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Influence of early mobilization program on pain, self-reported and performance based functional measures following total knee replacement

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ABSTRACT

Background: Total knee replacement (TKR) is an optimal treatment for persons with severe knee joint pain and disability, who were unsuccessful with conservative management. Early mobilization can be defined as moving out of bed and/or walking quickly after the surgery for reducing the risks allied with bed rest. There is a paucity of studies on effects of early mobilization on a performance-based measure of timed up and go test (TUG), six-minute walk test (SMWT) and a self-reported disease-specific measure of a knee injury and Osteoarthritis outcome score (KOOS) following TKR.
Methods: A prospective pre-post-trial was conducted at Manipal Hospital, Bangalore, India. Participants underwent early (POD '0') mobilization on the same postoperative day within 7 h post-TKR surgery. Outcome measures were recorded by an independent blinded observer. The statistical significance level was set at 'p' value < 0.05. The difference between pre-operative and post-operative outcome measure at 1 month and 3 months post-intervention were analyzed using repeated measures of ANOVA.
Results: The study included a total of 78 participants (59 Females; 19 Males) and the mean age of the included participants was 64.1 ± 7 years. Amongst, 78 participants, 53 underwent unilateral TKR, 25 underwent bilateral TKR. There were three dropouts in the study due to post-operative complications. Significant improvements from pre-operative to one month were observed following POD '0' mobilization on NPRS (7.35 ± 1.2 to 4.3 ± 1.7), SMWT (169 ± 70 to 236.7 ± 80.7). KOOS subscales of pain, symptom, and quality of life showed significant changes at one month and 3 months. TUG, Knee strength, Knee ROM and KOOS ADL subscale shown improvements only at 3 months post-intervention.
Conclusion: Our study findings suggest that POD '0' (early) mobilization can result in reduced pain and an increase in walking speed at 1 month. Significant changes were observed in pain, Knee strength, Knee ROM, TUG, SMWT and KOOS subscales at 3 months following total knee replacement.

1. Introduction

Osteoarthritis (OA) of the knee is a chronic joint disease which increases its prevalence with aging and leads to alter physical function with impaired mobility and physical disability.[1,2] Patients who were unsuccessful in conservative management following OA knee with functional disability and intractable joint pain will have a choice of total knee replacement (TKR).[3] TKR is a surgical procedure involving replacement of the diseased or damaged knee joint with the artificial components to restore normal alignment of the knee joint.[4,5]

Total knee replacement exhibited an increased knee range of motion (ROM), reduced knee pain, enhanced quadriceps strength and improved function of the affected joint.[1] However, following surgery, the patients showed a reduced functional performance with respect to their age-matched controls.[6] TKR participants who underwent a standard physical therapy rehabilitation shown short-term improvements in range of motion and functional activity.[7] Early mobilization following TKR may improve functional activities and exercise performance. Early mobilization following TKR can be defined as moving out of bed and/or walking quickly following the surgery for reducing the risks like deep vein thrombosis, pulmonary embolus, chest infection and urinary retention related to bed rest or immobility.[8]

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A study by Labarca et al[9] has shown that starting rehabilitation within 24 h of TKR improved knee ROM, Pain, and knee strength when compared to the delayed rehabilitation of 48–72 hours. A recent systematic review by Guerra et al[10] concluded that early mobilization post replacement resulted in the reduced length of stay in the hospital and favorable effects can be achieved within 24 h post-surgery. Enhanced functional recovery and early return to independent living following TKR may improve with early mobilization and early discharge.[11,12]

However, studies on additional effects of early mobilization to optimize rehabilitation protocols and determine function related to surgical outcome could not be retrieved. There is a dearth in the literature on studies to determine the influence of early mobilization following TKR on self-reported and performance-based functional measures.

The main objective of the present study was to find out the influence of early mobilization on functional measures like timed up and go test (TUG), six-minute walk test (SMWT) and patient self-reported outcome measure of Knee Injury and Osteoarthritis Outcome Score (KOOS). We hypothesized that early mobilization could contribute to improved physical function following TKR.

2. Materials and methodology

2.1. Study design

We applied an observer blinded prospective study design following total knee replacement. The study was conducted in Manipal hospital, Bangalore, India from April 2015 to December 2016.

2.2. Participants

Participants were part of an ongoing study and referred by orthopedic surgeons who were posted for elective total knee replacement. Participants those who met the requirements like diagnosed with primary knee osteoarthritis, aged more than 50 years were included in the study. Participants were excluded if diagnosed other than knee osteoarthritis, any neurological impairment which affects lower extremity function, a major medical, cardiac or vascular event in the past year which affects the functional performance of the lower extremity and any total hip replacement or other surgeries in either leg in the past year.

All the eligible participants signed an informed consent following enrollment. The present study was approved by Institutional Research committee, School of Allied Health Sciences, Manipal University, Manipal prior to the enrollment in the study, and the rights of all the included participants were secured.

2.3. Outcome measures

Baseline outcome measures of numeric pain rating scale (NPRS), knee flexion range of motion (ROM), knee strength, timed up and go test (TUG), six-minute walk test (SMWT) and knee injury and Osteoarthritis outcome score (KOOS) were taken prior to the surgery. Post outcome measures of the same were taken at 1 month and 3 months following the surgery. Both pre and post outcome measures were taken by an independent blinded observer, a faculty in the department of physiotherapy with more than 10 years of experience.

2.3.1. Numeric pain rating scale (NPRS)

The numeric pain rating scale (NPRS) is a numeric form of the visual analog scale. The participants select a number between from 0 to 10, to describe the intensity of their perceived arthritic pain. A horizontal bar or line is commonly used, where the endpoints are the extremes of 'no pain' and 'pain as worse as it could be'.

2.3.2. Knee range of motion

The available knee range of motion (ROM) was recorded using standard long-arm goniometer with stable arm allied to greater trochanter proximally and movable arm line up with the lateral malleolus. The participant positioned in supine lying and asked to bend the knee as far as possible with the heel supported. All knee ROM measurement was recorded to the nearest degrees with the axis of the goniometer placed at the lateral femoral condyle of measuring knee.[13,14] The goniometric measurement of knee flexion was shown to be highly reliable with an intra-tester reliability of 0.99 and criterion validity 0.98 for knee flexion ROM measurement.[15]

2.3.3. Knee strength

The knee extensor (quadriceps) strength was measured with participants in sitting with hip joint in 90° of flexion and knee joint in 75° of flexion. The volitional force of the quadriceps was measured with a hand-held dynamometer (HHD) (Fabricatio enterprises incorporation, New York) produced during maximal knee isometric extension. They were asked to produce maximal knee extension as hard as they can with hip and pelvis stabilized. The average of three trials was measured in pounds following one warm-up trial for the maximal volitional force generated on knee extensors. This method was shown to be a reliable and valid clinical tool for muscle strength testing in knee OA patients and those who underwent TKR.[16,17]

2.3.4. Functional performance measures

2.3.4.1. Timed up and go test. Timed-up-and-go test (TUG) is an ambulatory transitions test, an excellent predictor of decline in ADL and identifying problems in functional mobility.[17] During the test the participants rose from a standard chair (46 cm seat height) with armrest, walked in their normal manner for 3 m distance, return to their seated position.[19] They wore regular footwear during the test and were given one warm-up trial before being timed and fastest of two trial was averaged and recorded.[18,20] TUG is responsive to changes following TKR and the test could able to distinguish the physical functional performance of healthy subjects from TKR patients. It has an excellent Inter-rater and intra-rater reliability in older adults.[21–23]

2.3.4.2. Six-minute walk test. The six-minute walk test (SMWT) assess physical function by totaling the distance covered maximally by the participant during six minutes. They were allowed to walk with their free speed and it's a usual measure for patients with knee osteoarthritis and those progressing to surgery.[23–25] Participants walked quickly and safely on an uncarpeted rectangular indoor circuit, measured 46 m during the testing period. The participant walked as much distance as possible, an assistive device allowed if required and the readings were recorded to the nearest meter covered by the participant during the time frame.[25,26] An earlier study revealed excellent validity and reliability for this performance-based functional test (ICC = .94 for test-retest reliability, SEM = 26.3 m, and MDC $_{90}$ = 61.34 m).[27]

2.3.5. Knee injury and osteoarthritis outcome score (KOOS)

The KOOS is a knee-specific participant's self-reported survey instrument, developed to assess the patients' opinion about their knee joint problems.[28] The KOOS is a comprehensive instrument which evaluates consequences of knee injury through five dimensions. The patient-centered outcomes of knee pain,

symptoms, activities of daily living, sport and function, and knee-related quality of life were collected through the questionnaire. A total score of 100 indicates no symptoms and 0 with extreme knee symptoms on each subscale.[29] KOOS is a reliable and valid tool for measuring the knee related functional outcome and quality of life for patients undergoing total knee replacement with primary OA.[30]

3. Procedure

The diagnosis and staging of knee osteoarthritis based on the diagnostic criteria like history, physical examination, imaging studies were made by orthopedic surgeon.[31,32] The participants underwent a minimally invasive TKR with cruciate retaining total knee replacement and sub vastus approach[33] under spinal anesthesia. The enhanced recovery pathway was administered preoperatively, intraoperative and postoperative till discharge to promote early ambulation, to reduce general morbidity, adverse events, and surgical complications.[34]

All the participants underwent early mobilization (POD '0' mobilization) and it's important for fast-track pathway.[35,36] Our study participants underwent early mobilization within 7 h of post total knee replacement surgery. The participants were made to high sitting with backrest on the couch followed by sitting without support and when the vitals were stable they made to stand with the support of Walker and knee immobilizer on the operated leg. Early physiotherapy interventions, weight bearing on the operated knee and preferment of ambulation was administered in the same postoperative day.[34–36] Participants were mobilized with O2 if necessary and they were encouraged to walk a minimum of 2 m and return to the bed. The standard rehabilitation from day one till discharge was given to all the participants with two sessions each day and each session lasted for about 30–40 min. Following discharge, the participants underwent supervised rehabilitation for a 4–5 session in a week for 4 weeks and thereafter 2-3 sessions in a week for 12 weeks with each session conceded for about 40–45 min.[37]

4. Statistical analysis

All the statistical analysis was conducted using SPSS software (version 16.0; SPSS. Chicago, IL, USA). Baseline characteristics of the study participants were described in mean and standard deviation (SD). The difference in outcome measure at preoperative and postoperatively at 1 month and 3 months following the intervention was analyzed using Repeated measures of ANOVA. The significance level at $p < 0.05$ was set with 95% confidence interval.

5. Results

A total of 107 participants posted for elective joint replacement during the time period were screened preoperatively for eligibility. Twenty-nine participants were excluded in the study (11-diagnosed with rheumatoid arthritis, 3- associated neurological disorder, 6 - diagnosed with post-traumatic OA of the knee, 2-associated with COPD, 7- associated with hip OA). Seventy-eight participants were included and three female participants who underwent unilateral TKR had post-operative complications (1-Iatrogenic fracture, 2- shifted to ICU postoperatively for advanced support). The mean age of the included participants was 64.1 ± 7, amongst 74.7% were females and 24.3% were males. The baseline demographic characteristics of the included participants are depicted in Table 1. The mean BMI was 26.8 ± 2.5 kg/m^2 and the mean duration of arthritis is 3.09 ± 1.38 years.

The mean, standard deviation and mean change of knee strength, knee ROM, NPRS, functional measure TUG and SMWT at baseline and 1 month and 3 months post-intervention was shown in Table 2. The SMWT showed a statistically significant difference with a mean change at 95% confidence interval of 67 m (82.4, 52.8) and 139.8 m (170.5, 109.2) at one month and three months respectively. The intensity of the pain measured using NPRS showed a statistical difference with a mean change at 95% confidence interval of 3.0 (2.4, 3.5) at one month and 5.6 (5.2, 6.1) at 3 months. Significant changes were found at 3 months in the outcome measure at 95% confidence interval with a value of TUG 4.4 (1.4, 7.4) sec, Knee ROM 6.5 (10.7, 2.3) degrees, knee strength 6 (8.6, 3.3) pounds.

Table 1
Demographic characteristics of the participants (n = 75).

Characteristics (n = 75)	Mean ± SD; (%)
Age in years	64.1 ± 7
Gender	
Male	19 (24.3 %)
Female	56 (74.7 %)
BMI (kg/m^2)	26.8 ± 2.5
Height in Cm	160.9 ± 8.6
Weight in Kg	71.5 ± 10.3
Duration of arthritis (in years)	3.09 ± 1.38
Side of operation	
Right	30 (40%)
Left	20 (26.7%)
Bilateral	25 (33.3%)

The patient self-reported outcome measure of KOOS showed statistically significant changes following early mobilization at 1 month and 3 months duration in KOOS pain, KOOS symptom and KOOS quality of life subscales at 95% confidence interval. The changes observed were 15.1 (20, 31.6); 27.3 (31.6, 23) in KOOS pain, 9.8 (15, 25.5); 20.6 (25.5, 15.6) in KOOS symptom and 19.7 (24.9, 14.6); 33.3 (37.9, 28.8) in KOOS quality of life at one month and three months respectively (Table 3).

6. Discussion

The aim of the present study was to find out the influence of early mobilization on self-reported and performance-based functional measures following TKR. The functional measure of SMWT showed a significant change at 95% CI of 67 m (82.4, 52.8) at 1 month and 139.8 m (170.5, 109.2) at 3 months following early mobilization and exceeds the minimal detectable change of 61.34 m.[25] The TUG showed a clinical and statistical improvement at 3 months with a mean change of 4.4 s at 95% CI (1.4, 7.4) $p < 0.001$ which is more than the reported minimal detectable change of 2.45 s.

The self-reported outcome measure of KOOS improved in all subscale expect ADL and sports/recreation at 1 month, Sports and Recreation at 3 months with early mobilization following TKR. The minimal detectable change (MDC) for the KOOS subscale for pain, symptom, ADL, and quality of life was reported as 20.2, 24.1, 20.8, and 26.6 respectively.[38] The observed improvements exceed MDC at 3 months and MCID reported at 8–10 points for each KOOS subscales at one month and 3 months expect sports and recreation subscale. A recent study by Eli et al[39] assessed the short-term improvements following TKR at 6 weeks and 3 months found similar improvements in KOOS subscales.

The Knee extensor strength, Knee ROM, NPRS, self-reported outcome measure of KOOS subscales (pain, symptom, ADL, Quality of life) and performance-based outcome measure of TUG and SMWT showed statistically significant changes at 3 months post-intervention. Reduction in pain intensity following early mobilization may enhance the quadriceps femoris activity which further increased the strength. We believe that reduction in pain and

Table 2
Mean change in Outcome measures from baseline to postoperative 1 month and 3 months post Intervention.

Variable	Baseline Value Mean (SD)	1 Month post intervention Mean (SD)	3 Months post intervention Mean (SD)	Baseline to 1 month post intervention Mean change (95% CI)	p-value	Baseline to 3 months post intervention Mean change (95% CI)	F - statistics	p-value
NPRS	7.35 (1.2)	4.3 (1.7)	1.68 (1)	3(2.4, 3.5)	<0.001	5.6(5.2, 6.1)	345.5	<0.001
Knee flexion ROM	110.1 (12.9)	109.7 (8.8)	116.6 (8.0)	0.34 (−3.8,4.5)	1.000	−6.5 (−10.7, −2.3)	11.63	<0.001
Knee extensor strength	32.64 (6.5)	33.5 (6.8)	38.4 (7)	−1.1 (−3.1, .9)	<0.547	6.0 (−8.6, 3.3)	19.34	<0.001
Timed up and go test	21.7 (9.7)	20.4 (6.5)	17.2 (3.4)	1.5 (−1, 4.1)	<0.429	4.4 (1.4, 7.4)	9.0	<0.001
Six minute walk test	169 (70)	236.7 (80.7)	308.9 (103.2)	−67.6(−82.4, −52.8)	<0.001	−139.8(-170.5,-109.2)	77.0	<0.001

Table 3
Mean change in Knee injury and osteoarthritis outcome score (KOOS) from baseline to postoperative 1 month and 3 months post Intervention.

Variable	Baseline Value Mean (SD)	1 Month Post Intervention Mean (SD)	Postoperative 3 Months Mean (SD)	Baseline to 1 month post intervention Mean change (95% CI)	p-value	Baseline to 3 months post intervention Mean change (95% CI)	F - statistics	p-value
KOOS Pain	40.4 (15.2)	55.5 (14.1)	67.7 (12.5)	−15.1 (−20, −31.6)	<0.001	−27.3 (−31.6, −23)	110.79	<0.001
KOOS Symptom	51.2 (16.6)	61.0 (15.2)	71.8 (13.5)	−9.8 (−15, −25.5)	<0.001	−20.6 (−25.5, −15.6)	50.79	<0.001
KOOS ADL	45.9 (16.9)	47.5 (15.3)	71.3 (14.1)	−1.6 (−5.9, −30.3)	1.000	−25.3 (−30.3, −20.3)	102.84	<0.001
KOOS sport /Recreation	17.2 (2.3)	22.3 (3.1)	22.9 (2.6)	−5 (−14.4, 4.3)	.566	−5.6 (−13.6, 2.4)	1.53	.271
KOOS Quality of Life	29.5 (15)	49.3 (14.5)	62.9 (13.3)	−19.7 (−24.9,14.6)	<0.000	−33.3 (−37.9, −28.8)	155.18	<0.001

increase joint loading will enhance the knee joint stability by improving the strength of the surrounding muscles especially quadriceps femoris.

Thus, exercise emphasized on quadriceps muscle in the initial postoperative phase could possibly improve the functional measures by enhancing the stability of the knee joint. The study participants underwent less invasive surgery which may further enhance the knee strength in the initial postoperative phase.[40] Previous study by Jain et al in Indian elderly non-obese patients shown that the subvastus surgical approach has resulted in lesser damage to the quadriceps muscle which assisted in less pain, early rehabilitation and faster mobilization following TKR.[41]

The enhanced function following early mobilization at 3 months could be due to increased quadriceps strength and reduction in the pain intensity. The early functional gain of the participants may also be due to the lesser BMI, age group, knee ROM at the preoperative levels which tailored the post-operative rehabilitation and predicted the good function following early mobilization.[42] Labraca et al[9] in their study, established that starting rehabilitation within 24 h post knee arthroplasty improved muscle strength, knee range of motion and pain intensity when compared to delayed rehabilitation 36–72 hours post-surgery, our study participants underwent early rehabilitation 7 h post-surgery and found significant changes in one month.

Early mobilization increases the knee joint loading during standing and walking and thereby reducing the pain, Hurwitz et al[43] in their study reported that knee joint loading during walking will reduce the pain, and pain intensity was inversely correlated with the joint loading. The observed increments at one month in patient-reported outcomes may not be a true representation of patient experience, it could be also due to overestimation of functional recovery early after the surgery.[44] The declined performance was observed at one month following surgery in knee strength and TUG.

7. Limitation

There are some remaining limitations in the study with the lack of control group and /or non-osteoarthritis participants (age-matched controls) to interpret the results. The current study findings with a small sample size can't be generalized and hence we recommend future multi-centered randomized controls.

8. Conclusion

Total knee replacement is becoming common with a rise in its incidence, adopting early mobilization on the same postoperative day can reduce pain and improve function. Significant changes were observed in pain, Knee strength, Knee ROM, TUG, SMWT and KOOS subscales at 3 months following early mobilization on total knee replacement.

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Conflict of interest

The authors declare that they have no conflict of interest.

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