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Hip abductor strengthening improves physical function following total knee replacement: One-year follow-up of a randomized pilot study

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Abstract
Background: The most common surgical procedure for individuals with significant pain and reduced physical function due to end-stage knee osteoarthritis is total knee replacement (TKR). The hip abductors are known for stabilising the trunk and hip while walking, keeping the lower limbs in place, and transmitting stresses from the lower limbs to the pelvis.
Methods: At Life Kare Hospital in Amritsar, India, an observer blinded randomised pilot trial was conducted. The experimental group received hip abductor strengthening coupled with conventional rehabilitation (n=10), while the control group received standard rehabilitation alone (n=10). Performance-based outcomes such as the timed up and go test, single leg stance test, six minute walk test, knee extensor strength, and hip abductor strength were used to assess physical function over the course of a year.
Result: The study had eighteen participants, with an average age of 62.3 ± 5.7 years (10 males and 10 females). When compared to normal rehabilitation alone, improvement in hip abduction strength, single leg stand test was superior in the hip abductor strengthening group at 3 months and 1 year.
Conclusion: In both the single leg stance test and the six minute walk test, hip abductor strengthening demonstrated superior results. Following complete knee replacement, hip abductor strengthening exercises have the potential to improve physical function.

Keywords: Total knee replacement, Hip abductor strengthening, Knee exercises, Single leg stance, Osteoarthritis

Introduction

The most well-known surgical technique for individuals with significant knee pain and decreased function due to end-stage knee osteoarthritis is total knee replacement (TKR) [1, 2]. The key expectations after TKR were significant pain reduction, better function, and patient satisfaction [3]. Following TKR, participants reported significant reductions in arthritic pain but a wide range of physical performance [4, 5].

Despite the more advanced and excellent surgical procedure, functional tasks were reported to be worsened after TKR when compared to healthy age-matched controls, with 15% slower walking speed, 50% longer time to complete stair climbing tasks, and 20% less distance covered during the six-minute walk test [6, 7]. Franklin *et al.* [3] hypothesised that demographic and clinical factors, particularly quadriceps strength, would predict functional improvement. Previous research has demonstrated the quadriceps muscles' strength and short-term gains in physical function after TKR [8 - 10].

Future trials, according to Minnelowis *et al.* [11] and Artz *et al.* [12], should customise post-operative therapies for improved functional performance metrics and long-term benefits. Arnold *et al.* identified long-term changes in physical activity following TKR in their recent systematic review, albeit with little data, and advocated reaffirming the measures to enhance physical function and patients' expectations following TKR [13].

Recognizing the modifiable elements that contribute to functional results after TKR may aid in improving performance-based outcomes. One such changeable component is lower extremity muscle weakness due to knee osteoarthritis (OA). Isometric and isokinetic hip abductor strength were found to be deficient in symptomatic knee OA patients in a recent

comprehensive review and meta-analysis [14]. Hip abductor strength was significantly connected to quadriceps strength in recent research on total knee arthroplasty for improved performance-based function measures [15, 16]. The hip abductors are well-known as a fundamental muscle group for trunk and hip stabilisation during walking, femoropelvic alignment, femoral head stability, and force transfer from the lower limbs to the pelvis [17 - 19]. Furthermore, hip abductor weakness is linked to poorer functional performance in older individuals and lower physical performance in patients with knee OA [20]. As a result, we anticipated that hip abductor strengthening would improve physical function in people who had TKR.

Materials and Methodology

Study Design

We conducted a randomised, observer-blinded pilot trial with outcomes measured before surgery, 1 month, 3 months, and 12 months after TKR. The research was carried out at the Life Kare Hospital in Amritsar, India. The Institutional Research Committee at Life Kare Hospital in Amritsar, India, accepted the study protocol.

Participants

The inclusion and exclusion criteria were assessed for participants who had signed up for the elective TKR. Participants were eligible if they were 50 years old or older and had osteoarthritis in one or both knees, with the most bothersome knee being mentioned. Orthopaedic surgeons examined all research participants for the diagnosis and staging of knee osteoarthritis based on the major diagnostic criteria such as history, physical examination, and imaging studies [21, 22]. Participants with end-stage osteoarthritis of the knee were referred for total knee replacement surgery.

They were excluded if they had been diagnosed with anything other than knee osteoarthritis, had any neurological impairment that would affect lower extremity performance, or had had any orthopaedic surgery in either leg in the previous year. All of the participants who were eligible signed an informed consent form. Participants were randomly assigned to either the experimental or control groups using block randomization. Prior to the enrollment of the participants, the Institutional research committee of Manipal University approved the study. The rights of the included participants have been reserved.

Prior to surgery, a total of 20 participants were randomly allocated to either the hip abductor strengthening group (n=10) or the control group (n=10) using block randomization. The study included ten males (6 in the hip abductor strengthening group and 4 in the control group) and ten females (4 in the hip abductor strengthening group and 6 in the control group), with an average age of 63.3 (5.4) in the hip abductor strengthening group and 62.8 (5.9) in the control group. The hip abductor strengthening group had a BMI of 26.5 (3.2) while the control group had a BMI of 29.8 (3.2), respectively.

Rehabilitation Protocol

The authors developed the rehabilitation regimen at Life Kare Hospital in Amritsar, India, in the physiotherapy department. From the day of surgery until discharge, all members of the control group were subjected to a conventional rehabilitation programme. Both groups received 30- 40 minutes of supervised physical therapy twice a day until they were discharged. Following discharge, the participants underwent supervised therapy for 4-5 sessions per week for 4 weeks, followed by 2-3 sessions per week for 12 weeks, each lasting about 40-45 minutes. They were asked to continue their home-based exercise, and their compliance was monitored through a logbook and phone calls on a regular basis.

Variables

Prior to surgery, baseline outcome measurements such as the timed up and go (TUG), six minute walk test (SMWT), single leg stance (SLS), numeric pain rating scale (NPRS), knee extensor strength, and hip abductor strength were taken. At 1 month, 3 months, and 1 year after surgery, the post-surgical outcome was measured. The outcome measurements were gathered by an impartial blinded observer with more than 5 years of expertise in physical therapy.

Timed Up and Go Test

Timed up-and-go test (TUG) also termed as the ambulatory transitions test used for identifying problems in functional mobility [23, 25]. The TUG comprises various activities, such as sit-to-stand from a standard chair with armrest (46 cm seat height), walking 3 m distance in their usual manner, and turning at the end while walking and back to their chair to sit down again [26, 27]. With regular footwear, all the participants underwent one warm up trial prior to being timed with the fastest of two trials [23]. TUG has an excellent interrater and intrarater reliability in older adults and is responsive to changes after TKR and it has the ability to distinguish the physical functional performance of healthy subjects from patients with TKR [28, 29].

Six Minute Walk Test

In patients with knee osteoarthritis and persons who are suggested for surgery, the six minute walk test (SMWT) examines physical function by summing the distance covered maximally by the participant walking at their free speed [30-33]. During the 6-minute session, participants were asked to walk as swiftly as they felt safe on a 46-meter uncarpeted rectangular indoor circuit. The participants walked as far as they could, using an assistive device if necessary, and the distance was measured to the closest metre [34].

Single Leg Stance

SLS (single leg stance) is a technique for evaluating static postural control while standing on the operated limb. The participants were instructed to balance on their stance leg with their hands on their hips for 30 seconds, with the longest of the three attempts being recorded, followed by one warm-up trial. When the swing leg touched the stance limb or the floor for balance, the stance foot deviated from the ground, or the subject lifted his arm away from his hips, the test was stopped. This test has been demonstrated to be dependable, responsive to interventions, and a common clinical evaluation tool for measuring the functional ability of participants of varied ages and levels of enjoyment [35- 38].

Muscle Strength Test

The maximum isometric strength of the hip abductor and knee extensor muscles was measured using a hand held dynamometer (HHD) (Fabricatio enterprises incorporation, New York). For hip abductor measurement, they were positioned in a supine position with the tested leg in a neutral position. The HHD was positioned 5 cm above the tested limb's knee joint line, with the non-tested limb in neutral for stability. The therapist held the force transducer of the HHD and requested the participants to abduct their tested lower limb as forcefully as they could for 5

seconds. During the test, the participants were verbally exhorted to put up their best effort, and the highest volitional force generated by the subject was measured in pounds. The subjects' knee extensor maximum isometric strength (Quadriceps) was measured in a sitting position with the hip at 90 degrees and the knee at 70 degrees of flexion. They extended the tested limb's knee as far as they could while keeping the pelvis and trunk stable [39].

Numeric Pain Rating Scale (NPRS)

The participants are asked to rate the level of their pain on an 11-point numeric pain rating scale (NPRS), with 0 indicating no pain and 10 indicating the greatest pain possible. At baseline, 1 month, 3 months, and 1 year after surgery, an independent blinded observer recorded the participant's knee discomfort.

Statistical Analysis

SPSS software was used for statistical analysis (version 21.0; SPSS. Chicago, IL, USA). The benefits of hip abductor strengthening and routine therapy after complete knee replacement were studied using repeated measures ANOVA at baseline, 1 month, 3 months, and 1 year, respectively. The pairwise comparisons at different measurement levels between the experimental and control groups were determined using post-hoc analysis utilising Bonferroni's test. Leven's test was used to determine whether the continuous variables were equal in variance. All tests were 2-tailed and the statistical significance was established at p value 0.05 with 95 percent confidence intervals.

Results

Twenty participants (10 males and 10 females) with a mean age of 62.3 ± 5.7 years completed the study. Both groups were comparable on clinical and demographic characteristics at baseline, and also for functional measures of TUG, SMWT, SLS, NPRS, and hip and knee strength measurements. The baseline characteristics of the included participants are mentioned in (Table 1). The comparison between the groups of all the outcome variables is mentioned in (Table 2).

Table 1: Baseline characteristics of participants.

Variables	Hip abductor strengthening group Mean (SD) or N (%)	Control group Mean (SD) or N (%)	p value
Age in years	63.3 (5.4)	62.8 (5.9)	0.901
Sex M: F	6 (60): 4 (40)	4 (40): 6(60)	0.913
BMI	26.5 (3.2)	29.8 (3.2)	0.618
Knee strength in pounds	36.1 (8.4)	34.8 (4.9)	0.060
Hip Abductor strength in pounds	36.1 (6.0)	36 (7.0)	0.537
SMWT in meters	255.1 (79.2)	201.1(64.4)	0.597
TUG in meters	16.3 (4.2)	18(4.3)	0.538
SLS in sec	8.3 (4.5)	6.5 (2.5)	0.355
NPRS	7.1(.56)	6.5(1.5)	0.321

Table 2: Between group analysis of outcome measures.

Outcome measures	Baseline to 1 month Mean (95% CI)	p value	Baseline to 3 month Mean (95% CI)	p value	Baseline to 1 Year Mean (95% CI)	p value
Knee strength	-2.3(.5-.4)	<0.040	-2.9(-5.3 - -.45)	<0.023	-3.2(-6.5-.18)	<0.062
Hip abductor strength	3.0(.6-5.5)	<0.018	4.0(1.2-6.7)	<0.005	5.4(3.3-7.5)	<0.001
SMWT	19(-29.4-68.3)	<0.410	53.6(-10.4-117.7)	<0.095	88.3(36.5-140.2)	<0.002
SLS	-.82(-3.4-1.7)	<0.511	4.2(1.5-6.9)	<0.004	3.9(1.8-5.9)	<0.001
TUG	-.45(-5.6-4.7)	<0.857	.25(-3.2-3.7)	<0.883	.77(-2.9-4.4)	<0.661
NPRS	0.025(-1.4-1.5)	<0.972	1.02(-.4-2.4)	<0.148	-.72(-2.4-.86)	<0.330

Discussion

The major goal of this research is to see if hip abductor strengthening, as opposed to traditional rehabilitation, improves physical function after total knee replacement. Following TKR, the hip abductor strengthening group demonstrated statistically significant improvements in physical functional measures such single leg stance at 3 months and 1 year, as well as the six-minute walk test at 1 year.

The time taken to complete the TUG at one month and three months was not statistically significant, but participants in both groups took longer to finish the assignment. At one month, there were greater impairments in performance, which recovered to preoperative levels at three months, and then showed considerable increases at one year following surgery. Previous studies have also shown poor outcomes following TKR [7, 10], which could be attributed to decreased quadriceps and hip abductor strength one month after surgery.

At one year, the HAS participants walked faster and longer than the KS participants. At 3 months, the HAS group walked an extra 132 metres and 219 metres at a year, whereas the KS group walked an extra 118 metres at 3 months and 179 metres at a year. With a mean difference of 88.3 metres, the group's research revealed a substantial difference after one year. Moffet *et al*. [10], in a functional rehabilitation study, found that their subjects walked 145 metres less in SMWT after TKR after 12 months, while Petterson *et al*. [9] found that their study patients walked 150 metres further 12 months post-operatively. Our study participants walked an additional 219 metres during SMWT, and these improvements could be attributed to the TKR.

The test of knee extension strength revealed a substantial difference in both groups at 3 months, which was maintained until 1 year, while the NPRS revealed significant changes in both groups at all times. Improvements in quadriceps strength and pain intensity are critical, and these factors may have contributed to improved physical function following TKR.

When compared to the KS group, the HAS group showed significant improvement in hip abductor strength at 3 months and 1 year. Participants with strong hip abductor strength walked longer in the SMWT after a year and performed better on the SLS test after three months and a year. Given the improvement seen in the HAS group, it's safe to assume that the hip abductor will play a significant role in physical function

following TKR. We urge that future randomised controlled trials with a bigger sample size look at the effects of hip abductor strengthening after TKR.

Conclusion

At three months and one year, hip abductor strengthening resulted in greater improvements in the single leg stance test. When compared to knee strengthening alone, participants with strong hip abductors went further in a six minute walk test after a year. As a result, hip abductor strengthening activities may play a role in enhancing physical function after TKR.

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