

Patients often want to maintain sports activities and avoid surgery

Nonpharmacologic, nonsurgical management of knee osteoarthritis

ABSTRACT: Greater load in the medial compartment of the knee than in the lateral compartment may contribute to knee osteoarthritis (OA). Malalignment also has been associated with the progression of radiographic joint-space loss and loss of function. Treatment involves reducing the load to reduce knee pain and improve function. Osteotomies are technically demanding and associated with morbidity. Knee bracing may correct malalignment, reduce the load, reduce the varus moment, increase proprioception, and stabilize an unstable knee. Foot orthoses have been shown to reduce the symptoms of medial compartment knee OA. Weight loss in combination with exercise reduces pain and improves physical function. Many persons with knee OA experience instability problems; bracing and exercise may help improve them. (J Musculoskel Med. 2006;23:430-443)

Knee osteoarthritis (OA) is one of the most common causes of disability. Persons with knee pain resulting from OA often cannot perform activities of daily living, work, and sports.

Knee OA increases in prevalence with advancing age. About 10% of persons older than 65 years have symptomatic knee OA; during a 1-year period, about 25% of persons older than 55 years have knee pain on most days in a month.¹ The number of Americans older than 65 years is expected to roughly double in the next 25 years, and the challenge to providers of musculoskeletal care probably will increase accordingly.

Symptomatic knee OA develops

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in many persons in their 40s and 50s. Risk factors include obesity, occupational bending and lifting, knee injury, and previous surgery. The risk of knee OA is significantly increased in patients who have had a total meniscectomy.² With the advent of more conservative meniscus-sparing surgery, total meniscectomies rarely are performed, but even partial meniscectomy may increase the risk of knee OA.³

In addition, major ligamentous injuries, such as a torn anterior cruciate ligament (ACL), predispose persons to knee OA. Many younger patients currently seen in knee arthritis clinics have a history of either meniscal or ACL injuries. These patients often are interested in maintaining some lifetime sports activities, such as tennis, golf, cycling, softball, and walking for fitness. Usually, they are motivated to avoid or delay joint replacement surgery. As a result, these patients

are excellent candidates for an aggressive nonpharmacologic, nonsurgical approach to treatment.

Many therapies for knee OA have been proved to be effective, but to help patients achieve a high quality of life the physician must consider biomechanical interventions—rather than rely solely on medications or surgery—and the patient must be willing to work hard. Physicians and physical therapists often find working with patients to optimize the benefits of these potentially valuable interventions very rewarding.

In this 2-part article, we describe several nonsurgical, nonpharmacologic therapies for knee OA. This first part highlights the important role that knee bracing, foot orthoses, and weight loss may play. In the second part, to appear in a later issue of this journal, we will focus on exercise and fitness for knee OA treatment.

Load and malalignment

Load across the knee is not uniformly distributed during normal gait. The medial compartment experiences load greater than that of the lateral compartment. This imbalance may contribute to the start of OA and lead to narrowing of the joint space in the medial compartment, an early sign of OA (Figure 1).

During the midstance phase of gait, an estimated 60% to 80% of the load is distributed to the medial compartment of a normal knee. This is explained by the external varus moment (or adductor moment), the torque generated from the ground reaction force during the stance phase that results from the body's center of gravity falling medial of the knee joint. This uneven distribution, in part, is why medial compartment OA is more prevalent than lateral compartment disease.

Malalignment also has been associated with the progression of radiographic joint-space loss and deterioration in function in patients with knee OA. Varus alignment increases the risk of medial compartment OA progression; valgus alignment increases the risk of lateral compartment OA progression.⁴ In a patient who has medial compartment knee OA with significant cartilage loss or varus malalignment or both, the percentage of the load that is distributed to the medial compartment during the midstance phase of gait may be much higher than 80%.

Correction of malalignment and reduction of load

By understanding normal knee biomechanics and the impact of

malalignment on knee OA, clinicians may increase the therapeutic options for patients who have symptomatic unicompartmental knee OA beyond the usual medications, injections, and surgery. The strategy is to reduce the load on the symptomatic compartment to reduce knee pain and improve function.

Historically, osteotomies of the proximal tibia or distal femur have been performed to improve mal-

alignment and reduce the load on the affected compartment. These procedures are technically demanding and associated with known morbidities, such as infection, nerve injury, deep venous thrombosis, and malunion/nonunion; also, risks are inherent in administration of anesthesia. If the patient eventually has total knee arthroplasty, the surgery may be more difficult than that performed in a knee that has not previously un-

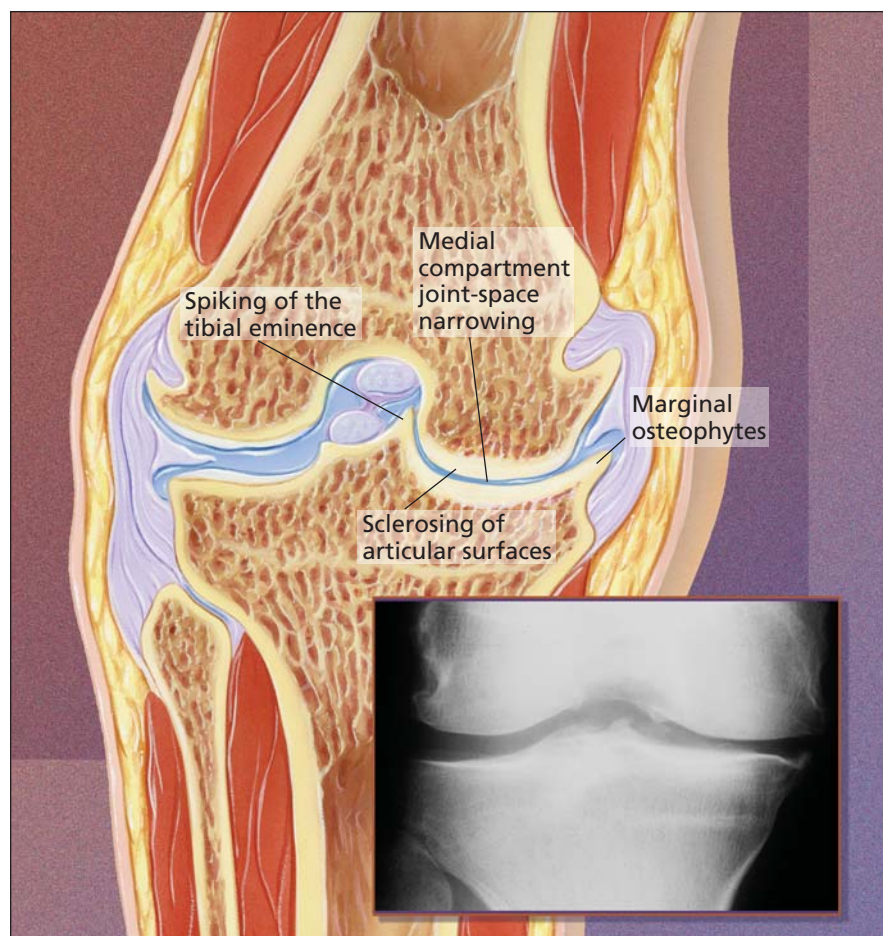


Figure 1 – Narrowing of the joint space in the medial compartment of the knee is an early sign of osteoarthritis (OA). Bony sclerosis and formation of spikes on the tibial eminence and osteophytes also may become apparent. Medial joint-space narrowing with tibial osteophyte formation consistent with medial compartment knee OA is seen in this x-ray film (inset).

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Table – Potential benefits of knee bracing for knee OA

- Correction of malalignment
- Reduction of the biomechanical load on the diseased knee compartment
- Increased mechanical stability in an unstable knee with ligamentous injury
- Increased mechanical stability in a knee with pseudolaxity
- Increased proprioception
- Increased patient perception of knee stability
- Placebo effect

OA, osteoarthritis.

dergone osteotomy. Nonsurgical alternatives for improving malalignment and reducing the load on the affected compartment include knee bracing and foot orthoses.

The benefits of bracing

Knee bracing has become an accepted intervention for patients with knee OA. The potential benefits include correction of malalign-

ment, reduction of the load across the involved compartment, reduction of the varus moment, increased proprioception, stabilization of an unstable knee, and increased patient perception of stability (Table).

Some patients with knee OA have true ligamentous instability, such as a torn ACL. Many patients have pseudolaxity that resulted from loss of articular cartilage and reduced muscle tone. With their rigid shells and hinge systems, well-fit knee OA braces provide patients with increased stability.

A key characteristic of the knee OA brace is its ability to create a valgus or varus force on the limb

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Figure 2 – Braces used for knee osteoarthritis (OA) help create a valgus or varus force on the limb to reduce the load on the involved knee joint compartment. Several brace designs for right knee medial compartment OA are shown here. Specific braces may have different hinges, shells, padding, straps, and angle adjustments. Having a variety of designs to choose from helps physicians match a design to a specific patient’s needs. Companies that make models for the various designs are listed above each brace type.

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to reduce the load on the involved knee joint compartment. This can be accomplished with several brace designs, including a double upright system, single upright system, single upright system with a contralateral strap, and cloth-based sleeves with hinges embedded (Figure 2).

Many features of a specific brace are unique to the manufacturer and protected by patent law. These features include the hinge design, adjustability of the brace's angle, shell materials, and strapping mechanisms.

Having a growing variety of available OA brace designs is a big advantage: a design may be chosen that best suits a patient's knee pathology, leg size (thigh and calf girth), vanity, and desired activities. For example, a patient who has true ACL deficiency may benefit from a more rigid double upright knee brace design that is quite similar in design to the typical functional ACL brace. An older woman with limited muscle mass may prefer a low-profile cloth-based brace that has little biomechanical stability/leverage.

Knee brace clinical trials are difficult to control adequately because obtaining a true control group presents challenges. In the largest clinical trial to date (119 patients with medial compartment knee OA in 3 treatment groups), symptoms and function improved more in the group with a valgus knee brace than in placebo and neoprene sleeve groups.⁵

Gait laboratory studies have shown improved symmetry in gait in patients who are wearing a valgus knee brace.⁶ Digital radiographic studies of the gait cycle

have shown nicely that it is possible to demonstrate increased medial joint space during midstance and heel strike in patients who are using a single upright valgus brace compared with identical radiographs taken without the brace.⁷

Many improvements have been seen in the materials and design of knee braces during the past decade. Knee OA braces currently on



Figure 3 – Applying a valgus force to the patient's leg helps determine whether the patient might benefit from wearing a brace. Using one hand as the fulcrum with the patient's knee flexed about 10° to 15°, the clinician may apply a force to see whether the malalignment can be reduced. Allowing the patient to hold a brace is another helpful office screening method.

the market may have distinct advantages for various patient populations. In many of the braces, the angle of the hinge or the hinge attachment can be adjusted to the shell of the thigh or calf. This allows the physician and orthotist to dial in a dose effect for an individual brace.

Fitting of the brace and instructions on how to don it properly are crucial for success. The orthotist, a key member of the team, must be familiar with the nuances of several varieties of knee braces to allow the clinician some flexibility in using different braces for different patients.

A helpful office evaluation maneuver used to determine whether the patient might benefit from a brace is applying a valgus or varus force to the patient's leg (Figure 3). The physician's hand is used as a fulcrum at the joint with the patient's knee slightly flexed. If a varus or valgus knee can be reduced to near neutral easily with this simple maneuver, there is a reasonable chance that a properly fit and adjusted knee brace can improve the malalignment.

Another office screening method for prescribing a knee brace is to have some sample braces in the office and allow the patient to hold the brace. If the patient is not interested in trying the brace after holding it, he or she probably will never wear it.

Custom knee braces may cost between \$800 and \$1800. Off-the-shelf models are less expensive but may have limitations in fitting or compromise quality, such as in the hinge or shell materials. Knee braces are only for a niche within the large population of patients

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with knee OA, but when use of them is successful, patients often accept them and are able to return to some of their lifetime sports or work activities (Figure 4).

If a patient has a good clinical response, with decreased pain and increased ability to perform activities, he often will wear a knee OA brace for many years. Some of our patients have worn braces for more than 10 years; other patients wear knee braces for a few years and then consider surgical intervention. With the advent of new lighter-weight and more comfortable braces, long-term adherence may be enhanced.

Foot orthosis options

Lateral heel wedges and lateral wedge foot orthoses have been shown to reduce the symptoms of medial compartment knee OA.⁸ Biomechanical studies have demonstrated that both the external varus moment and the estimated medial compartment load of the knee are reduced with lateral wedge orthoses.

There appears to be a dose response with the degree of lateral wedging. However, the benefits of a higher degree of wedging are limited by foot and ankle discomfort. A reasonable amount of lateral wedging for medial compartment knee OA appears to be about 4° to 6°.

Custom foot orthoses may be beneficial in patients with foot and ankle abnormalities; however, a simple off-the-shelf lateral wedge orthosis may suffice for patients who have medial compartment knee OA and a basically normal foot and ankle. Although the results from clinical trials conducted to validate the benefit of

Weight loss in combination with exercise reduces pain and improves physical function in patients with knee osteoarthritis.

foot orthoses for knee OA have been mixed, these devices provide a low-cost, safe intervention that merits an empiric trial in many patients.

The value of weight loss

Obesity is well established as a risk factor for knee OA. Studies have clearly shown that weight

loss in combination with exercise reduces pain and improves physical function in patients with knee OA.⁹ Clinicians may encourage weight loss in patients with symptomatic knee OA by sharing the following concept:

A load of 3 to 5 times a person's body weight is transmitted across the knee joint during walking (and this load is significantly higher during running). Therefore, a decrease in weight of 10 lb can decrease the load across the knee joint by 30 to 50 lb.

Instability in persons with knee OA

A significant proportion of persons with knee OA experience problems with knee instability. In a recent study, Fitzgerald and associates¹⁰ reported the prevalence of self-reported knee instability (defined as a sensation of buckling, shifting, or "giving way" at the knee during functional activities) and its relationship with physical function.

More than 60% of study patients reported episodes of instability, and 44% indicated that knee instability affected their ability to perform activities of daily living. The severity of knee instability was associated with poorer functional performance, even after controlling for other factors that could affect function in persons with knee OA, such as pain, muscle weakness, and reduced joint mobility. The authors concluded that knee instability is a prevalent problem in persons with knee OA and that it contributes to disability above and beyond what may be expected from the presence of other impairments.

The instability experienced by



Figure 4 – When wearing of braces is successful, patients with osteoarthritis often can return to lifetime sports or work activities.

persons with knee OA probably is multifactorial; it may result from increased capsuloligamentous laxity, structural damage to the knee, and altered muscular strength and neuromuscular control. Investigators have reported increased passive knee laxity in persons with knee OA.

The laxity has been described as a "pseudolaxity." Although capsuloligamentous structures remain intact, the laxity is thought to result from reduced tension in the joint capsule and ligaments secondary to progressive degenerative changes in the joint and increased joint-space narrowing.¹¹

The passive restraints are thought to slacken as the disease process progresses. Sharma and colleagues¹² reported that greater amounts of passive varus/valgus laxity are associated with greater amounts of bony attrition and joint-space narrowing of the knee, providing some support for the notion of pseudolaxity.

Evidence is mounting to indicate that knee instability and in-

Practice Points

- In patients with knee osteoarthritis (OA), improving malalignment and reducing the load on the symptomatic knee joint compartment helps reduce pain and improve function.
- Applying a valgus or varus force to the patient's leg may help determine whether the patient might benefit from a brace. Allowing the patient to hold a sample brace helps determine whether the patient will wear it.
- Foot orthoses have been shown to reduce the symptoms of medial compartment knee OA. There appears to be a dose response with the degree of lateral wedging.

creased laxity may influence physical function and motor control patterns of the lower extremity. Given that knee instability may contribute to the decline of physical function above and beyond that which may be explained by other impairments (eg, loss of joint motion, muscular weakness, and pain), simply addressing range of motion, pain, and muscular weakness in exercise programs may not be enough to overcome problems with knee instability.

Adjunctive interventions that

have been used to address instability in other patient populations, such as knee bracing and agility and perturbation training, may be needed in conjunction with general exercise programs to resolve instability problems. Further research is needed to determine how knee instability and laxity may influence the outcome of rehabilitation and whether adjunctive treatments that directly address knee instability can improve the overall effect of exercise therapy for persons with knee OA. ■

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Tailoring programs to fit each patient's specific needs may improve results

Exercise for management of knee osteoarthritis

ABSTRACT: Exercise and physical activity programs have been shown to reduce pain and improve function in patients with knee osteoarthritis (OA). However, their overall effect may have been limited by lack of tailoring to fit each patient's specific needs. Both isometric and isotonic exercises have been used effectively to strengthen the lower extremity muscles. Open chain and closed chain exercises may be used, depending on a specific patient's goal. Strengthening of hip and ankle muscles should be addressed. The key to a flexibility and mobility program is to address limitations in all lower extremity joints. There is growing interest in the use of balance and agility training activities in knee OA exercise programs. (J Musculoskel Med. 2006;23:505-509)

As a result of knee osteoarthritis (OA), patients often cannot perform activities of daily living, work, and sports. Many patients would like to maintain some level of sports activity but want to avoid or delay joint replacement surgery. Non-pharmacologic, nonsurgical approaches provide other options that may help them in their quest for a higher quality of life.

Numerous studies have demonstrated that exercise and physical activity programs provide effective treatment for persons who have knee OA.¹ Most programs include muscle strengthening, flexibility, and aerobic exercises. Although these programs have been found to be beneficial in reducing pain and improving function, their

overall effect has been limited to moderate at best.^{2,3}

One possible reason is that traditional approaches to exercise for patients with knee OA have been generalized. There is a considerable amount of variability in patients' physical capacity and individual characteristics (eg, obesity, lower extremity alignment, knee instability, structural damage, pain tolerance, fear, and anxiety) that may account for differences in their responsiveness to exercise.⁴ Recent evidence suggests that tailoring exercise programs to more closely fit each patient's specific needs may improve the treatment results.⁵

In this 2-part article, we discuss various nonsurgical, nonpharmacologic therapies for patients with knee OA. The first part ("Nonpharmacologic, nonsurgical management of knee osteoarthritis," *The Journal of Musculoskeletal Medicine*, June 2006, page 430) de-

scribed the important role that knee bracing, foot orthoses, and weight loss may play. In this second part, we feature exercise and fitness for knee OA treatment. We discuss the key elements of an exercise program and factors that may help enhance its overall effectiveness in improving patients' physical function.

MUSCLE STRENGTHENING EXERCISES

Strengthening of the lower extremity muscles is an important component of an exercise program for persons with knee OA. Muscle weakness has been shown to be associated with greater levels of disability in patients with knee OA⁶⁻⁸; some investigators have argued that muscle weakness may be a precursor to knee OA.^{9,10} In addition, because muscles may play a significant role in absorbing and dissipating loads across the joints, maintaining adequate strength

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and fitness of the lower extremity muscles is an important component of rehabilitation.

A variety of methods may be used for lower extremity strength training in knee OA rehabilitation programs. Both isometric exercises (muscular force is exerted against a static resistance) and isotonic exercises (muscle contraction is resisted through a range of motion of the target joint) have been used effectively.^{5,6,11,12}

Many patients can tolerate isotonic exercises without difficulty. However, shear forces that are created when resistance is applied during joint motion may reproduce symptoms in some patients with knee OA. Isometric exercises offer an effective alternative for these patients, because relatively high resistance loads can be toler-

ated without exposing the joint to high shear forces.

Types of strengthening exercises

Another factor to consider in muscular strength training programs is the use of open chain or closed chain exercises. Typically, open chain exercises are non-weight-bearing exercises in which the movement occurs mostly at 1 joint and resistance to a single muscle group is emphasized (eg, a leg extension exercise for quadriceps strengthening or a leg curl exercise for hamstring strengthening) (Figure 1). Closed chain exercises usually are weight-bearing exercises in which movement occurs at several joints and resistance is applied to several muscle groups (eg, squatting or leg press exercises)

(Figure 2). During closed chain exercises, movement must occur at the hip, knee, and ankle to complete the task and the hip extensors, knee extensors, and ankle plantar flexors all are involved in overcoming or controlling the resistance.

Both open chain and closed chain exercises may be used in rehabilitation. If the goal is to target a specific muscle group to improve force output capabilities, open chain exercises may be more effective. If the goal is to encourage coordinated use of multiple lower extremity muscle groups, closed chain exercises would be used. Patients who cannot bear weight because of pain may be more successful with open chain exercises; other patients may not tolerate some open chain exercises but are

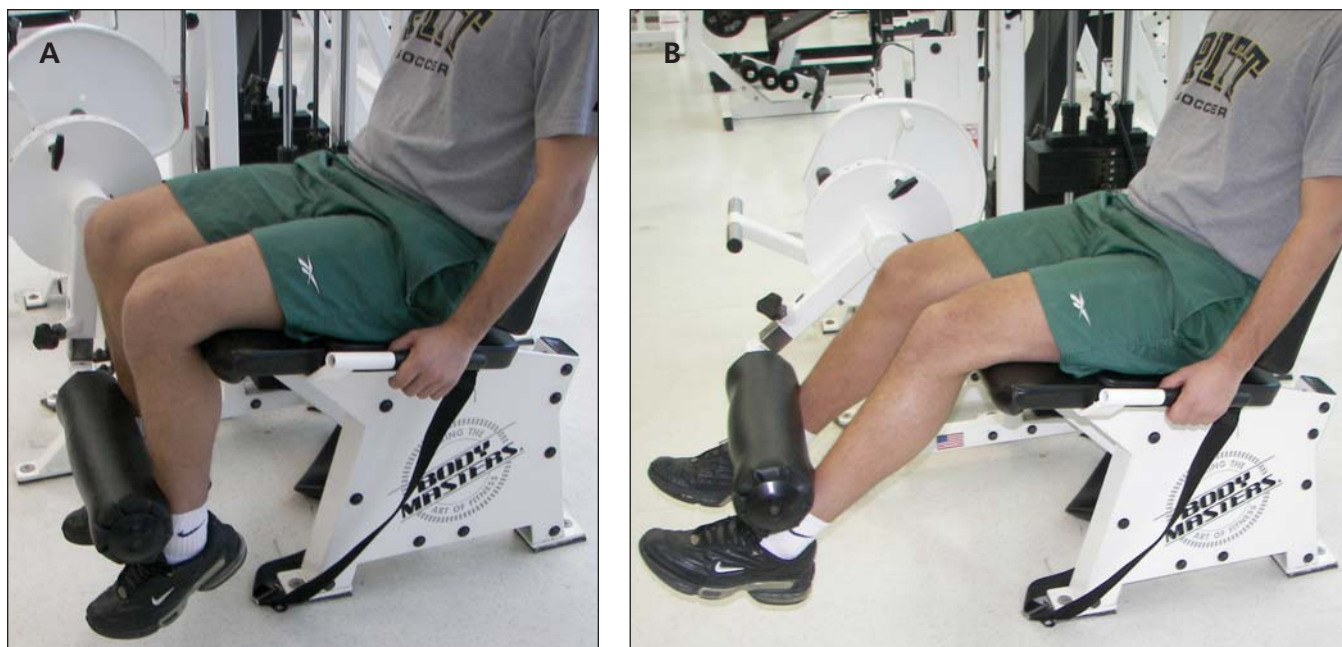


Figure 1 – Open chain and closed chain exercises may be used in muscular strength training programs for patients with knee osteoarthritis. Open chain exercises usually are non-weight-bearing exercises in which the movement occurs mostly at 1 joint. A leg extension exercise for quadriceps strengthening is shown with the leg in extension at 90° of knee flexion (start position, A) and the leg in extension at 45° of knee flexion (end position, B).

able to perform closed chain exercises without difficulty.

Another factor to consider is the arc of motion through which open chain and closed chain exercises are performed. Patellofemoral joint stress may be systematically increased when an open chain leg extension exercise is performed from 90° of flexion to full extension. In contrast, patellofemoral joint stress is systematically increased during a closed chain leg press exercise from full extension to 90° of flexion.

Patellofemoral joint stress can be minimized during both of these exercises if the arcs of motion are limited to the ranges in which there is less joint stress. For open chain leg extensions, patellofemoral joint stress is minimized from 90° to 45° of flexion (see Figure 1). The closed chain squat and leg press exercises can be performed with minimal joint stress from full extension to about 45° of flexion (see Figure 2).

There is evidence to indicate that open chain leg extension exercises also may increase anterior tibial translation and, therefore, increase anterior shear forces when the leg is extended from about 60° of flexion to full extension in patients with anterior cruciate ligament deficient-knees.^{13,14} Anterior translation may be reduced in these patients during open chain leg extensions by limiting the arc of motion to a range of 90° to 45° of flexion.

Although quadriceps strengthening often is emphasized in a knee OA rehabilitation program, strengthening of hip and ankle muscles also should be addressed. Weakness of the hip abductor and external rotator muscles has been associated with various knee pa-



Figure 2 – Closed chain exercises generally are weight-bearing exercises. Movement must occur at the hip, knee, and ankle, and several muscle groups help overcome or control the resistance. Shown is a leg press with the knee at 45° of flexion (end position). The start position is 0° of flexion.

thologies, including knee OA.^{15,16} Poor motor control of the hip is thought to alter the stress on the knee during locomotion, placing knee structures at risk for injury. Weakness of ankle muscles has been shown to be associated with balance deficits in persons with knee OA.¹⁷ Techniques that focus on hip and ankle muscle strengthening should be included in an exercise program for these patients (Figure 3).

Intensity of strengthening exercises

Another consideration in planning a strengthening program for persons with knee OA is the intensity of exercise. The amount of tension produced in the muscle during

training is a key factor in inducing a training effect. If the program is not intense enough, it probably will not be beneficial.

In studies that have reported positive results in improving muscle strength, progressive resistance that is tailored to the individual patient's force-producing capabilities was used.^{5,6,11,18} One approach is to use a percentage of the patient's maximum force production, starting the training load at 10% of maximum and increasing it by 10% each week to 70% of maximum.⁶

Some investigators have used a resistance load that was equated with a moderately intense rating on the Borg Perceived Exertion Scale to tailor individual resis-

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Figure 3 – Strengthening of hip and ankle muscles should be addressed in a knee osteoarthritis rehabilitation program, because weakness of hip abductor and external rotator muscles has been associated with knee pathologies and weakness of ankle muscles has been shown to be associated with balance deficits. Thigh adductor (A), thigh abductor (B), and calf curl (C) exercises are shown.

tance loads.^{11,18} As the Borg rating decreased for a given load, the resistance was then increased accordingly. Others have described the training load as the maximum resistance that can be performed in 2 sets of 10 repetitions. Resistance is then increased as the patient is able to perform 2 sets of 12 repetitions in 3 consecutive sessions.¹²

In patients with knee OA, the definition of *maximum* also may include the maximum amount of

resistance that can be lifted or resisted without reproducing joint pain symptoms. These maximum loads are then reestablished every 1 or 2 weeks so that the training loads can be increased as the patient improves.

FLEXIBILITY AND AEROBIC EXERCISES

Reduced joint motion may result in a reduced area of joint load distribution during locomotion; this, in turn, may increase joint stress.

Limitations in joint motion also may alter the patient's ability to perform various functional tasks. Deyle and associates⁵ included a comprehensive flexibility and joint mobilization program in their study, which yielded greater improvements in pain and function than previous studies. Flexibility exercises were performed on the quadriceps, hamstring, gastrocnemius, hip adductor, and hip flexor muscle groups, as well as the iliotibial band. The key to the flexibility and mobility program, if greater gains in function are expected, is to address limitations in all lower extremity joints and not just in the knee.

Aerobic exercise has long been shown to help improve function and measures of cardiovascular fitness in older persons and in persons with knee OA.^{12,19-21} Lower impact aerobic activities (eg, walking, cycling, and aquatic aerobic exercises) performed at an intensity ranging from 60% to 75% of maximum heart rate for 30 to 45 minutes, 3 to 5 days per week, also have been shown to be beneficial. These activities may provide benefit without exacerbating knee pain and inflammation. Aerobic exercise combined with a proper dietary regimen also may help reduce obesity, a major risk factor for progression of knee OA.²²

BALANCE AND AGILITY TRAINING

There is growing interest in the use of balance and agility training activities in knee OA exercise programs. Techniques used to challenge balance may include tandem walking and wobble or tilt board activities.

(continued)

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Agility training techniques emphasize quick stops and starts, quick changes in direction, and obstacle negotiation. These types of activities, which traditionally have been used for younger, physically active persons, are being modified for use in exercise programs for persons with knee OA.²³ The rationale is that these activities expose patients to higher-level movement problems and challenges to lower extremity stability that typically are encountered during normal activities of daily living.

General flexibility, strengthen-

Practice Points

- In strengthening exercises for persons with knee osteoarthritis, open chain exercises target a specific lower extremity muscle group; closed chain exercises encourage coordinated use of multiple muscle groups.
- Flexibility exercises are used to improve pain and function. The key is to address limitations in all lower extremity joints, not just in the knee.
- Balance and agility training activities provide patients an opportunity to learn how to solve more complex movement tasks.

ing, and aerobic exercises alone do not provide this type of experience. The addition of balance and agility training activities might

add to the benefit of these exercises by providing patients with an opportunity to learn how to solve more complex movement tasks. ■

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