxib, have been shown to be as effective as nonselective NSAIDs for mild-to-moderate pain in patients with knee or hip OA.[175,176] However, caution is advised in prescribing a COX-2 (as well as other NSAIDs), as there is the potential for renal complications. There is evidence that rofecoxib tends to cause fluid retention in older adults and that, in addition, taking it without aspirin carries increased cardiovascular risk in this population.[177,178] The choice of agents for treating OA patients with preexisting renal insufficiency requires careful consideration.[179,180]

For patients with OA of the knee and other joints who have mild to moderate pain, topical formulations of analgesics or counterirritants (e.g., methyl salicylate or capsaicin cream, menthol) might be beneficial.[181–184] Expert geriatricians have indicated that pharmacologic modalities for OA pain, besides acetaminophen, NSAIDs, and opioids, include topical formulations of these agents and intraarticular injections of corticosteroids or hyaluronic acid.[160]

Intraarticular therapy is an alternate approach to pain management in those individuals who either have not obtained relief through systemic medications or in whom oral NSAIDs are contraindicated. This is especially true for patients with OA of the knee. Intraarticular administration of glucocorticoids (e.g., triamcinolone hexacetonide) has been beneficial in treating acute episodes of pain, especially when there is evidence of inflammation and joint effusion.[185,186] More recently, the intraarticular administration of hyaluronic acid preparations has been shown to have efficacy in relieving pain that is not adequately relieved with non-invasive, non-pharmacologic and pharmacologic therapies.[187–189] Other agents that have shown benefit in treating the pain associated with OA of the knee include glucosamine and chondroitin.[190,191] However, additional studies are necessary to demonstrate long-term safety and efficacy of these agents.

For some patients with severe OA pain that is refractory to other forms of therapy, stronger analgesic drugs may be required. Carefully titrated opioid analgesic drugs may be preferable to NSAIDS, cortisone, or other pharmacologic or invasive interventions that pose appreciable risks in older people.[1] It has also been suggested that opioid analgesics may be better for treating acute exacerbations of OA pain than for long-term use.[159]

CONCLUSIONS

Chronic pain and functional dependency are not inevitable consequences of aging with joint disease. Identifying the modifiable risk factors (Table 1) enables practitioners to focus their therapeutic interventions, reduce pain, and improve function. Randomized, controlled trials clearly show that regular moderate-level exercise does not exacerbate OA pain or accelerate the pathological process of OA. Furthermore, these studies strongly indicate that increasing the level of physical activity in OA patients reduces pain and morbidity. Exercise programs should be individualized to address the specific needs of the patient. The goals of any exercise program should focus on controlling pain, increasing flexibility, and improving muscle strength and endurance.

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