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Effect of a Progressive Functional Exercise Program on Pain and Functional Performance in a Patient with Knee Osteoarthritis

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Abstract: ***Background: Knee osteoarthritis causes pain, weakness and functional limitations. Case presentation: A 52-year-old female with osteoarthritis of the left knee and a Baker's cyst presented with pain and difficulty in walking and climbing stairs. Objectives: To evaluate the effect of progressive functional exercises on pain and functional performance. Intervention: 4-week progressive exercise program including strengthening, stretching, range of motion, balance and functional training. Result: Pain, strength, ROM, TUG and WOMAC scores improved. Conclusion: Progressive exercises improved pain and functional performance in KOA.***

Keywords: Knee Osteoarthritis, Progressive Exercises, Knee Pain, Functional Performance, Baker's Cyst

1. Introduction

Knee osteoarthritis (KOA) is the most common form of osteoarthritis and a leading cause of pain, disability and impaired physical function in middle-aged and older adults. It is a chronic, degenerative joint disease with progressive destruction of articular cartilage, remodeling of subchondral bone, development of osteophytes and varying degrees of synovial inflammation These changes in the structure of the joints can lead to pain, stiffness, muscle weakness, poor balance and problems with such activities as walking, climbing stairs and rising from a chair.Quadriceps muscle weakness is a major clinical feature of KOA and contributes to decreased knee stability and functional decline. Therefore, progressive functional strengthening of the quadriceps has become an integral part of conservative physiotherapy management to improve pain, muscle strength and daily functional performance.

Definition

Knee osteoarthritis (OA) is a progressive and degenerative disorder of the synovial joints characterized by degeneration of the cartilage, changes in the subchondral bone, upgrowth of osteophytes and mild inflammation of the synovium. You may develop pain, stiffness, crepitus, limited range of motion, and midrange motion, as well as a gradual loss of physical function. Weakness of the quadriceps muscle can further compromise joint stability and lead to functional limitations.

Etiology

Knee osteoarthritis is a multi- factorial disease with many mechanical, biological, genetic etc., risk factors. Age is one of the most important risk factors because the regenerative capacity of articular cartilage decreases with age. When the knee joints are subjected to high compressive forces by a force weighing on them, the tissue is damaged by such heavy forces. Another possible cause of knee osteoarthritis is a previous injury to a knee that injured the meniscus or injured the ligaments. Or work that involved regular long periods of kneeling or squatting or exercise at sport.

Epidemiology

Knee OA is a very common musculoskeletal disease in the world and causes much pain and disability to many elderly people. The incidence and prevalence of knee OA increase dramatically with age, especially after age 50, because of the progressive degeneration of the articular cartilage that occurs with aging and the accumulation of mechanical stresses that are applied to the knee joint. Knee OA appears to be more common in women than men, especially after menopause. There is evidence that women have at least a 1.5 to 2 fold higher risk of developing symptomatic knee OA than men. This difference can be attributed to several factors including hormonal changes, increased body weight (obesity) and differences in lower limb biomechanics

The global prevalence of OA was around 365 million, according to the Global Burden of Disease 2019 study. This is the largest number of people with musculoskeletal conditions. Community based studies conducted in India have shown the prevalence rate of knee OA to be in the range of about 22% to 39% The rate of prevalence was significantly higher among the elderly and females. As obesity continues to increase, the number of people who lead sedentary lifestyles increases, and average life expectancy continues to increase, the burden of knee OA is expected to increase worldwide.

The prevalence

Knee osteoarthritis is a major cause of disability in older adults and affects hundreds of millions of people globally. It increases markedly with increasing age and is generally higher in females than males. Studies from community in India have reported a prevalence of knee osteoarthritis of about 22-39% with higher prevalence in older adults and in rural areas. The increasing prevalence of obesity and physical inactivity is anticipated to contribute to the burden of knee osteoarthritis over the coming years. The inadequacy of the quadriceps may elevates joint loading which may generate pain and functional difficulties in knee osteoarthritis individuals.

Anatomy of knee joint: The knee is the largest synovial joint of the body and consists mainly of the tibiofemoral and

patellofemoral joints. It includes the distal femur, proximal tibia and patella. Articular surface is shiny and smooth and is covering the articular cartilages. The medial and lateral meniscus mechanical design increases bone congruency and joint stability and improves the knee shock absorption mechanism. The ACL, PCL, MCL, and LCL are the primary ligaments that provide static stability of the joint capsule. Knee laxity does not cause additional injury. Much of this support is provided by the surrounding muscles, particularly the quadriceps and hamstring muscles. The quadriceps muscle acts through the patellar tendon to extend the knee.

The quadriceps femoris is a large muscle group which consists of four individual muscles (the rectus femoris, the vastus medialis, vastus lateralis and the vastus intermedius). The quadriceps tendon encircles the patella before proceeding to the tibial tuberosity as the patellar ligament.

Biomechanical Functions of the Knee: The knee is described primarily as a hinge joint which allows the movement of flexion and extension along with the internal and external rotation with the flexed position. When terminal extension occurs, the screw-home mechanism takes place whereby an external rotation of the tibia on the femur occurs. This is done to make the joint stable. Knee extension is mainly performed by the quadriceps. This supports action when one walks, negotiates stairs, transfers from sitting to standing, and more. In patients with knee osteoarthritis, the quadriceps' weakness has harmful effects on the dynamic stability of the joint. A slow and gradual increase in strength of the quadriceps will enhance force production, daily activities related to pain and mechanics of knee joint.

Pathophysiology

It is a progressive degenerative disease of the whole joint, due to imbalance of cartilage degradation and repair in knee osteoarthritis. Aging, obesity, joint injury and mechanical stress are risk factors of articular cartilage degeneration and progressive cartilage loss. This is associated with subchondral bone remodeling, osteophyte formation and mild synovial inflammation These changes result in pain, stiffness and joint dysfunction that can lead to reduced activity and quadriceps weakness. The progressive muscle weakness leads to further deterioration of knee stability and functional limitations in activities such as walking, stair climbing, sit-to-stand.

Investigations

1) **Clinical Examination:** Clinical assessment includes evaluation of pain, tenderness, swelling, crepitus, range of motion, muscle strength, gait and overall functional status.
2) Plain radiography (X-ray) Plain radiography is the first line imaging investigation for knee osteoarthritis. It can show narrowing of joint space, osteophytes, subchondral sclerosis and cysts. The severity of osteoarthritis can be determined by the Kellgren–Lawrence classification.
3) Magnetic Resonance Imaging (MRI) MRI is performed in cases where soft-tissue injury or early cartilage changes are suspected.
4) Ultrasonography (USG) Ultrasonography can detect joint effusion, synovitis, Baker's cysts, and other soft tissue abnormalities.
5) Laboratory Investigations, ESR, CRP, rheumatoid factor (RF) and anti-CCP antibodies may be done when necessary to rule out inflammatory arthritis.

Treatment and Management of knee osteoarthritis:

Aims to decrease pain, increase mobility and joint function and improve quality of life. The treatment must be individualized to address the symptoms, functional impairment, clinical findings, and treatment response of the patient. Conservative management is the initial line of treatment. Patient education teaches patients about the disease, activity barriering, joint protection and an active lifestyle. Overweight and obese individuals experience enhanced physical function, alleviated pain, and reduced mechanical stress on the knee as a result of shedding pounds. It should be done progressively, that is, the exercises should be increased according to the patient's pain, function and tolerance ahead Physiotherapy is of cardinal importance and progressive muscle strengthening, flexibility, balance and functional exercises will greatly help improve muscle strength.

Scope

This case study looks at the role of a progressive functional exercise program in the conservative management of knee OA. The study aims to evaluate the efficacy of physiotherapy for pain relief and increase of muscle strength and functional performance and activity of daily living.It also emphasizes individual exercise progression based on the clinical presentation and functional limitations of the patient. The findings may support the use of structured exercise programs as a safe and effective approach to improve functional outcomes and quality of life in patients with knee OA.

2. Case Description

A 52 years old woman presented with pain and disability of left knee. Clinical examination and ultrasonography revealed a Baker's cyst associated with degenerative osteoarthritis of the left knee.

a) Pain around left knee and intermittent swelling. Pain is increased with weight bearing, especially walking and climbing stairs. Day to day functional activities are difficult to perform
b) History of Present Condition Symptoms were associated with left knee osteoarthritis. Functional limitations were found for knee-loading activities, particularly stair climbing and prolonged walking.
c) Radiological Findings (USG of left knee) Few degenerative osteophytes with mild suprapatellar effusion. Cystic lesion between the medial gastrocnemius and the semimembranosus tendons, consistent with a Baker's cyst with distal leakage. Quadriceps and patella tendons, popliteal artery and vein were normal.
d) **Clinical Impression:** Mild degenerative osteoarthritis of left knee with associated Baker's cyst.Pain and functional performance were measured prior to the start of the progressive functional exercise program.

Pre-outcome measurement Baseline assessment was done by using NPRS, WOMAC, MMT, TUG test and knee goniometry. The patient reported moderate pain (NPRS 6/10), quadriceps strength of 4-/5, knee flexion of 115° and impaired functional mobility (TUG 15.2 sec; WOMAC 48/96).

Uniqueness of the Study

This case study evaluates the effectiveness of a progressive functional exercise program in the conservative management of knee osteoarthritis. This study aims at improvement in pain and functional outcome using an individualized progressively structured exercise program to improve daily activities and functional outcome, as opposed to an approach that focuses on pain relief.

Physiotherapy interventions

A controlled program of progressive functional exercises for 4 weeks with 3 sessions per week in the physiotherapy unit with a home exercise programme. The exercises were designed for the patient's tolerance, pain, and function levels. The primary focus was pain relief and strengthening the muscles of the lower limb, improving the movement of the knee joint and ultimately improving quality of life by facilitating activities of daily living like walking, and climbing stairs.

Weeks 1–2: pain management, mobility and muscle activation.

1) Moist hot pack: Patient position: Supine with affected knee supported and exposed. Therapist position: Standing next to the injured knee. ***Procedure:*** A hot pack that was moist and wrapped in numerous layers of towel was applied over the left knee to relieve pain, stiffness. During the application, the skin condition and thermal tolerance level of the patient were monitored. Time required: 10–15 minutes.
2) **Rom Exercises of Active Knee: Patient position:** The patient is supine with the affected limb properly supported and exposed. Therapist position: Standing beside the affected limb. The patient was instructed to actively flex and extend the knee through a comfortable, pain-free/tolerable range. The movement has been done slowly at the end range without any force.10 repetitions for 2 sets
3) **Isometric Quadriceps Exercise:** Patient position: The patient should be in a supine position, the affected knee should be extended and a small towel roll should be placed under the knee. An expert stands beside the crippled limb. Approach: The patient was taught to tighten on his quadriceps and press the towel roll against the posterior aspect of the knee without moving the knee. The contraction lasted for 10 seconds and then relaxed. Ten repetitions of ten seconds each.
4) **Straight Leg raising Exercise:** Patient position: The patient will be supine with the unaffected knee flexed and the affected knee extended. Standing next to the affected limb – therapist position. Under these identical conditions, the patient was instructed to contract the quadriceps of the affected limb while allowing it to float/lie down. The limb was then gently lowered to the starting position. Ten repetitions for 2 sets
5) **Hamstring stretch:** Patient in Supine Position. The therapist stabilizes the low limb and stands beside the affected limb. The knee was straightened, while the hip was gradually flexed until a mild strain was felt at the posterior aspect of the thigh. The stretch was carried out without using a bounce or force on the join. Dosage for 3×30 seconds.
6) **Gastrocnemius Stretch:** The patient stands facing away from a wall, with the leg behind them affected, knee straightened and heel down. The therapist is next to the patient to monitor and assist balance. The participant was instructed to lean forward while the knee of the affected limb was kept extended and heel on the floor until a comfortable stretch was experienced in the calf. The recommended hold time is three times for thirty seconds.
7) **Heel raise:** Patient position: Standing with feet, provide support if needed. The therapist will make sure they are close to the patient for the safety. The individual was instructed to start with both feet on the floor before raising their forefoot so that their heels are raised off the floor without losing contact on the ground. Do two sets of ten repetitions.
8) **Walking training:** Standing position of patient. The therapist can only work at the pace of the patient. The patient was instructed to walk on flat even surface at a comfortable pace. Injury, gait and tolerance were monitored. It will require 10-15 minutes.

Week 3-4: Progressive strengthening and functional training

1) *Advancement of the Straight Leg Raise Position of the patient:* Supine with the affected knee straight. Take a stand along the affected limb. To enhance the legs and knees, initially, straight leg raising was started with progression of repetition as per patient tolerance with the extension of the knee and control of the movement. Reps were increased as tolerated.
2) *Hip abductor strengthening:* The patient should lie on the unaffected side with the knee straight. The therapist will be standing behind the patient to monitor pelvis stability. The patient was instructed to lift the affected leg up and out to the side, keeping the knee straight and pelvis stable before returning to starting position smoothly. Duration: 3 sets of 10 reps.
3) *Sit to Stand training:* The patient is to sit comfortably in a chair with both feet flat on the floor. Therapist position should be in front/side/patient, for safety. The patient was instructed to lean the trunk slightly forward, push through the feet and stand upright. The patient was returning to sitting slowly and in a controlled manner. Two sets of 10 repetitions.
4) *Mini squats:* There will be a stable support available if needed. Feet regularly shoulder-width apart. Therapist's position: Standing in front of or beside the patient to check upon the alignment of the knee. The patient was asked to perform a shallow squat by flexing the hips and knees to a pain-free/tolerable ROM while keeping the knee alignment in place. The patient then went back to standing. Take 2 sets and do 10 reps.
5) *Low Step-Up Exercise:* The patient is required to stand on the step facing the instructor. Position of the therapist: Standing beside the patient for balance and safety. The patient put the injured leg on the step, transferred his weight on to the limb and stepped up in a controlled

manner. The patient slowly descended step by step. Two sets, ten repetitions.

6) *Weight Shift & Balance:* Patient Position: Patient stands with feet apart, holding onto a stable object. Position of the therapist: Standing on the side of the patient. The patient was instructed to shift his weight from one leg to the other with an erect upper body and controlled lower extremities. The exercise went on according to balance and tolerance.
7) *Walking Progressions: Patient position:* Sitting. Therapist position- At first walking next to the patient for supervision. ***Procedure*:** The walking time was increased gradually at a comfortable pace and appropriate gait pattern. Duration: Worked up to 20-25 minutes as tolerated.
8) *Stair Climbing practice:* Patient Position: Standing at bottom of stairs holding onto handrail as needed. Therapist position, Standing at the side/slightly behind the patient for safety and guarding. ***Procedure*:** Initially the patient was trained to walk stairs in a stepwise manner. Gradual progress in stair practice with pain, lower-limb strength and tolerance. The patient showed improvement in pain and functional performance after 4 weeks of progressive functional exercise program.

3. Result

The patient experienced less pain in walking and stair climbing and was able to perform functional activities easily. The patient had improvement in his knee range of motion, muscle performance, and functional performance. After physiotherapy intervention, there was a noticeable improvement in the patient's outcomes. NPR score was down to three out of ten. The study resulted in an improved WOMAC score of 25/96. The strength of quadriceps improved to 4+/5. There was an improvement in the TUG time to 11.8 sec. The patient was able to flex the knee up to 125 °. As a result, we can say there was an improvement in pain, muscle strength, flexibility and functional ability.

4. Discussion

According to the evidence from this case study, exercise rehabilitation of knee osteoarthritis is supported. A 2021 study by Allen and colleagues revealed that exercise programs are beneficial for treating knee Osteoarthritis (OA). According to Ahmad et al. (2023), there were clinically significant improvements in pain and function following a structured home exercise programme. Furthermore, the BEEP Trial (2023) reported improvements in pain and functional outcomes following exercise-based physiotherapy. The current case illustrates the advantage of a personalized progressive functional exercise program, adapted according to one's pain and function, ultimately leading to an improvement in pain and functional performances in daily activity.

The conclusion: Progressive exercise intervention is better than other conservative interventions in knee o/a. The intervention managed pain and improved functionality and efficiency in daily activities of the patient. An individualized and progressively advanced exercise program may be a valuable component of physiotherapy rehabilitation for a knee osteoarthritis patient.

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