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RESEARCH ARTICLE

PATHOPHYSIOLOGY OF KNEE OSTEOARTHRITIS AND IMPORTANCE OF QUADRICEPS STRENGTHENING IN REHABILITATION

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ABSTRACT

Knee osteoarthritis is the most common degenerative disease affecting about 17% people age over 45 and 40% of people age over 65.
The purpose of this article is to understand the role of quadriceps muscles and pathophysiology behind the development of knee osteoarthritis.
Knowing pathophysiology is very important for effective management of condition. Quadriceps muscles play an important role in pathogenesis of knee OA.Greater quadriceps strength is associated with lower risk for development of tibiofemoral OA.
So this research aim to discuss various pathophysiological mechanism for OA and how quadriceps strength is important for management of condition.

INTRODUCTION

Osteoarthritis (OA) of the knee is the most common type of arthritis and the major cause of chronic musculoskeletal pain and mobility disability in the elderly, and therefore represents a significant burden on healthcare provision. It is being encountered with increasing frequency as the population continues to age. Risk factors of OA of the knee include older age, female sex, obesity, osteoporosis, occupation, sports activities, previous trauma, muscle weakness or dysfunction, proprioceptive deficit and genetic factors.

In primary OA of the knee, varus alignment increases the risk of medial OA progression and valgus alignment increases the risk of lateral OA progression. Optimal management of patients with OA of the knee requires a combination of non-pharmacological and pharmacological therapies. Conservative treatment is advocated in patients with mild to moderate OA of the knee. Because muscle weakness is associated with pain and physical dysfunction and influences the progression of the disease in patients with OA of the knee, muscle strengthening is a key component in cases of OA. The objective of this paper is to discuss the effectiveness of exercise for OA of the knee based on a review of the literature.

Pathophysiolody of Knee oa

OA is char acterized by a no inflammatory deterioration of the particular cartilage with reactive new bone formation at the joint's surface and margins. Whether this new bone formation originates from the cartilage or from the subchondral bone is still uncertain. Many authors (Anderson J*et al*, Acheson R *et al*) have considered that the primary lesion of OA is in the articular cartilage, in which the earliest change is diminution of mucopolysaccharide chondroitin sulphate relative to the collagen in the matrix. This depletes the ground substance and unmasks the collagen. Normally, the matrix dissipates stresses hydrostatically. However, when the collagen is unmasked, its fibers are subjected to excessive flexural and torsional stresses, leading to their rupture. This produces the characteristic lesions of early OA. Much like bone, the health of cartilage depends on the mechanical loading it experiences. Cartilage is an avascular tissue, and the chondrocytes within it depend on diffusion and convection for nutrition. The cyclic loading induced by everyday activities produces deformations, pressure gradients, and fluid flows within the tissues that enhance this process. Laboratory and animal investigations have shown that mechanical stress has a direct effect on the synthetic and catabolic activities of chondrocytes (Akeson W *et al*, Ratcliffe A *et al*). Moderate to strenuous articular loading, such as that associated with regular distance running, seems to have no adverse affects on the health of normally congruent joints.

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However, high-impact joint loading, through either a single traumatic event or through repetitive events of less severity, may also lead to joint degeneration (Radin E *et al*, Thompson RC *et al*). On the other hand, too little loading can be equally detrimental, and disuse has been shown to have adverse, but reversible, effects on cartilage health (Palmoski J *et al*, Setton L *et al*). However, normal loads can accelerate degeneration in deformed, unconstrained, or damaged joints because of instability of the arthritic joint and uneven loading force (Moskowitz R 1992). Therefore, increasing the stability of an arthritic joint helps prevent further deterioration. Therapeutic exercise in OA may prevent accelerated degeneration caused by disuse without causing further degeneration and pain as a consequence of joint deformity or incongruence. Several recent longitudinal studies conclude that carefully controlled exercise programs designed primarily to address OA of the knee are beneficial (Kovar PA *et al* 1992, Van Baar ME *et al* 1998). Among the benefits reported were increased joint mobility, increased strength, and enhanced activity performance. The therapeutic effects of different exercises were evaluated by changes in the visual analogue scale (VAS) (Dalton JA *et al* 1998), ambulation speed (AS), Lequesne index (LI) (Lequesne M. 1982) and peak torques of knee flexion and extension.

Mechanical factors have been implicated in the etiology and progression of knee osteoarthritis (OA) [1,2]. In particular, knee alignment is thought to play an important role [3, 4]. Knee alignment determines load distribution across the knee. During normal gait, 70% of knee joint loading passes through the medial compartment [5] due to the ground reaction force passing medial to the knee joint. Malalignment is a local joint factor that can affect how well the knee copes with imposed forces. Varus malalignment, commonly associated with medial tibiofemoral OA, serves to increase the moment arm of the ground reaction force and further increase loading in the medial compartment [6, 7]. As a result, varus malalignment is a major contributing factor to OA progression in this compartment [4, 8, 9]. Quadriceps strengthening exercises are commonly prescribed for patients with knee OA because they can reduce pain and improve function [10–12]. However, little is known about their effects on knee loading and disease progression, and it is unclear whether these effects are influenced by the presence of knee malalignment. A recent longitudinal study found that greater quadriceps strength at baseline increased the risk of disease progression in patients with malaligned knees but not in those with neutrally aligned knees [13]. The authors suggested that the inability of malaligned knees to evenly distribute muscle forces could result in greater structural progression in these joints. It is also possible that greater quadriceps strength increases compressive forces across the knee joint [14], and that these effects may be accentuated with knee malalignment. In other words, local joint abnormalities such as malalignment could render muscle forces pathogenic [3, 15]. Increased knee joint loading has been associated with an increased risk of disease progression [16.] A commonly used surrogate measure of medial knee loading is the external knee adduction moment as determined from 3- dimensional (3-D) gait analysis. The knee adduction moment is directly related to the ratio of medial to lateral joint reaction force, and a higher knee adduction moment is indicative of higher medial compartment joint load [5, 14, 17.] The peak knee adduction moment has been shown to be closely related to both the severity [18] and progression of knee OA [8.] Thus, the knee adduction moment is widely accepted as a biomechanical marker of medial knee OA disease progression. Author state that no study to date has evaluated the effects of quadriceps strengthening on the knee adduction moment in people with knee OA. This study aimed to examine whether the effects of 12 weeks of quadriceps strengthening on the knee adduction moment, pain, and function in people with medial knee OA differ in those with and without varus malalignment. They hypothesized that varus malalignment would attenuate the effects of quadriceps strengthening, resulting in a higher knee adduction moment and poorer symptomatic outcomes. (Does knee malalignment mediate the effects of Quadriceps strengthening on knee adduction Moment, pain, and function in medial knee Osteoarthritis? A randomized controlled trial.Boon-whatt lim *et al*. Arthritis & Rheumatism (Arthritis Care & Research) Vol. 59, No. 7, July 15, 2008, pp 943–951)

Quadriceps Strengthening Exercise

(A Clinical Trial of Neuromuscular Electrical Stimulation in Improving Quadriceps Muscle Strength and Activation Among Women With Mild and Moderate Osteoarthritis. Riann M. Palmieri-Smith, Abbey C. Thomas, Carrie Karvonen-Gutierrez, MaryFran Sowers. *Phys Ther.* 2010; 90:1441–1452.)

Quadriceps muscle weakness is commonly associated with tibiofemoral OA, [19, 20] is linked with physical disability, [21] and may play a role in disease pathogenesis.[22] Quadriceps muscle strength (force-generating capacity) appears to be highly related to functional performance,[23] and minimizing weakness has been shown to result in clinical or mechanical improvements in a variety of populations. [24–25] Enhancing quadriceps muscle strength, therefore, is considered to be of benefit, as it may improve quality of life. Research is limited on the benefits of quadriceps muscle strengthening early in the OA disease process, as most investigations have targeted people in the end stages of the disease or following total knee arthroplasty.[26] Improving quadriceps muscle strength during the early stages of the disease process may prove beneficial, not only for maximizing function and minimizing pain but also for delaying the rate of disease progression. Furthermore, enhancing quadriceps muscle strength in people with radiographic evidence of the disease who are without symptoms may contribute to preventing the onset of symptomatic OA.[27]

Neuromuscular electrical stimulation (NMES) delivered at high intensities to the quadriceps muscle has been successful at improving quadriceps muscle strength and activation in patients who have undergone anterior cruciate ligament reconstruction and total knee arthroplasties. [28–29] However, the efficacy of NMES to improve quadriceps muscle function in people with early-stage OA is lacking.

(Agility and Perturbation Training Techniques in Exercise Therapy for Reducing Pain and Improving Function in People With Knee Osteoarthritis: A Randomized Clinical Trial .G. Kelley Fitzgerald, Sara R. Piva, Alexandra B. Gil, Stephen R. Wisniewski, Chester V. Oddis, James J. Irrgang. *Phys ther.* 2011; 91:452-469.)

Exercise therapy programs for knee OA traditionally have been impairment based in design, focusing on impairments associated with knee OA such as lower-extremity joint motion deficits, muscle weakness, and reduced aerobic capacity(.Zhang W *et al* 2008, American College of Rheumatology Subcommittee on Osteoarthritis Guidelines Recommendations for the medical management of osteoarthritis of the hip and knee: 2000 update. Arthritis Rheum).Although these programs may be effective in improving these impairments, they do not provide the individual with exposure to other challenges of motor function (eg, quick stops, turns, and changes in direction; challenges to balance; negotiating obstacles) that may be encountered during daily functional activities. Overall physical function might be further improved if individuals with knee OA were better prepared to deal with these challenges to motor function. This improvement in overall physical function might be accomplished if individuals were exposed to such challenges in motor function in conjunction with traditional impairmentbased exercise therapy programs. It also is well recognized that some people with knee OA may complain of knee instability (Fitzgerald GK *et al* 2004, Schmitt LC *et al* 2008). Patients usually describe this knee instability as "giving way" or "buckling" of the knee during activities of daily living. The prevalence of self-reported instability among people with knee OA has ranged from 11% to 44% and has been shown to be correlated with reduced functional ability (Fitzgerald GK *et al* 2004, Schmitt LC *et al* 2008). There is evidence that complaints of knee instability contribute to reduced function in people with knee OA above and beyond what is explained by impairments such as knee pain, quadriceps muscle weakness, and limited joint motion (Fitzgerald GK *et al* 2004). This evidence may indicate that in order to enhance functional gains with exercise therapy, exercise programs should include activities that will address problems with knee instability. Therapeutic exercise approaches have been shown to reduce complaints of knee instability in some people with anterior cruciate ligament (ACL) injury (Fitzgerald GK *et al* 2000). These approaches included the use of lower-extremity strengthening as well as agility and perturbation training techniques. Agility training techniques involve quick stops and starts, cutting and turning, and changes in direction. Perturbation training incorporates the use of roller boards and wobbles boards to challenge balance and knee stability.

The idea is that exposing individuals to activities that challenge the knee to potentially destabilizing loads during therapy may help them learn to deal with these loads when encountered in regular daily activity. Adding these types of training techniques to standard rehabilitation programs was found to be more effective in reducing dynamic knee instability (or improving dynamic stability) upon return to high-level physical activity than an impairment-based standard program in people with ACL deficient knees (Fitzgerald GK *et al* 2000). The purpose of the current study was to formally test the effectiveness of adding agility and perturbation training to an exercise therapy program in comparison with the same exercise therapy program without agility and perturbation training for people with knee OA in a randomized clinical trial. They hypothesized that participants who received agility and perturbation training techniques in conjunction with a standard exercise therapy program would have greater improvements in physical function compared with those who received only the standard exercise program.

Several studies have demonstrated that strength training (ST) decreases joint stiffness and increases muscle strength and proprioception in patients with knee OA. (Bouet V *et al* 200, Huang MH *et al* 2003, Jan MH *et al* 2008, Marks R. 1994). Proprioception not only allows humans to detect position and motion of limbs and joints (Lephart SM *et al*, Lord SR *et al* 2003, Sturnieks DL *et al* 2004) but also provides sensation of force generation to allow for better regulation of force output. (Baker V *et al* 2002, Hurley MV *et al* 1998, Williams GN *et al* 2001) Furthermore, Hurley *et al* and Sharma *et al* have reported that proprioception is closely related to functional performance and walking speed.

Segal NA *et al*. (Nov 2011) conducted a study to find out the relationship between quadriceps muscle strength and risk for knee OA and they conclude that quadriceps muscle plays a significant role in incidence of radiographic knee OA.In addition, greater muscle strength is associated with a lower risk for progression of tibiofemoral joint space narrowing and cartilage loss in women.

Systematic reviews and meta-analyses of studies have established the beneficial effects of exercise in patients with mild to moderate OA of the knee, including muscle strengthening and aerobic exercises which have been reported to be effective in reducing pain and improving physical function[van Baar ME *et al* 1999, Fransen M *et al* 2009]. With regard to aerobic exercise, walking programs, aquatic exercise, jogging in water, yoga, and Tai Chi have been shown to be effective in improving the functional status, gait, pain, and aerobic capacity in people with OA of the knee [Fransen M *et al* 2003, Crow TJ 2004]. Both high and low intensity aerobic exercise appear to be equally effective in improving a patient's functional status, gait, pain and aerobic capacity for people with OA of the knee[Brosseau L *et al* 2003]. Bennell *et al* reported that strengthening exercise appears to be superior to aerobic exercises in the shortterm for specific impairment-related outcomes (e.g. pain), whereas aerobic exercise appears to be more effective for functional outcomes in the long-term in patients with OA.

In contrast, Brosseau *et al* has reported that aerobic exercise in general is more beneficial for the OA patient than no exercise at all, and is superior or equivalent to strengthening exercise. However, Roddy *et al* showed that both aerobic walking and home-based muscle strengthening exercises reduced pain and disability in cases of OA of the knee and that there were no significant differences in effects between the two types of exercises. Although it still remains controversial as to which type of exercise programs may be more effective for the treatment of OA of the knee, this line of evidence does indicate the short-term beneficial effects of both muscle strengthening and aerobic exercises on the pain, muscle strength and physical function in patients with mild to moderate OA of the knee. Although muscle strengthening exercise has been shown to improve pain and physical function in patients with OA of the knee, it appears that facility-based supervised exercise is superior to independent home-based exercise for pain reduction.

DISCUSSION

A review of the literature has suggested that muscle strengthening and aerobic exercises are effective in reducing pain and improving physical function in patients with mild to moderate OA of the knee. The effects of high-resistance strength training are not always greater than those of low-resistance strength training in patients with OA of the knee (Jan MH *et al* 2008). Although there is still no evidence that the type of strengthening exercises (isometric, isotonic, isokinetic, concentric, eccentric and dynamic) have an important impact on the program outcome (Pelland L *et al* 2004), isometric and isotonic strengthening exercises may be practical. A recent report shows that patients with OA of the knee demonstrate significant weakness of the hip musculature compared with asymptomatic controls (Hinman RS *et al* 2010). Intervention studies show that targeting hip, rather than only knee musculature, represents an effective biomechanically based treatment option for medial knee OA (Thorp LE *et al* 2010) and that hip strengthening reduces symptoms in patients with medial knee OA and varus malalignment (Bennell KL *et al* 2010). Therefore, not only the knee extensor and flexor muscles but also the hip muscles should be trained in order to maintain the effect of exercise on muscle strength in patients with OA of the knee. In conclusion, based on the review of the literature, it has been shown that muscle strengthening and aerobic exercises are effective in reducing pain and improving physical function in patients with mild to moderate OA of the knee.

CONCLUSION

Understanding pathophysiology and quadriceps role in development of this condition will guide therapist to rehabilitate the condition effectively.

Summary: In summary, understanding the pathophysiology of the knee osteoarthritis can guide treatment of knee joint pain and can shorten the length of treatment, effectively cutting medical costs and more importantly, decrease the patient's suffering therefore improving the patient's quality of life.

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