

## Effects of Early Balance Training on Functional Outcomes in Total Knee Replacement

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### ABSTRACT

Falls are a major concern for Total Knee Arthroplasty patients, especially during the early postoperative period due to impaired balance, which can lead to complications and delayed recovery. Implementing evidence-based balance training may mitigate fall risks and improve patient safety preventing in adaption of impaired balance and gait. So, this study aimed to focus on balance training immediately after the total knee replacement to find out evidence- based balance training protocol which can have long lasting effects.

**Materials and Methods:** 126 Subjects who underwent total knee arthroplasty from both genders were included in the study, into two groups. It's a double blinded study where subjects and the analyst were unaware of group allocation. The outcomes of balance were measured using berg balance scale, functional mobility using timed up and go test and functional exercise capacity by six-minute walk test. Both the groups received active intervention for 2 weeks with 5 sessions per week. The other joint specific outcomes like pain severity using visual analogue scale and knee flexion mobility using universal goniometer were measured. These measurements were recorded at baseline, at discharge, at 2 months & 6 months of follow up.

**Results:** Post-treatment the visual analog scale ( $p=0.0001$ ), Knee mobility( $p=0.0001$ ), TUG score ( $p=0.0001$ ), Berg Balance Scale ( $p=0.0001$ ) and 6MWT ( $p=0.0001$ ) results showed a significant difference with all outcome measures more than  $p=0.001$  at the 6th month of follow- up.

**Conclusion:** Significant differences were noted in the balance measures after the administration of specific balance exercise combined with standard rehabilitation exercises for TKR individuals on a long stance. Therefore, the present study recommends addition of specific balance exercise in the early post-operative phase in total knee arthroplasty patients. Overall, early balance training program proved to exhibit superior outcomes in TKA individuals with long-lasting benefits.

**Keywords:** Balance, berg balance scale, Timed up and go test, six-minute walk test, 6 months follow-up..

### 1. INTRODUCTION

Total knee arthroplasty (TKA) is one of the most commonly performed surgeries for pain relief and functional restoration of the patients suffering from advanced knee osteoarthritis.<sup>1</sup> TKA has also achieved a significant market share in India. As of today, more than 2.5 lakh procedures are performed annually in the country.<sup>2</sup>

Earlier total knee arthroplasty surgeries were associated with many complications such as excessive blood loss, infection, post-operative stiffness etc. As far as the Indian population is concerned, the reach of the modern medical services has improved to the grass root levels and it has led the common man to seek better medical facilities which were not available before. With the introduction of various government issued health schemes for people who are financially backwards, people are able to afford and get variety of treatment options especially for surgeries. 9.36 percent of Indian adults over 45 years old have arthritis. The prevalence among men was 7.49 percent, while that of women was 11.03 percent. With an odds ratio of 1.59, women are at a higher risk than men to develop arthritis.<sup>3</sup>

Some of the complications following TKA are reduced joint range of motion, diminished muscle strength and impaired balance. One of the important aspects of physical function which is least addressed following TKA is the balance function on weight bearing activities.<sup>4</sup>

Falls are a major concern for Total Knee Arthroplasty patients, especially during the early postoperative period. Impaired balance increases the risk of falls, which can lead to complications and delayed recovery. Implementing evidence-based balance training may mitigate fall risks and improve patient safety.

A higher incidence of falls has been reported in patients with osteoarthritis of knee and hips and also in patients after total knee arthroplasty.<sup>5</sup> Post-operative rehabilitation focuses on optimizing the patient's independence in self-care, transfer capacity, functional mobility and safety.

Most of the current post-operative rehabilitation protocols available after TKA concentrate on increasing the joint range of motion and strengthening the knee musculature. These exercise programs do not adequately address the issue of compromised static and dynamic balance component in mobility and physical function of the individual, which is very essential for the mitigation of daily activities.<sup>8</sup> As a result, further studies are needed to study the effects of various balance improvement strategies in patients who have undergone TKA. Hence the present study intended to analyse the effects of early balance training in TKA.

## 2. MATERIALS AND METHODS

After obtaining ethical clearance certificate an experimental study with sample size of 126 (the sample size was determined by using Open Epi software 2.1.3 version with a power of 80% and confidence interval scale 95%) was done using simple convenient sampling method.

Subjects who underwent unilateral total knee arthroplasty (TKA), both genders with age varying from 40-70 years were included. Injuries and fractures of lower extremity, any lower extremity amputation, Acute cardiovascular illness, Visual impairments, Neurological disorders that can affect balance, Infected TKA, TKA for Rheumatoid arthritis and Revision arthroplasty were excluded from the study.

Subjects who met the inclusion criteria were allocated into two groups i.e. control group and experimental group. An informed consent was obtained from all the subjects for voluntary participation in the study. It's a double blinded study where subjects and the analyst were unaware of group allocation. The postoperative physical therapy assessment includes the outcomes of balance was measured using berg balance scale, functional mobility using timed up and go test and functional exercise capacity by six-minute walk test. Both the groups received the active intervention for 10 sessions in duration of 2 weeks. The other joint specific

outcomes like pain severity using visual analogue scale and knee flexion mobility using universal goniometer were measured. These measurements were recorded at baseline, during discharge, at 2 months and 6 months of follow up.

### OUTCOME MEASURES

**Pain** was rated using the visual analogue scale. Assessment of **knee flexion mobility** was assessed in prone lying or side lying by the accessor using goniometer.

In **Timed up and go test** the subjects were given the arm rests chair for the sit – stand and stand – sit movements. 3 meters away from the chair a piece of tape or a marker is used so that it is easily seen by the subject. No assistance will be provided. The time to perform the test is recorded using a stop-watch.

Instructions to the patient: “On the word GO you will stand up, walk to the line on the floor, turn around and walk back to the chair and sit down. Walk at your regular pace.

**Six-minute walk test** (American Thoracic Society Guidelines, 2002)

The patient is asked to walk along a 30 ft corridor or hallway at his own pace for six minutes. The distance walked is then measured. Participants are instructed prior to the test to wear comfortable clothing and shoes and to use their typical walking aid during the test.

**Berg Balance Scale** with instructions for each of the 14 components were given separately. (Berg et al, 2008) with completion time of 15-20 minutes.

### CONTROL GROUP

The subjects in the control group received a traditional set of range of motion and strengthening exercises which includes

- Assisted knee flexion in supine lying position
- Static quadriceps and hamstrings exercises

- Knee extension in high sitting position
- Straight leg raises
- Ankle toe movements
- Full weight bearing ambulation using walker support

### **EXPERIMENTAL GROUP**

The subjects in the experimental group received traditional set of exercises and set of specific balance training exercises.

Balance training exercises<sup>6&7</sup>

- Rotate trunk clockwise and then in anti-clockwise direction in standing without support
- Lunge in walk standing position without support on both the legs
- Shift weight to one side in a stride standing position without support and then repeat on the other side
- Cross over steps
- Foam pad activity: - patient stands on a soft foam pad placed on the ground. Therapist attempts to perturb patient's balance in random fashion. One bout of 30 seconds is performed.
- 
- Tilt board: - Patient stands on a tilt board with both feet on the board. The therapist perturbs the tilt board in forward and backward and side to-side directions for approximately 30 seconds each.
- Both the foam pad and the tilt board are placed within the parallel bars for additional support and ensuring safety.
- Tandem walking

### **BALANCE TRAINING PROGRAM**



**FIGURE 1: WEIGHT TRANSFERS WITH WALL SUPPORT**

**FIGURE 2: CROSS OVER STEPS**





**FIGURE 3: STANDING ON THE TILT BOARD WITH EYES OPEN**

**FIGURE 4: STANDING ON BALANCE FOAM PAD WITH EYES OPEN**



After 2 weeks of intervention, the outcomes are measured at time of discharge, after 2 months and 6 months of follow up. During the follow up period, subjects were instructed periodically to adhere towards exercises at home.

### **STATISTICS**

The descriptive statistics, frequency analysis and percentage analysis were used for categorical variables and the mean & S.D were used for continuous variables. To find the significant difference within the group and between the control and experimental groups, the paired sample “t-test” was used to compare the statistically significant change over time within a group. Repeated measures ANOVA was used to find the differences in means across the same group at different time. Independent t-tests was used to compare the differences between groups. For all the above statistical tools the probability value at .05 was considered statistically significant.

### **3. RESULTS**

#### **Subject characteristics:**

126 subjects participated in this experimental study of which 44 were males and 82 were females. In both the groups, subjects were nearly similar with mean age and BMI.

**Table 1: Demographic details**

VARIABLES	CONTROL GROUP	EXPERIMENTAL GROUP
Age (Years)	61.5±5.7	60.1±3.5
Height (Cms)	157.3±3.51	159.3±4.3
Body Weight (Kgs)	55.4±6.52	56.4±3.56
Body Mass Index (BMI) (Kg/m <sup>2</sup> )	22.9±1.85	22.15±1.89
Male Subjects	23	21
Female Subjects	40	42

**Table 2: Between group analysis**

Variables	Timeline	Control Group	Experimental Group	p Value	Effect Size (Cohen's d)
Berg Balance Scale	At Discharge	36.4 ± 5.57	43.7 ± 3.74	0.0128	1.42
	At 2 Months	39.6 ± 5.03	53.6 ± 1.02	0.0001*	3.36
	At 6 Months	45.0 ± 4.0	58.0 ± 2.0	0.0001*	4.21
Six-Minute Walk Test	At Discharge	136 ± 38.88	230 ± 52.84	0.004*	2.14
	At 2 Months	170 ± 49.51	398 ± 18.1	0.001*	5.63
	At 6 Months	200 ± 45.0	450 ± 20.0	0.0001*	5.87
Timed Up and Go Test	At Discharge	1.452 ± 0.457	0.981 ± 0.354	0.8231	1.15
	At 2 Months	0.941 ± 0.402	0.253 ± 0.058	0.0002*	2.01
	At 6 Months	0.800 ± 0.350	0.200 ± 0.050	0.0001*	2.22
Pain Severity	At Discharge	2.8 ± 0.45	1.5 ± 0.50	0.0004*	3.02
	At 2 Months	0.7 ± 0.34	0 ± 0	0.0002*	2.06
	At 6 Months	0.5 ± 0.30	0 ± 0	0.0001*	1.67

Flexion ROM	At Discharge	67.51 ± 10.81	87 ± 8.28	0.004*	2.03
	At 2 Months	91 ± 10.81	119.5 ± 4.27	0.0001*	3.07
	At 6 Months	100 ± 10.0	130 ± 5.0	0.0001*	3.20

\*Note: Significant at  $p < 0.05$

The Cohen's d effect sizes are calculated based on the mean differences and pooled standard deviations. Generally, an effect size of 0.2 is considered small, 0.5 medium, and 0.8 or higher large.

#### 4. DISCUSSION

Almost all traditional rehabilitation TKA protocols address the mobility and strength issues, but the functional recovery is of importance. This study was conducted to analyse the long- term benefits of early balance training following TKA. Indian population has been included in the study to avoid bias from multicentre approach.

The need for incorporating balance exercises especially after total knee arthroplasty surgery is very crucial as knee is a major weight bearing joint. Indian population involves in multifactorial regions in day-to-day activities and involves in lot of cross-leg or squatting activities. Hence, rehabilitation will be focused on reverting back to their near normal life following surgery.

In this study the patients who underwent TKA were prevalent in the age group of 50-76 with range 61.5±5.7 in control group and 60.1±3.5 in experimental group. Moreover, the results

from the current study can be considered as the study subjects were homogenous in nature in age, BMI (22.9±1.85 & 22.15±1.89) and with equal gender distribution (male:female - 17:23) & female:male -20:23) in both control and experimental groups. (Table 1)

But there are other variables like degree of degeneration, duration of disorder, occupation, co- morbid status, socio-economic status and lifestyle factors which influences the outcomes of TKA which would have altered the outcomes of the study.

Recovery of TKA poses different challenges for the Indian population with regard to cultural and socioeconomic factors, which may affect rehabilitation service access. Early balance training programs can be implemented effectively in this population. The feasibility of a balance training program has been evidenced by high exercise adherence, low dropouts, and no adverse events.<sup>4</sup> These programs would also be particularly targeted to address the needs of the Indian patients, so that adequate support is provided towards the optimal recovery.<sup>6</sup> The present study evaluated the functional recovery by measuring the balance ability, walking distance in a stipulated time and time taken to accomplish a functional task. Compared to control group, experimental group proved to exhibit highly statistically significant results in BBS and 6MWT. These results conclude the key importance of incorporating balance reactions in acute stage of TKR. (Table 2)

After TKR, there is local oedema and inflammation due to surgical intrusion which causes accumulation of pain substances in and around the joint. This in turn causes the patient to become more apprehensive about movement and restricts the mobility of the joint. The inclusion of exercises into the post-operative rehabilitation of TKR gives benefits to the individuals and they become more mobile and pain free.

A systematic review (Fernando et al, 2018) stated that the balance training didn't show any significant improvement in pain or range in patients who underwent total knee replacement.

The between group comparison of timed up and go test at discharge, two months and six months follow up as shown high statistically significant improvement at follow up following balance training from both the control and experimental denoting the constant improvement in experimental group even after discharge (Table 2).

Pain severity levels measured by Visual Analogue Scale were significantly reduced in both the control and experimental groups following interventions. This is due to adapting and strengthening their new knee at the early phase.

The between group comparison of involved side knee flexion ROM of surgical knee at discharge, two months and six months follow up has shown statistically significant improvement after intervention given in both groups.

The pioneering study which was done by Sara.R. Piva et al, 2010 to test the feasibility of adding balance exercises to the typical functional exercises used in the postoperative rehabilitation of patients who undergo total knee replacement showed that there were significant differences in the performance-based measures for balance which insisted the need of inclusion



of such exercises into the rehabilitation. The study also reported that improvements were significantly seen starting from 2 months into the follow up period. The results of the present study are in coherence with the above stated study.

Remarkable improvement in berg balance scale and timed up and go test was observed with balance training program which is in line with findings published by Liao et al, 2013 in patients undergoing knee replacement after giving a balance exercise program.<sup>8</sup>

A study by An et al. (2024) also showed that combined balance exercises improved knee range of motion, balance, gait, and overall functional outcomes.<sup>(9)</sup> This was a single-blind randomized controlled trial, therefore highlighting how balance training in the immediate post-operative period is effective. In another study, Sun et al. (2023) reported that strength training in the preoperative high intensity combined with balance training resulted in

enhanced early results after TKA.<sup>10</sup> In summary, these results suggest an additional benefit of early balance training when initiated during the early phases of rehabilitation in terms of recovery and functional performance.

Key Findings of the study was significant pain reduction, improved knee flexion mobility, enhanced functional mobility, better balance, and increased functional exercise capacity

Future studies could explore on Longer Follow-Up Periods beyond six months, Larger Sample Sizes, Diverse Populations by examining the effects across different populations, Different Interventions like Comparing different types of balance training exercises to identify the most effective protocols and Cost-Effectiveness Analysis by Evaluating the economic viability of implementing balance training programs in routine post-operative care.

Potential Bias includes sampling technique as convenient sampling, self - reported measure (VAS) subjective bias and adherence to home exercise program.

Limitations of this study will be short intervention duration of 2 weeks, limited study center and the potential for measurement error in assessing balance.

## 5. CONCLUSION

In this longitudinal study there has been a significant difference in the balance measures after the administration of specific balance exercise combined with the standard rehabilitation exercises for TKA individuals. Therefore, the present study recommends the addition of specific balance exercise in the early post-operative phase in total knee replacement patients. Overall, the early balance training program proved to exhibit superior outcomes in TKA individuals on long-term basis.

### *Clinical implications:*

- Standardized balance protocol immediately after surgery
- Reduction of falls with increased mobility.

### **CONFLICT OF INTEREST:**

The authors declare no conflict of interest

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