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Effects of Community Exercise Rehabilitation on Pain Management, Range of Motion, and Physical Function in Knee Osteoarthritis*

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ABSTRACT

Osteoarthritis leads to muscle weakness, reduced joint range of motion (ROM), and increased pain in the muscles surrounding the knee. This study investigated pain management and joint function recovery after participation of 78 patients with knee osteoarthritis (KOA) in a 12-week community-based exercise rehabilitation program. We assessed the pain associated with KOA and verified knee angles. We measured physical activity function level in terms of muscular endurance, walking in place, timed up-and-go, and single-leg stance tests. Additionally, we used muscular endurance and balance (measurements at 2-week intervals to assess functional recovery and adjust exercise programs. An assessment was performed after the 12-week intervention period. After the intervention, the pain visual analog scale score was significantly decreased ($P < 0.001$). Maximum flexion was significantly increased ($P < 0.001$). Flexion contracture was markedly improved ($P < 0.004$), confirming recovery of knee joint ROM. Moreover, significant improvements were observed in various indicators of physical function, indicating the effectiveness of the individualized exercise rehabilitation programs. Thus, our personalized exercise rehabilitation programs coupled with periodic assessments of pain and joint function were highly effective in facilitating functional recovery. This underscores the necessity for sustained exercise rehabilitation following musculoskeletal disorder treatment. In particular, the protocol for exercise rehabilitation should be tailored to the post-treatment phase and individual functional level.

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1. Introduction

Osteoarthritis is a prevalent chronic degenerative condition characterized by age-related deterioration and damage to the joint cartilage between the bones, leading to pain. The incidence of osteoarthritis is continues to increase worldwide. In South Korea, the incidence of osteoarthritis is highest in individuals aged 70 years and above. However, the age group with the greatest increase relative to the previous year was the 50s, with a notable surge of 184.4% (Health Insurance Review & Assessment Service, 2021). The knee joint, which bears a significant weight load, experiences the highest level of pain (82.6%) due to osteoarthritis (Kim et al., 2021). The resulting pain, joint functional limitations, and reduced quality of life have been documented to have a substantial impact on health indicators (Chen et al., 2020).

Osteoarthritis results in an imbalance of the muscles around the knee. This contributes to muscle weakness, reduced joint range of motion (ROM), and increased pain in the muscles surrounding the knee (Baliunas et al., 2002). Furthermore, as aging progresses, balance ability declines, and physical capacities, such as lower limb strength and core muscle strength, decrease rapidly. Consequently, individuals experience more severe chronic pain because of physical aging (Kim et al., 2021).

Conservative approaches, such as drug therapy, physical therapy, and exercise, are commonly employed to treat osteoarthritis. Exercise has minimal side effects and the reported benefits include symptomatic relief, stress reduction, and joint protection (Callaghan & Oldham, 1996). Resistance exercise offers particular advantages, such as enhanced muscle strength, increased muscle and bone mass, and improved balance and mobility, which are essential for everyday functional abilities (Kim et al., 2020). However, engaging in general exercises that do not align with exercise capacity and with an intensity that is not suitable for patients with osteoarthritis may elevate muscle tension and increase pressure within the knee joint, potentially worsening knee osteoarthritis (Lee & Park, 2013). Therefore, the role of a specialized fitness instructor and thorough assessment of each individual's exercise capacity are crucial.

In exercise rehabilitation for degenerative knee osteoarthritis, a personalized approach based on the treatment methods used and recovery stage of the patient is essential. Following treatment or surgery, many patients experience rapid muscle atrophy, which leads to an abrupt decline in muscle strength. This, coupled with increased joint stiffness and instability, limits daily activities. Therefore, during this phase, interventions, such as reducing swelling, preventing joint constriction, and restoring knee ROM, are crucial (Rejeski et al., 2002). Furthermore, recovery of activities of daily living (ADL) through the stabilization of gait, balance, and coordination is essential. However, in many studies, exercise rehabilitation for knee osteoarthritis has traditionally emphasized improving knee ROM and quadriceps muscle strength (Bade et al., 2012). The application of exercise rehabilitation according to recovery stage remains insufficiently addressed in the existing literature. Failure to engage in rehabilitation during this period not only leads to delayed recovery and increased pain but also negatively impacts the quality of life in daily activities. Moreover, it can influence secondary pain and other conditions. Therefore, the role of post-treatment rehabilitation services is of paramount importance.

Consequently, this study explored the effectiveness of individualized exercise rehabilitation programs conducted at local community exercise centers as a treatment for patients with knee osteoarthritis.

In particular, we investigated whether participation in community-based exercise rehabilitation programs resulted in improvements in pain and joint function recovery.

2. Methods

2.1 Participants

This study recruited 80 participants aged 50 years and above, with a history of knee osteoarthritis, from the local community. After receiving a full explanation of the study, including an explanation that if they experienced discomfort or felt that conditions were inappropriate at any point during the study, they had the right to withdraw from the study, individuals who expressed their willingness to participate voluntarily and provided written informed consent were enrolled. This study was approved by the Research Ethics Committee of G University (Approval No. 1044396-202301-HR-018-01).

The inclusion criteria for the study participants were an age of 50 years or above and previous diagnosis with osteoarthritis by a specialist. Additionally, participants were required to have a sufficient understanding of and capability to perform tasks directed by the researchers. We excluded those who were medically advised to restrict exercise participation and those with neurological issues.

Among the 80 participants initially recruited for the study, 2 withdrew during the course of exercise participation, resulting in a final sample of 78 participants for data analysis. Personal information of the participants was stored in an encrypted form to ensure confidentiality.

2.2 Data collection

In terms of disease-related information of the study participants, we obtained mandatory record access approval prior to the experiment, and recorded clinical characteristics, including medical history, onset date, causes of onset, and KCD code characteristics. General characteristics, such as age, height, and weight, were also recorded. We assessed the pain associated with knee osteoarthritis in the study participants and verified the knee angles. Additionally, we measured physical activity function level through various tests, including muscular endurance (chair stand test), walking in place (2-min walking test [2-MWT]), timed up-and-go (TUG), and balance (single-leg stance test). Additionally, we used muscular endurance (standing and sitting) and balance (single-leg stance test) measurements at 2-week intervals for assessing functional recovery and making program adjustments. A post-assessment was performed using the same methods as during the pre-test after the 12-week intervention period.

2.3 Measuring tools

2.3.1 Pain measurement by visual analogue scale (VAS)

Pain intensity was rated on a VAS with 0–10 points and with the labels “no pain” and “unbearable pain" on the scale's outer ends (Fig. 1). Thus, a high score indicated a high level of perceived pain intensity. The pain intensity was rated as knee pain on the day of assessment.

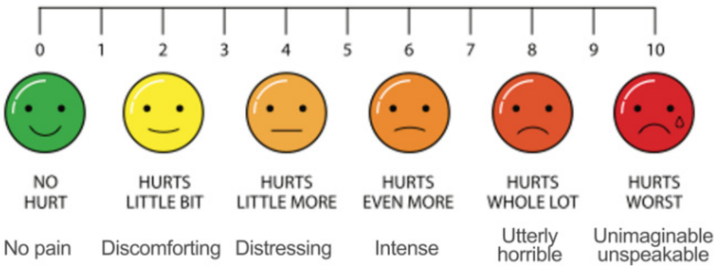

Fig. 1. Universal visual analogue scale conversion

2.3.2 Knee ROM

Knee ROM is most accurately measured by using a goniometer. A goniometer is a specially designed protractor that measures joint angles. The active range of movement of the knees (including presence of maximum flexion ≤140° and flexion contracture [0–10°]) were measured clinically by using a goniometer in the pre-operative period and on the most recent follow-up (Fig. 2).

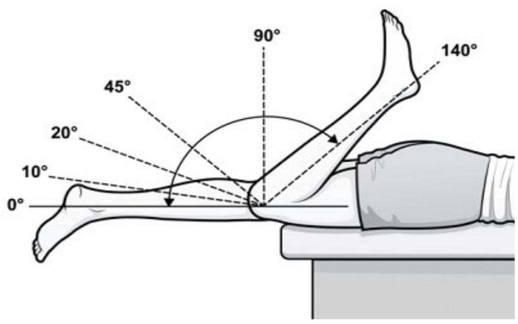

Fig. 2. Measurement of knee range of motion

2.3.3 Muscular endurance (Chair stand test)

The chair stand test is similar to the squat test in terms of measuring leg strength, in which participants stand up repeatedly from a chair for a period of 30 s. The chair was placed against a wall to stabilize it safely. The participants sat in the middle of the seat with their feet shoulder-width apart and flat on the floor. Their arms were bent, crossed at the wrists, and held close to the chest. In the sitting position, the participant stood up completely up and then sat back down completely. This process was repeated for 30 s. The total number of completed chair stands was counted (standing up and sitting down equaled one chair stand). If the participant had completed a full stand from the sitting position when the time elapsed, the final stand was counted in the total (Jones et al., 2000).

2.3.4 Flexibility (Chair sit and reach)

The chair sit and reach test is a variation of the traditional sit-and-reach flexibility test. Participants sat on the edge of a chair (placed against a wall for safety). One foot remained flat on the floor. The other leg was extended forward with the knee straight, heel on the floor, and ankle bent at 90°. One hand was placed on top of the other using the tips of the middle fingers. The participants were instructed to inhale and then, as they exhaled, to reach forward toward the toes by bending at the hip, while maintaining the back straight and keeping the head up. They were told to avoid bouncing or making quick movements and never to stretch to the point of pain. They were to keep the knee straight and to hold the maximum reach position for 2 s. The distances between the fingertips and toes were measured. If the fingertips touched the toes, the score was set as zero. If they did not touch, the distance between the fingers and toes was measured as a negative score. If they overlapped, the distance was measured as a positive score.

2.3.5 Walking in place (2-MWT)

The 2-MWT was used to measure the physical performance of patients who underwent total knee arthroplasty (Rikli & Jones, 1999) and senior tests. During the test, the participant would step in place, and the examiner recorded the number of knee lifts performed within 2 min. Before starting the test, the examiner marked the wall with tape at the midpoint between the anterosuperior iliac spine and middle of the patella. The participants were instructed to begin walking without running when given a signal. For each participant, the examiner counted the number of right and left knee lifts required to reach the mark. Knee elevations that fell short of this mark were not counted. To familiarize themselves with the test, the participants performed a 30-s trial. During the test, the examiner stood next to the participants to ensure their safety and provided verbal instructions to them.

2.3.6 Functional mobility (TUG)

Coordination and agility tests for older people, which is part of the Senior Fitness Test (SFT) Protocol. A chair was placed next to the wall for safety purposes and a marker was placed 8 feet in front of the chair. There was a clear path between the chair and the marker. The participants placed their hand on the knee, placed it flat on the ground, and sat down completely. At the "Start" command (when the timer was started), the participant stood up and walked around the marker as fast as possible (without running), returned to the chair and sat down (at which time the timer was stopped). Each participant performed two attempts in each session (Rose et al., 2002).

2.3.7 Single-leg stance test

For the single-leg stance balance test, participants began by standing 1 m away from a wall, facing the wall. Participants then lifted one leg, while standing on one foot. The time (in seconds) that participants were able to balance on one foot before this foot touched the ground or they lost balance and touched the wall was recorded, with a maximum time of 60 s.

2.4 Statistical analysis

SPSS 23.0 Version (IBM Co., Armonk, NY, USA) was used for data analysis. A paired *t*-test was conducted for analyzing variables before and after the 12-week exercise rehabilitation program. Furthermore, changes in the chair stand test and the single-leg stance test, measured at 2-week intervals throughout the program, were assessed using repeated-measures analysis of variance to examine score differences. Bonferroni post-hoc tests were conducted to investigate differences across measurement time points. For all tests, the significance level was set at $p<0.05$.

3. Results

This study, conducted on 78 individuals aged 50 years and above who had knee osteoarthritis, implemented personalized exercise rehabilitation programs tailored to each participant's pain and physical function level over a 12-week period. The characteristics of the participants are presented in Table 1.

Table 1. Clinical characteristics of participants

		n=78
Age	Year	64.13±7.55
Sex	Male	17
	Female	61
Clinical characteristics	Arthritis, unspecified **(M13.9)**	11
	Gonarthrosis, unspecified **(M17.9)**	7
	Pain in joint **(M25.56)**	9
	Myalgia **(M79.168)**	7
	Internal derangement of knee, unspecified **(M23.99)**	44

After 12 weeks of intervention, changes related to body composition were noted (Table 2). Specifically, a significant weight reduction was observed after 12 weeks of exercise rehabilitation ($P<0.012$). Although the change in body mass index (BMI) was not significant, there was a noticeable trend towards a reduction.

Table 2. Body composition characteristics at the baseline and week 12

		Pre	Post	*P*
Body-composition	Height (cm)	161.26 ± 7.84	161.19 ± 7.64	0.944
	Weight (kg)	62.65 ± 11.05	60.38 ± 11.56	0.012
	Body mass index (kg/m²)	24.07 ± 3.48	23.86 ± 3.99	0.480

* P<0.05, ** P<0.01, *** P 0.001, tested by performing paired t-test,
Data are presented as mean ± standard deviation

Using the VAS as a pain indicator, the participants indicated the level of pain or symptoms they experienced in their knees during daily activities. The results indicated a significant reduction in pain (P<0.001) after the exercise rehabilitation intervention as compared to that before the intervention (Table 3). Knee joint ROM showed a significant increase in maximum flexion (P<0.001), and a significant decrease in in flexion contracture (P<0.004; Table 3).

Table 3. Measurements at the baseline and week 12 in terms of pain, ROM, and SFT

		Pre	Post	*P*
Pain	VAS	4.86 ± 2.51	1.65 ± 1.47	0.001***
ROM	Maximum flexion	115.64 ± 17.14	123.08 ± 14.06	0.001***
	Flexion contracture	5.62 ± 8.61	3.12 ± 4.86	0.004**
SFT	Chair stand test (reps/30 s)	15.88 ± 5.90	28.14 ± 15.05	0.001***
	Chair sit and reach	9.19 ± 9.06	13.22 ± 7.75	0.001***
	2-MWT	88.90 ± 22.68	107 ± 25.35	0.001***
	TUG	7.73(± 1.78)	6.8 ± 2.06	0.001***
	Single-leg stance test	20.99 ± 17.01	40.6 ± 30.57	0.001***

* P<0.05, ** P<0.01, *** P 0.001, tested by performing paired t-test,
Data are presented as mean ± standard deviation,
VAS, visual analogue scale; ROM, range of motion; SFT, Senior Fitness Test; 2-MWT, 2-min walking test; TUG, timed up-and-go

In addition, from a functional perspective, all items in the SFT showed a significant increase, indicating functional recovery. These included the results of the chair stand test (P<0.001), chair sit and reach test (P<0.001), 2-MWT (P<0.001), TUG (P<0.001), and single-leg stance test (P<0.001) (Table 3). Particularly noteworthy was the progressive improvement in functionality observed in the chair stand and single-leg stance tests as measured at 2-week intervals (Fig. 3). This indicated the appropriateness of individualized exercise rehabilitation programs.

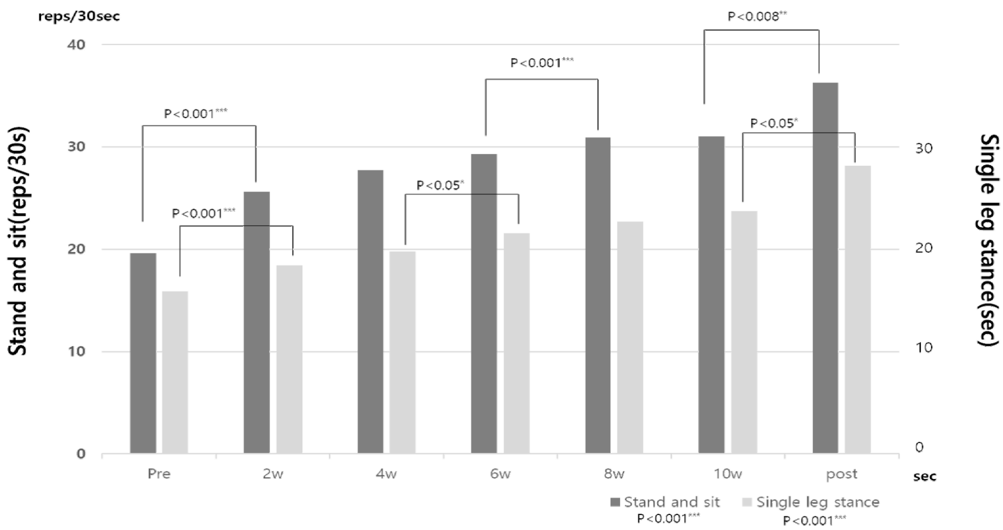

Fig. 3. Changes in physical activity function level in response to exercise rehabilitation programs as measured at 2-week intervals.

Tested by performing repeated measure ANOVA. Post hoc was * P<0.05, ** P<0.01, *** P 0.001

4. Discussion and Conclusion

In the present study, we investigated pain management and joint functional recovery after participation of 78 patients with knee osteoarthritis in a 12-week community-based exercise rehabilitation program. We found that, after the intervention, the pain VAS score was significantly decreased (P<0.001), maximum flexion was significantly increased (P<0.001), and flexion contracture was significantly decreased (P<0.004), indicating recovery of knee joint ROM. Moreover, various physical function indicators showed significant improvements. Thus, our personalized exercise rehabilitation programs coupled with periodic assessments of pain and joint function were highly effective in facilitating functional recovery of the knee joint in patients with knee osteoarthritis.

Pain resulting from knee injury leads to muscle weakening due to reduced sensory input from proprioceptors, thereby causing instability in the knee joint (Reider et al., 2003). Mechanical receptors distributed on the skin and proprioceptors located within the joints and muscles provide information regarding joint-position sense and kinesthesia (Riemann & Lephart, 2002). In particular, the pressure exerted on the patellofemoral joint increases with body weight, particularly during activities, such as ascending stairs, rising from a chair, and engaging in closed-chain exercises. Consequently, elevated pressure may be a risk factor for patellofemoral joint inflammation. Obesity, defined as a BMI of 30 kg/m² or higher, is recognized as a risk factor for knee pain, knee osteoarthritis, and patellofemoral joint arthritis (McAlindon et al., 1996). The 2021 American Academy of Orthopedic Surgeons (AAOS) (2021 American Academy of Orthopedic Surgeons) guidelines recommend weight loss for patients with a BMI of 25 kg/m² or higher who experience patellofemoral joint pain (Brophy et al., 2022). The risk of developing lifelong patellofemoral joint arthritis symptoms in patients with obesity is estimated to be approximately 60%. In a meta-analysis of 30 studies with 4,651 participants, the most effective measures for reducing pain were reported to be a low-calorie diet, exercise, weight loss, and physical activity. One study indicated that, with every 1% reduction in body weight, the Western Ontario and McMaster Universities Osteoarthritis scores for pain, function, and stiffness decreased by 2% (Panunzi et al., 2021). In this study, the participants' BMI measured before the intervention was 24.07 ± 3.48 kg/m². After 8 weeks of exercise rehabilitation, a trend toward a decrease in BMI of 23.86 ± 3.99 kg/m² was noted, although the reduction did not reach statistical significance.

The majority of exercise rehabilitation programs to date have emphasized the strengthening of the quadriceps muscles, which play a significant role in the stability of the patellofemoral joint and can impact factors such as reinjury. Rehabilitation exercises have shown positive effects on pain, swelling, ROM, and muscle function in patients with patellofemoral joint damage. In particular, rehabilitation exercises accompanied by diverse auxiliary tools have been shown to be more effective than conventional resistance exercises in the functional recovery of the lower extremities (Park et al., 2023).

Furthermore, such functional improvements signify restoration of proprioceptive sensitivity. This implies an immediate muscle contractility response to externally applied forces, which is considered crucial for reducing functional instability or reinjury of damaged joints. Therefore, the recovery of proprioceptive sensitivity through exercise programs is an important goal in rehabilitation (Kim et al., 2020).

According to previous studies, regular exercise, including healthy lifestyle habits, alleviates pain and improves joint function associated with patellofemoral joint arthritis. The 2019 Osteoarthritis Research Society International and 2021 AAOS guidelines strongly recommend strength training, aerobic exercise, and neuromuscular exercise (Brophy et al., 2022). Moreover, engaging in physical activity with progressively increasing loads has been shown to enhance joint function and increase the joint ROM (Brosseau et al., 2008; Germanou et al., 2012). Specifically, quadriceps-strengthening exercises with supported knee loading help to reduce pain and improve lower-limb functional abilities (Kim et al., 2020).

However, interventions in exercise rehabilitation should include personalized exercise therapy for each individual. In particular, a thorough educational intervention by instructors providing explanations and exercise guidance with careful consideration of each participant's appropriate exercise intensity (ranging from low to high intensity), frequency, and duration, can be effective in reducing pain, improving ADL, and relieving symptoms of knee arthritis (Chen et al., 2019). According to a study by Hurley et al. (2018) involving 2,372 patients, individuals who did not receive education on exercise rehabilitation tended to avoid daily activities because of the fear that engaging in these might worsen pain or symptoms. In contrast, systematic education for patients with arthritis improved both pain and function and had a positive impact on conservative treatments related to arthritis, as reported by Sinatti et al. (2022).

The 12-week exercise rehabilitation program implemented in this study, aimed at knee pain management and joint function recovery, proved to be beneficial in that it significantly improved knee joint muscle function. Muscle function indicators, assessed at 2-week intervals, indicated a significant positive effect on functional recovery within the exercise rehabilitation setting. This suggests that exercise programs require highly skilled guidance and intervention from instructors. We propose that the provision and management of a systematic exercise program capable of managing degenerative diseases in the context of an increasingly aging population and facilitating functional recovery within the local community could have a positive impact.

Conflicts of Interest

No author has any other conflict of interest to declare.

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