Effect of Knee Pain on Exercise Participation

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Chapter II

Review of the Literature

The purpose of this section is to provide research based information regarding the importance of regular exercise in maintaining a healthy lifestyle and reducing disease. The risks of injury through exercise will also be addressed as well as the implications of injury in the development of knee pain. The structure of the knee will be defined so as to facilitate the understanding of the impacts of injury and knee pain on an individual’s ability to perform daily functions as well as the role of pain and injury in preventing individuals from participating in regular exercise.

Benefits of regular exercise

According to the American College of Sports Medicine (ACSM), a physically active lifestyle combined with moderate cardiorespiratory fitness has been shown to lower the risk of developing chronic diseases such as coronary artery disease, hypertension, obesity, osteoporosis, type II diabetes, and some forms of cancer (ACSM’s Guidelines, 2000). Higher activity and fitness levels have been associated with lower death rates from heart disease, the leading killer of Americans. Minimum activity levels established by the ACSM and the Centers for Disease Control state that “every US adult should accumulate 30 minutes or more of moderate-intensity physical activity on most, preferably all, days of the week” (ACSM’s Guidelines, 2000). An optimal activity level, based on the ACSM’s Activity Pyramid, includes aerobic activities and recreational sports 3-5 times per week. Flexibility and resistance training should be performed 2-3 days per week as well as leisure activities (such as golf or yard work). Sedentary activities such as watching television should be minimal. It should be noted that physical activity and
exercise, by definition, are not analogous. However, for the purpose of this chapter, they will be used interchangeably, so as to include all active behaviors an individual performs each day.

**Exercise and injury**

While the ACSM recommends 2-3 days per week of resistance training and 3-5 days per week of cardiorespiratory training, little benefit seems to come from exercising more frequently. Higher rates of injury are associated with higher training frequencies, and are most often due to overuse. These types of injuries can range from muscle pain to tendonitis, or in extreme cases, compromised joint stability, which can lead to serious physical complications. Depending on the severity of injury and required treatment, an individual may be immobile for brief to extended periods of time therefore compromising their physical fitness level.

Injuries to the knee joint are particularly devastating, yet are among the most common musculoskeletal injuries (Andersen, Crespo, Ling, Bathon, & Bartlett, 1999). Sprains, cartilage injuries, dislocations, as well as degenerative conditions such as bursitis, tendonitis, and osteoarthritis (OA) are some of the most common knee injuries that lead to joint pain and malfunction. Complete knee function is essential to maintaining stable ambulatory movement and preventing disability among a wide range of ages. Knee flexion and extension are essential for walking, squatting, stepping, and many other daily tasks, not including exercise requirements. Jadelis, Miller, Ettinger, and Messier (2001) found that knee strength played the most significant role in maintaining balance among the elderly.

A knee injury threatens an individual’s ability to perform daily tasks as well as regular aerobic exercise (Bookwala, Harralson, & Parmelee, 2003). Unfortunately, the knee is the most susceptible joint to injury because of its vulnerability to lateral movements and horizontal blows.
such as those associated with contact sports. However, knee injuries are equally likely among non-athletes.

Damage to meniscus cartilage typically requires arthroscopic surgery in which the damaged cartilage is removed. When large portions of the meniscus are removed, the articular surface is exposed, further compromising the shock-absorbing ability of the joint and often leading to intense pain. Degeneration of the articular cartilage leads to osteoarthritis and often results in loss of fitness, impaired physical functioning, and disability (Andersen, et al., 1999).

When undue stress and tension is placed on a ligament, it stretches in attempt to maintain stability at a joint. Stretched ligaments remain stretched but can only stretch approximately 6% of their length before they snap. Anterior cruciate ligament injuries are becoming increasingly prevalent in competitive and recreational sports. ACL injuries require surgery and lengthy rehabilitation in order regain strength, range of motion, and mobility. Instances of ACL injuries have been linked to increased instances of knee pain (Neyret, Donell, & Dejour, 1993).

**Structure of the knee**

Understanding the structure of the knee joint is crucial when discussing not only injuries but exercise as well. The knee joint is the largest and most complex joint in the human body (Hamilton, & Luttgens, 2002). Each day the knee joint is subject to severe stresses and strains due to its role in supporting the body during weight bearing locomotion. The knee must be able to accommodate stresses from numerous angles and employ various structural aides. Strong ligaments and powerful musculature make the knee ideally suited for meeting stability and mobility requirements, including flexion, extension, and inward and outward rotation from a flexed position.
Located at the distal end of the femur are the medial and lateral condyles that rest on two concave areas at the top of the broad head of the tibia. On the anterior side of the condyles is the patellar surface, where the patellar articulation is located. The patella (knee cap) is a sesamoid bone that is held in place by the quadriceps tendon above, the patellar ligament below, and the fibers that form a pocket for the patella (Marieb, 2001).

The articular surfaces of the concave areas located on the head of the tibia are covered with circular rims of fibrocartilage called menisci. Menisci are thick around the outer borders but taper to a thin edge along the inner circumference. Menisci serve primarily as shock-absorbers during movement. The lateral meniscus closely adheres to the shape of the articular facet and almost connects at the center of the joint. The “C” shaped medial meniscus is less freely movable than the lateral meniscus because it is anchored to the medial collateral ligament and the medial side of the knee.

Knee ligaments are designed to resist lateral stresses as a result of muscle action. The patellar ligament is a strong, flat ligament that connects the lower patella to the tuberosity of the tibia. It is sometimes referred to as the patellar tendon because its fibers are continuations of the quadriceps femoris tendon (Marieb, 2001).

The two collateral ligaments serve to check and prevent certain motions. The band-like medial collateral ligament is broad, flat, and membranous. It is attached at the medial epicondyle of the femur and the medial condyle of the tibia, as well as to the medial meniscus. The medial collateral ligament prevents lateral motion of the knee. The strong, rounded cord, known as the lateral collateral ligament is attached to the back of the lateral epicondyle of the femur and the lateral surface of the head of the fibula. It serves to prevent medial movement of the knee.
Two ligaments that are part of the knee joint but not enclosed within the joint are the two cruciate ligaments: the anterior cruciate and the posterior cruciate ligaments. Both are strong, cordlike ligaments that cross each other and attach to the tibia. They limit extension and prevent rotation while in an extended position. In addition, they also prevent the femur from sliding backward on the tibia, maintaining stability of the knee. The posterior cruciate is a shorter, stronger ligament than the anterior cruciate ligament (Hamilton, & Luttgens, 2002).

**Musculature of the knee joint**

The musculature responsible for movement of the knee joint can be classified as anterior, which cause extension, and posterior, which causes flexion. The anterior muscles include the muscles of the quadriceps femoris group. This group consists of the rectus femoris and the vasti: vastus intermedius, vastus lateralis, and vastus medialis. The 4 muscles of the quadriceps group converge into a tendon that crosses and completely encases the patella. The patellar ligament is a continuation of the quadriceps tendon. A contraction of any of the components causes knee extension (Callaghan, & Oldham, 1996). Balanced muscular activity between the vastus medialis obliquus (VMO) and the vastus lateralis (VL) is crucial to maintain stabilization of the patella (Lam, & Ng, 2001).

The posterior muscles of the knee joint consist mainly of the hamstring group. The hamstring group, consisting of the biceps femoris, semimembranosus, and semitendinosus, along with the sartorius, gracilis, popliteus, and the gastrocnemius act to cause flexion of the knee.

When the knee is in a position of full extension, static action by the quadriceps pull and set the patella. This pull is often referred to in rehabilitation settings as the Q angle. The Q angle is measured at the intersection of lines drawn from the center of the patella to the anterior superior iliac spine and from the tibial tuberosity to the center of the patella. Normal Q angles
range from 8-17 degrees and are usually higher in females than in males. Large Q angles have been associated with increased incidence of patellofemoral problems (Hamilton, & Luttgens, 2002).

**Patellofemoral syndrome**

Unlike degenerative conditions, patellofemoral syndrome (also called anterior knee pain) afflicts those without prior instance of injury. Patellofemoral syndrome is the most common musculoskeletal condition among children, adolescents, and adults (Ruffin, & Kinningham, 1993). It is most frequent in the 16-25 year age group (Witvrouw, Cambier, Danneels, Bellemans, Werner, Almqvist, & Verdonk, 2003). When experiencing patellofemoral syndrome, it is difficult for a patient to pinpoint the exact location of the pain or a specific instance of injury. Patients typically describe the pain location as around the knee cap and more intense following activity. Prolonged sitting, ascending and descending stairs, in addition to physical activity, exacerbate patellofemoral knee pain (Callaghan, & Oldham, 1996).

Rehabilitation procedures for patellofemoral syndrome involve improving VMO strength and function and knee stability. Exercises such as seated leg extensions are frequently prescribed for patellofemoral syndrome. Callaghan and Oldham (1996) suggested further studies evaluating the EMG activity for the rectus femoris, VMO, and vastus lateralis during straight leg raises, as well as other rehabilitation exercises for patellofemoral syndrome.

Alaca, Yilmaz, Goktepe, Mohur, & Kalyon (2002) examined the effect of isokinetic exercise on functional capacity and pain in those diagnosed with patellofemoral syndrome. Each participant performed 3 tests: six-meter hopping, three-step hopping, and single-limb hopping. Peak torque, total work, average power, and endurance ratios were measured during each test. The treatment period lasted for 6 weeks, and at the conclusion, functional and isokinetic
variables improved significantly, as did pain scores. The researchers concluded that the treatment program effectively prevented VMO power loss as a result of patellofemoral syndrome.

**Osteoarthritis**

Osteoarthritis (OA) is the most common degenerative disease and affects over 14 million individuals. Previously, OA was associated with the elderly, but the World Health Organization reported that knee osteoarthritis is the fourth most common cause of disability in all women and the eighth in men (Vad, Hong, Zazzali, Agi, & Basrai, 2002). Osteoarthritis is often referred to as “wear-and-tear arthritis” and results from more cartilage being destroyed than replaced (Braham, Dawson, & Goodman, 2003), although severe knee injuries, such as ACL tears, have been associated with increased risk of developing osteoarthritis. Knee osteoarthritis is the second most common form, behind only OA of the hand (Ettinger, Jr., & Afable, 1994).

Osteoarthritis of the knee develops as a result of degeneration of the articular cartilage in the knee joint. Factors such as aging, obesity, and physical injury all contribute to the degeneration of joint cartilage (Braham, Dawson, & Goodman, 2003). Sports and activities that subject joints, including the knee, to repeated, high-impact shock absorption requirements increase the risk of developing arthritis. Spector et al. (1996) made similar conclusions. Among ex-elite middle distance runners and female tennis players, OA increased in both the hip and knee joints in the ex-elite athletes.

Although most OA risk factor studies concluded that greater training volumes and longer training periods were associated with increased instance of OA, Konradsen, Hansen, & Sondergaard (1990) found that among a cohort of ex-long distance runners with identical age, body weight, and height, there was no significant difference in onset of OA.
Few researchers have devoted much attention to theories of osteoarthritis progression. Saxon, Finch, and Bass (1999) outlined 3 models for the development of osteoarthritis: “too much physical activity or sport participation, sports injuries and overuse injuries as a result of damage and repetitive use, and the result of surgery and/or poor rehabilitation strategies.” Obesity and prior instance of surgery in particular increased the risk of knee osteoarthritis. Age also affected an individuals’ likelihood of the onset of OA.

Kujala, Kaprio, Sarna (1994) found that among retired weightlifters, soccer players, and long distance runners, more weightlifters and soccer players had developed OA. Previous injury also accounted for increased OA, as well as increased lifetime hours of training. Of the athletes who had knee injuries, 50% developed osteoarthritis of the knee.

Because of the prevalence of OA, various treatment methods have been explored. Despite research-based criticism of traditional therapy-based rehabilitation strategies, Vad et al. (2003) advocated a 5 stage non-surgical rehabilitation approach. The goals of stage 1 included reducing swelling within and around the joint, controlling inflammation, and managing pain. Secondary objectives of stage 1 included improving range of motion (ROM) and motor control of the quadriceps group.

During stage 2, non-weight-bearing exercises, such as straight leg raises or seated knee extensions, were implemented to begin retraining lower leg muscles through isometric contractions, in order to protect the knee during action.

The third phase of rehabilitation involved progression to closed kinetic-chain exercises such as leg press that minimized the ground reaction forces on the patellofemoral joint. Proprioceptive exercises and stationary cycle regiments were also introduced as the patient progressed.
Phase 4 of rehabilitation involved the gradual return to sport or functional level before injury and minimizing risk of re-injury. Concentric and eccentric training were prescribed in addition to exercises to enhance neuromuscular responsiveness.

During the fifth and final stage of rehabilitation, the patient was advised to continue a maintenance program 2 to 3 times per week (similar to exercises performed during rehabilitation) to reduce the risk of re-injury. At this point, the patient was allowed to resume normal exercise. Some researchers have documented that exercise interventions, not physical therapy, can reduce pain and improve function, especially among older adults.

Considering the prevalence of osteoarthritis of the knee, relatively few research studies have been conducted evaluating the effects of exercise programs in reducing pain and restoring functional performance. Petrella (2000) conducted a review of 17 randomized controlled trials evaluating the effectiveness of exercise treatment on pain, self-reported disability, and walking. In all but one of the studies, all variables were improved with various exercise treatments.

In a study performed by Ettinger et al. (1997), 439 adults 60 years of age and older participated in an 18 month program. The participants were divided into 3 groups: aerobic exercise, resistance exercise, and health education. At the conclusion of the program, each of the exercise groups experienced a reduction in knee pain.

Kovar et al. (1992) and Schilke, Johnson, Housh, and O’Dell (1996) used an exercise group and a control group and found that pain decreased only in the exercise groups. Mangione et al. (1999) and Fisher, Gresham, and Pendergast (1993) experienced similar results, despite different program designs. The participants ranged in age from 60 years old to 71 years old, while the program duration varied from 8 weeks to 18 months. Mangione used a high- and low-
intensity cycle program, but both groups had decreased pain. Schilke used one strength training group and a control group. There was a decrease in pain in the group that strength trained.

A study conducted by Coleman, Buchner, Cress, Chang, and deLateur (1996) among 105 adults who were 75 years old among 4 groups (strength training, endurance training, combination, and control) showed no change in pain for any group. Petrella (2000) concluded that those outcomes could be attributed to different exercise programs or scales used to evaluate pain.

While research is limited, most researchers concluded through their studies that exercise interventions were effective in reducing pain and disability associated with osteoarthritis of the knee.

**Knee pain and exercise participation**

Despite evidence from research studies that show improvements in knee joint pain through exercise programs, high levels of obesity indicate that most adults are not accumulating the daily minimum amount of physical activity and exercise as recommended by the ACSM. Previous studies, including the ones discussed in this chapter, have largely neglected any psychosocial component related to exercising with pain. Limited research exists regarding pain anxiety and activity in those with chronic pain. Keen, Dowell, Hurst, Klaber Moffett, Tovey, and Williams (1999) studied how individuals with low back pain perceived physical activity. According to responses, the participants viewed physical activity as “activities of daily living, activities causing breathlessness that they went out of their way to do, and more competitive-type activity.” Each participant underwent treatment that successfully reduced their low back pain. However, participation in physical activity following treatment was hindered by fear of pain.
returning despite the fact that the majority of respondents knew that being physically active eased their low back pain.

Ettinger and Afable (1994) recommended further research examining psychosocial factors as modifiers of the relationship between disease and disability in the elderly with OA. They suggested that certain personality traits, such as dispositional optimism, may provide key insight into understanding physical disability. They defined dispositional optimism as “generalized positive outcome expectancies,” which has been associated with more rapid recovery from surgery or other illness. They postulated that in some individuals, this optimism might buffer the effect of knee OA on physical disability. Other variables like pain coping strategies might also interact with an individual’s personality to affect their level of disability as a result of OA.

Currently, no such studies exist for knee pain. However, the notion of pain-related anxiety can be applied to all injuries, not just low back injuries. Stages of rehabilitation are tailored to acclimate the patient to gradual increases in physical activity and exercise capacity. The topic of pain-related anxiety as a barrier to exercise and physical activity is definitely worthy of further exploration. While numerous studies have shown pain reduction due to exercise, it continues to prevent individuals from accumulating the necessary exercise to improve their health and risk of early death as a result of diseases associated with inactivity. Perhaps better treatment strategies for osteoarthritis and patellofemoral syndrome, as well as other joint pains, can be developed to help assuage patients’ fears and encourage them to continue physical activity without worrying about pain or re-injury.

Existing research indicates that knee pain can be improved through strength training and aerobic exercise programs. Strength gains in the vastus medialis and vastus lateralis provide
greater knee stability and are largely responsible for improvements in pain. Despite the role of exercise in management of chronic pain, high levels of activity and sports participation have also been associated with increased risk of developing osteoarthritis and patellofemoral pain. Individuals who participate in certain sports such as soccer and football are also more likely to experience serious knee injury, which increases their susceptibility to knee pain as result of osteoarthritis or patellofemoral pain. Loss of vastus strength due to immobility or surgery makes the knee even less stable and more prone to injury.

The dichotomy of exercise and pain presents a complex problem for physicians and therapists alike. Although exercise improves pain, its association with increased risk for developing OA and patellofemoral syndrome has been shown to prevent individuals recovering from injury from accumulating activity in accordance with the recommendations of the ACSM. Future research examining the psychosocial implications of pain related anxiety as a barrier to exercise would prove beneficial for health professionals, such as physical and occupational therapists working to restore function to their patients.
References


