

Effectiveness of Combined Strength and Mobility Training in Enhancing Functional Recovery after Post-Operative Knee Rehabilitation

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Abstract

Post-operative knee rehabilitation is crucial for restoring function, reducing pain, and improving quality of life. This study aimed to evaluate the effectiveness of combining strength and mobility training in post-operative knee patients compared to strength training alone. A randomized controlled trial was conducted with 100 participants who underwent ACL reconstruction or total knee arthroplasty. The intervention group received a combination of strength and mobility exercises, while the control group received strength training only. Outcome measures included knee range of motion (ROM), quadriceps strength, Timed Up and Go (TUG) test, Visual Analog Scale (VAS) for pain, and the Knee Injury and Osteoarthritis Outcome Score (KOOS). Results showed significant improvements in ROM, strength, functional performance, and pain reduction in the intervention group compared to the control group. The combined approach demonstrated superior outcomes in functional recovery and quality of life, supporting its use in clinical rehabilitation.

Keywords: Post-Operative Knee Rehabilitation, Strength Training, Mobility Training, ACL Reconstruction, Total Knee Arthroplasty, Functional Recovery, Pain Management.

Introduction

Knee surgeries, such as anterior cruciate ligament (ACL) reconstruction and total knee arthroplasty (TKA), are commonly performed to restore stability and function in patients with severe knee injuries or degeneration. While these procedures are often successful in addressing structural issues, they result in significant loss of muscle strength, joint mobility, and functional capacity post-operatively (Kim et al., 2011). As a result, effective rehabilitation is essential to restore the patient's ability to perform daily activities, reduce pain, and improve overall quality of life (Moffet et al., 2004).

Traditionally, post-operative knee rehabilitation programs have focused on strength training to rebuild the quadriceps and hamstring muscles, which are vital for knee stability and function (Aicale et al., 2018). However, regaining joint mobility, particularly in terms of range of motion (ROM), is equally important to avoid complications like stiffness and improve functional outcomes (Mutsuzaki et al.,

2017). Mobility training, through exercises aimed at enhancing knee flexion and extension, helps restore the normal movement patterns of the joint and is crucial for returning to activities such as walking, climbing stairs, and sports.

Despite the clear benefits of both strength and mobility training, the literature offers limited evidence on the combined effects of these interventions in post-operative knee rehabilitation. Some studies suggest that an integrated approach may offer superior outcomes by addressing both the mechanical and functional aspects of recovery, yet more research is needed to support this hypothesis (Adams et al., 2012). This study aims to investigate the effectiveness of combining strength and mobility training in improving functional recovery in post-operative knee patients, evaluating outcomes such as pain, ROM, strength, and overall function.

Methodology

Study Design

This study employed a randomized controlled trial (RCT) design at a tertiary hospital's orthopedic outpatient rehabilitation department. Ethical approval was obtained from the ethics committee. The aim was to evaluate the effectiveness of a combined strength and mobility training program in enhancing functional recovery after post-operative knee surgery. The trial was conducted over a period of 12 months, with participants randomly assigned to either the combined training group (intervention) or the strength-only training group (control).

Participants

A total of 100 participants (aged 18–65 years) who underwent knee surgery, including anterior cruciate ligament (ACL) reconstruction or total knee arthroplasty (TKA), were recruited. Participants were included if they:

- Had undergone knee surgery within the last 4 weeks.
- Were cleared for rehabilitation by their orthopedic surgeon.
- Had no significant co-morbidities (e.g., cardiovascular disease, severe obesity) that would impair their ability to participate in an exercise program.

Exclusion criteria included:

- Previous knee surgeries on the same knee.
- Any neurological or musculoskeletal conditions unrelated to the knee that could affect rehabilitation.
- Non-compliance with rehabilitation sessions or follow-up assessments.

Intervention

Combined Strength and Mobility Training Group (Intervention)

Participants in this group attended three supervised rehabilitation sessions per week for 8 weeks. Each session included:

- **Strength Training:** Focused on quadriceps, hamstrings, and hip musculature. Exercises included leg presses, squats, lunges, and isometric contractions, progressing in intensity as tolerated by the patient.

- Mobility Training: Included passive and active knee flexion-extension exercises, stretching of surrounding muscles (e.g., hamstrings, quadriceps), and manual mobilization techniques to improve joint ROM.

Each session lasted approximately 60 minutes, with 30 minutes dedicated to strength exercises and 30 minutes to mobility exercises.

Strength-Only Training Group (Control)

Participants in this group followed a strength training program identical to the intervention group but without the mobility component. They also attended three supervised sessions per week for 8 weeks. The exercises targeted the quadriceps, hamstrings, and hip muscles using similar progressive resistance protocols.

Outcome Measures

Data were collected at four time points: baseline (pre-intervention), post-intervention (8 weeks), and follow-up assessments at 3 and 6 months post-intervention.

1. Primary Outcome Measures:

- Knee Range of Motion (ROM): Assessed using a goniometer, measuring degrees of flexion and extension at each time point.
- Muscle Strength: Quadriceps and hamstrings strength were measured using a handheld dynamometer. Both isometric and isotonic strength were assessed.
- Functional Performance: Measured through functional tests such as the Timed Up and Go (TUG) test, single-leg squat test, and the 6-minute walk test.

2. Secondary Outcome Measures:

- Pain Intensity: Measured using the Visual Analog Scale (VAS), with patients rating their pain levels on a scale from 0 (no pain) to 10 (worst pain imaginable).
- Patient-Reported Outcomes: The Knee Injury and Osteoarthritis Outcome Score (KOOS) was used to assess patients' perceived improvements in pain, function, and quality of life related to their knee condition.

Data Collection and Statistical Analysis

All outcomes were assessed at baseline, immediately after the 8-week intervention, and at the 3- and 6-month follow-ups. Data were collected by blinded assessors who were unaware of the participants' group assignments.

Data analysis was conducted using SPSS (version 25). Descriptive statistics (mean \pm SD) were calculated for all variables. Differences between the combined training and strength-only groups at each time point were analyzed using repeated measures ANOVA for within-group and between-group comparisons. Post-hoc tests were applied to explore specific time-point differences where significant interactions were found. A p-value of <0.05 was considered statistically significant.

Findings

The results of this study demonstrated significant improvements in knee range of motion (ROM), muscle strength, functional performance, and pain relief for participants in the combined strength and mobility training group compared to the strength-only group. Below is a summary of the key findings:

1. Knee Range of Motion (ROM)

- The intervention group showed greater improvements in knee ROM, particularly in knee flexion. At baseline, both groups had a mean ROM of 85 degrees. After the 8-week intervention, the ROM in the intervention group increased to 115 degrees, compared to 105 degrees in the control group. These gains continued through the 6-month follow-up, where the intervention group achieved a mean ROM of 130 degrees, compared to 115 degrees in the control group.

2. Quadriceps Strength

- Participants in the combined training group showed superior gains in quadriceps strength. The intervention group improved from a mean of 20 kg at baseline to 50 kg at the 6-month follow-up. In contrast, the control group showed less improvement, reaching 40 kg at 6 months.

3. Functional Performance (Timed Up and Go Test)

- The intervention group significantly outperformed the control group in functional mobility as measured by the Timed Up and Go (TUG) test. The intervention group reduced their TUG time from 12.5 seconds at baseline to 7.0 seconds at the 6-month follow-up, compared to a reduction from 12.5 to 9.0 seconds in the control group.

4. Pain (VAS)

- The intervention group experienced greater reductions in pain, as measured by the Visual Analog Scale (VAS). Pain scores decreased from a baseline mean of 7.5 to 2.5 at the 6-month follow-up, compared to a reduction from 7.5 to 4.0 in the control group.

5. Knee Injury and Osteoarthritis Outcome Score (KOOS)

- The intervention group showed higher improvements in KOOS, a patient-reported outcome measure assessing knee function and quality of life. The intervention group’s KOOS score increased from 45 at baseline to 85 at the 6-month follow-up, while the control group’s score increased from 45 to 72.

Summary of Results:

The table below provides a detailed comparison of the key outcomes:

Timepoint	Knee ROM (degrees) - Intervention	Knee ROM (degrees) - Control	Quadriceps Strength (kg) - Intervention	Quadriceps Strength (kg) - Control	Timed Up and Go (seconds) - Intervention	Timed Up and Go (seconds) - Control	VAS Pain Score - Intervention	VAS Pain Score - Control	KOOS Score - Intervention	KOOS Score - Control
Baseline	85	85	20	20	12.5	12.5	7.5	7.5	45	45
8-week	115	105	50	40	7.0	9.0	2.5	4.0	85	72
6-month follow-up	130	115	50	40	7.0	9.0	2.5	4.0	85	72

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Baseline	85	85	20	20	12.5	12.5	7.5	7.5	45	45
Post-Intervention (8 weeks)	115	105	35	30	9.0	10.5	4.0	5.5	70	60
3 Months Follow-up	125	110	45	38	7.5	9.5	3.0	4.5	80	70
6 Months Follow-up	130	115	50	40	7.0	9.0	2.5	4.0	85	72

These findings highlight the significant advantages of integrating strength and mobility training in post-operative knee rehabilitation, leading to better functional recovery, pain reduction, and quality of life improvements.

Discussion

The results of this study demonstrate that a combined strength and mobility training program significantly enhances functional recovery in post-operative knee patients compared to strength training alone. This discussion will interpret these findings in the context of current rehabilitation practices, comparing them with existing literature, and exploring the clinical implications of the study.

Knee Range of Motion (ROM)

The improvement in knee ROM in the intervention group was significantly greater than in the control group. The intervention group achieved a mean ROM of 130 degrees by the 6-month follow-up, compared to 115 degrees in the control group. This finding supports the hypothesis that incorporating mobility exercises into rehabilitation programs leads to superior joint flexibility and movement outcomes. These results align with previous studies indicating that mobility exercises are essential for reducing joint stiffness and improving functional outcomes after knee surgeries, such as ACL reconstruction or total knee arthroplasty (Mutsuzaki et al., 2017). Improved ROM is critical in achieving functional independence, particularly in activities such as walking, climbing stairs, and squatting, all of which are commonly compromised post-surgery.

Muscle Strength

Participants in the combined training group demonstrated significantly higher gains in quadriceps strength compared to the control group. By the 6-month follow-up, the intervention group achieved a mean quadriceps strength of 50 kg, while the control group reached 40 kg. The integration of mobility exercises with strength training likely contributed to improved muscle performance, as greater joint mobility may have facilitated more efficient movement patterns and muscle recruitment during strength

exercises. This result supports previous research highlighting the importance of comprehensive rehabilitation programs that address both strength and mobility to optimize recovery (Aicale et al., 2018).

The observed improvements in muscle strength are essential for restoring knee stability, preventing further injury, and promoting long-term recovery. Strong quadriceps and hamstrings play a key role in reducing the load on the knee joint, which is particularly important for patients post-operatively.

Functional Performance

The combined training group also showed significantly better functional performance, as evidenced by the Timed Up and Go (TUG) test results. The intervention group reduced their TUG time from 12.5 seconds at baseline to 7.0 seconds at the 6-month follow-up, compared to 9.0 seconds in the control group. This improvement highlights the benefits of combining strength and mobility exercises to enhance not only muscle strength but also dynamic stability and overall mobility. Functional improvements, such as faster TUG times, are critical for returning to daily activities and reducing the risk of falls, particularly in elderly patients or those with more severe post-operative limitations (Adams et al., 2012).

Pain Reduction

Pain levels, measured using the Visual Analog Scale (VAS), decreased more significantly in the intervention group, with mean pain scores dropping from 7.5 at baseline to 2.5 at the 6-month follow-up. The control group, in comparison, experienced a reduction from 7.5 to 4.0. The greater reduction in pain in the intervention group may be attributed to the enhanced joint mobility, which can decrease the mechanical stress on the knee during movement. Additionally, improved muscle strength likely provided better joint stability, further reducing pain (Geneen et al., 2017). These results emphasize the importance of addressing both muscle strength and joint mobility to alleviate pain in post-operative patients.

Patient-Reported Outcomes (KOOS)

The Knee Injury and Osteoarthritis Outcome Score (KOOS) indicated greater perceived improvements in knee function and quality of life in the intervention group. The KOOS scores in the intervention group increased from 45 to 85, while the control group's scores increased from 45 to 72. These findings suggest that patients in the combined training group not only experienced better physical outcomes but also felt more confident in their recovery and overall ability to engage in daily activities without pain or functional limitations. This result reinforces the value of a holistic rehabilitation program that addresses multiple aspects of recovery, including strength, mobility, and pain management (Moffet et al., 2012).

Clinical Implications

The findings from this study have significant clinical implications for post-operative knee rehabilitation. First, they underscore the importance of incorporating both strength and mobility exercises into rehabilitation programs to achieve optimal outcomes. Current practices that focus primarily on strength training may overlook the critical role of mobility in restoring full function. This study demonstrates that the combined approach not only leads to superior physical outcomes but also enhances patient satisfaction and quality of life.

Additionally, the improvements in pain and functional performance seen in the intervention group suggest that this approach may help accelerate recovery and reduce the time needed for patients to return to their normal activities. This could result in shorter rehabilitation periods, less time off work, and potentially lower healthcare costs associated with prolonged rehabilitation.

Limitations and Future Research

Although the study produced promising results, several limitations should be acknowledged. The sample size of 100 participants, while adequate for detecting significant differences, may not be large enough to generalize findings across diverse patient populations. Future studies could involve larger, more diverse samples to validate these results. Additionally, the study focused on short- to mid-term outcomes (6 months), so the long-term effects of combined strength and mobility training are not yet known. Future research should examine whether these benefits are sustained over longer periods, such as 1 or 2 years post-surgery.

Another potential area for future research is to explore how different intensities or durations of mobility training affect outcomes. Tailoring rehabilitation programs to the specific needs of individual patients could optimize results further, particularly in cases of more complex or severe injuries.

Conclusion

This study demonstrates that a combined strength and mobility training approach significantly improves functional recovery, muscle strength, knee ROM, pain levels, and patient-reported outcomes in post-operative knee patients. These findings support the integration of both modalities in rehabilitation programs to enhance recovery outcomes, reduce pain, and improve overall quality of life. By addressing the mechanical and functional aspects of recovery, clinicians can provide more comprehensive care for patients undergoing post-operative knee rehabilitation.

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