DOES CONCENTRIC-ECCENTRIC COMBO EXERCISE DURING POST-OPERATIVE TOTAL KNEE REPLACEMENT REHABILITATION IMPROVE QUADRICEPS STRENGTH AND KNEE MOBILITY?

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Abstract

Background: Total knee arthroplasty (TKA) is the preferred surgical remedy for osteoarthritis with severe degeneration of knee. But the functional recovery deficits related to muscle strength remains a rehabilitation challenge in most of the patients. The inclusion of negative muscle work (eccentric contraction) over concentric work has recently received rehabilitative attention.
Objective: The aim of this study was to investigate the effect of combined eccentric-concentric program over the routine concentric program in alleviating pain, improving muscle strength and range of motion of knee joint after TKA.
Methods: A prospective experimental design including 30 subjects following TKA was conducted. This study was conducted in Alva's Health Center, Moodubidire, Dakshina Kannada, Karnataka, India. Thirty subjects who underwent unilateral TKA were randomly allocated in a 1:1 ratio into E-C (Eccentric-concentric) group and C group (concentric) during the routine early rehabilitation program post TKA. Outcomes measured for comparison included Numeric pain rating scale, circumferential measurement of thigh, active knee flexion – extension ROM and quadriceps muscle strength. Independent t test was used to analyse measurements taken at baseline and follow up at 6 weeks.
Results: Follow up assessment at 6 weeks demonstrated a significant improvement in knee extension ROM and quadriceps muscle strength. No significant improvement was observed in pain, thigh girth and flexion ROM.
Conclusion: These findings suggest that individuals undergoing TKA would benefit from the rehabilitation program that includes eccentric exercise in improving quadriceps strength and knee extension without lag.

Keywords: Total knee arthroplasty, pain, muscle girth, eccentric exercise, range of motion

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1. Introduction

Total knee arthroplasty (TKA) is frequently implemented as a treatment for knee osteoarthritis when more conservative options have been attempted and have failed to relieve disabling symptoms. [1] TKA has reliably shown to reduce pain and improve health-related quality of life in 90% of patients. Yet despite a subject satisfaction rate of 85% (NIH, 2003), deficits in strength, range of motion, and functional abilities still persist following TKA. [2] Subjects after TKA are often plagued with quadriceps femoris weakness and functional deficits that continue for years after surgery. Hamstring strength deficits have also been reported after TKA surgery [3]; however, the focus on the quadriceps is due to the association of the quadriceps to normal functional activities such as walking and stair climbing. [4] These limitations in strength and function are thought to result from a combination of pre-existing weakness before surgery and pain and swelling post surgery. [5] While the reason for quadriceps weakness is not well understood in this subject population, it has been suggested that a combination of muscle atrophy and neuromuscular activation deficits contribute to residual strength impairments. [6]

Physical therapy on the other hand is an effective therapeutic intervention if prescribed properly in managing pain and improving quality of life. [7] Physical therapy following TKA aims at reversing these deficits and focuses on pain reduction, strengthening, normalization of gait pattern, and maximization of ROM and functional performance. [8] A recent review of Australian inpatient physiotherapy services after TKA highlighted the lack of clinical trials examining this area, particularly active exercise, despite these being considered treatments of choice by clinicians. [9] The restoration of quadriceps muscle volume and strength (force-generating capacity) following TKA continues to be a rehabilitation challenge. Interventions that can safely and effectively overload muscle early are needed to minimize the residual atrophy and weakness that often are recalcitrant to standard management approaches.

The application of eccentric exercise is one such intervention that has been shown to safely increase muscle volume and strength in various populations. Eccentric muscle actions have shown to possess several distinct physiological properties; broader and faster cortical activity as movements are being executed; inversed motor unit pattern; increased cross education effect; faster neural adaptations; attenuated muscle sympathetic nerve activity; decreased fatigability; increased metabolic efficiency. [10] Eccentric exercise has received much less experimental attention than either isometric or concentric exercises. The purpose of this study was to investigate the effects of eccentric exercise on quadriceps functioning early after TKA compared with conventional rehabilitation methods.

2. Methods

Study design

This is a randomised clinical trial was conducted between July 2014 to January 2016 at physiotherapy department of Global health city in Chennai, India.

Subjects

Thirty subjects who underwent a primary unilateral, tri-compartmental, cemented TKA with a medial para-patellar surgical approach were referred by orthopaedic surgeons from Alva's Health Center, Moodubidire, Dakshina Kannada, Karnataka, India, were participated in this study. Subjects were excluded if they had 1) bilateral/revision TKA, 2) cardio-respiratory complications, 3) body mass index (BMI) _40 kg/m2, 4) symptomatic OA in the contralateral knee (defined as self-reported knee pain _4 on a 10-point verbal analogue scale), 5) other lower extremity orthopedic problems limiting function, 6) neurologic impairment.

All participating subjects who met eligibility criteria and agreed to participate in this study signed a consent form approved by the institutional review board of Alva's College of Physiotherapy and research centre, Moodubidire, Dakshina Kannada, Karnataka, India.

All participating subjects underwent a routine history and physical examination to rule out red flags to participate in this study.

Outcomes

Numeric pain rating scale (NPRS)

NPRS ranging from 0 – 10, 0 being described as "no pain at all" and 10 being "the worst pain imaginable." A 2 point change on the NPRS is necessary to exceed bounds of measurement error and to be considered clinically meaningful. [11]

Circumferential measurement of thigh

Circumferential measurements of the operated thigh were done in supine position. Measurements were taken by one of the researcher who was kept blinded to the subject group assignment. Measurement was taken 3" proximal to the centre of the patella. All measurements were taken with the same non-elastic tape measure. Ross and Worrell documented the reliability of lower extremity girth measurement following knee surgery with a non-elastic tape which demonstrated excellent reliability for intra-session and inter-session testing (ICC>0.90) [12]

Range of motion (ROM)

Knee active ROM was assessed by one of the researcher who was kept blinded to the subject group assignment. Measurements were taken with a

standard universal goniometer with the subjects in high sitting. ROM measurement procedure used in this study has been described by Norkin and White. [13]

Knee extensor strength

Quadriceps muscle strength was tested using a computerised dynamometer (Cybex Inc.,). Participants were positioned in the chair, and the knee joint was aligned with the axis of rotation of the dynamometer.

Randomization

Eligible subjects were randomly assigned into two equal groups after baseline evaluation (3rd postoperative day). 15 subjects assigned to conventional exercise group and 15 to the eccentric exercise group.

Interventions

Both groups received Cryotherapy and compression as needed. Both groups underwent interventions under the supervision of the physical therapist from 3rd postoperative day. Subjects continued their respective interventions as outpatient service, after their discharge from inpatient hospital stay. Both groups received single session of physiotherapy intervention every day for 6 weeks from the day of surgery. Subjects in both groups underwent routine home exercise program.

Conventional exercise group (n = 15)

Subjects in this group performed 3 sets of 10 repetitions of supine ankle plantar flexion and dorsiflexion (ankle pumps), quad sets, straight leg raises, hip abduction in side lying, supine knee flexion, and standing hamstrings curls. 3 sets of 30 repetitions of patellar mobilisation; superior/inferior, medial/lateral (table 1).

Eccentric exercise group (n = 15)

Subjects in this group undergone eccentric exercise for quadriceps along with the same exercises performed by conventional exercise group. Eccentric exercise for quadriceps was performed by positioning the subject in high sitting with therapist holding the subjects knee in full extension and allowing him to control and flex the knee in a slow, gradual and controlled manner. 3 sets of 10 repetitions of eccentric exercise were performed. No resistance was used in this eccentric exercise intervention.

Data analysis

Data collected in this study was analysed using the SPSS package 20. Baseline demographics and outcome measures were analysed using a two sample t-test to detect between group differences, and the Wilcoxan Rank sum test was used as an alternative measurement for cases where the data did not have a normal distribution. Baseline measurements of the dependent variable compared in this study included: pain level, active knee ROM, thigh girth measurement 3" proximal to mid patella and quadriceps muscle strength.

Comparison of change from baseline to 6 weeks of the dependent variables in this study was analysed using the two sample t test and analysis of covariance (ANCOVA). The two sample t test was used to detect between group differences while the ANCOVA was used to equate groups on extraneous variables and to correct for heterogeneity among subjects. A p-value of 0.05 or less is considered a statistically significant change in outcome scores.

3. Results

Flow of participants

From July 2014 to January 2016, 48 unilateral tri-compartmental TKA subjects were recruited and 13 subjects were excluded due to complications and 3 subjects were from out of state and 2 subjects refused to participate in this study. Hence a total of 30 eligible subjects agreed to participate and provided informed consent. 15 subjects were randomly assigned to conventional exercise group and 15 subjects to eccentric exercise group. Study protocol was explained in the flow chart in figure 1.

Outcome measures

Baseline variables including pain, thigh girth, active knee flexion – extension ROM and quadriceps muscle strength for each group in this study are summarised in the table 2. Significant differences were found among the two groups for a few of the baseline variables. P values for change in dependent measures between groups from baseline to 6 weeks is summarised in table 3. Analysis of these dependent variables including pain, thigh girth, active knee ROM and quadriceps strength from baseline to 6 weeks resulted in no significance between groups, however significant difference was found for knee extension ROM (P = 0.045) and Quadriceps muscle strength (P = 0.001) favouring the eccentric exercise group.

4. Discussion

This RCT was therefore undertaken to investigate whether addition of eccentric exercise to conventional exercise program improved early functional recovery more than conventional exercise program alone. By day 6 after surgery, those in the eccentric exercise group had significant performance in straight leg raises, quadriceps muscle strength and active knee extension ROM with minimal or no lag. Eccentric exercise intervention produces active lengthening of the quadriceps along with higher force generation. [14] Isometric contractions also help in pain relief that could have occurred due to decrease in the

intrafusal and extrafusal fiber disparity and reset of the inappropriate proprioceptive activity. [15] According to Gerber JP et al, eccentric exercise has the potential to be highly effective at producing large quadriceps size and strength gains early after anterior cruciate ligament rehabilitation. [16-19] A descriptive study by Robin L Marcus and colleagues in 2011 proved that eccentrically biased rehabilitation program after TKA, is effective in quadriceps strengthening. [20] They had limitations in their study such as quasi experimental without a comparison group, baseline measurements for the study was at 3rd post operative week and RENEW an eccentric stepping machine as the intervention tool. In our study interventions were provided early from 3rd post operative day and all our interventions are manual exercise based without resistance, which makes our study more unique.

No studies to our knowledge have been published investigating the use of eccentric exercise following TKA. Our study result will encourage more therapists working in orthopaedic rehabilitation team to perform future research studies utilising eccentric exercise program following various lower extremity surgical procedures.

5. Conclusion

This study demonstrated that the addition of eccentric exercise in conventional exercise program, resulted in significant improvement in quadriceps femoris muscle strength and active knee extension ROM. The overall magnitude of improvement in quadriceps femoris muscle strength at 6 weeks was more than 30% greater in the eccentric exercise group compared with the conventional exercise group. Overall functional improvement in performing straight leg raises and active knee extension without lag was significantly achieved in eccentric exercise group. These findings clearly emphasise the importance of eccentric exercise during the early stage of TKA rehabilitation.

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Figures

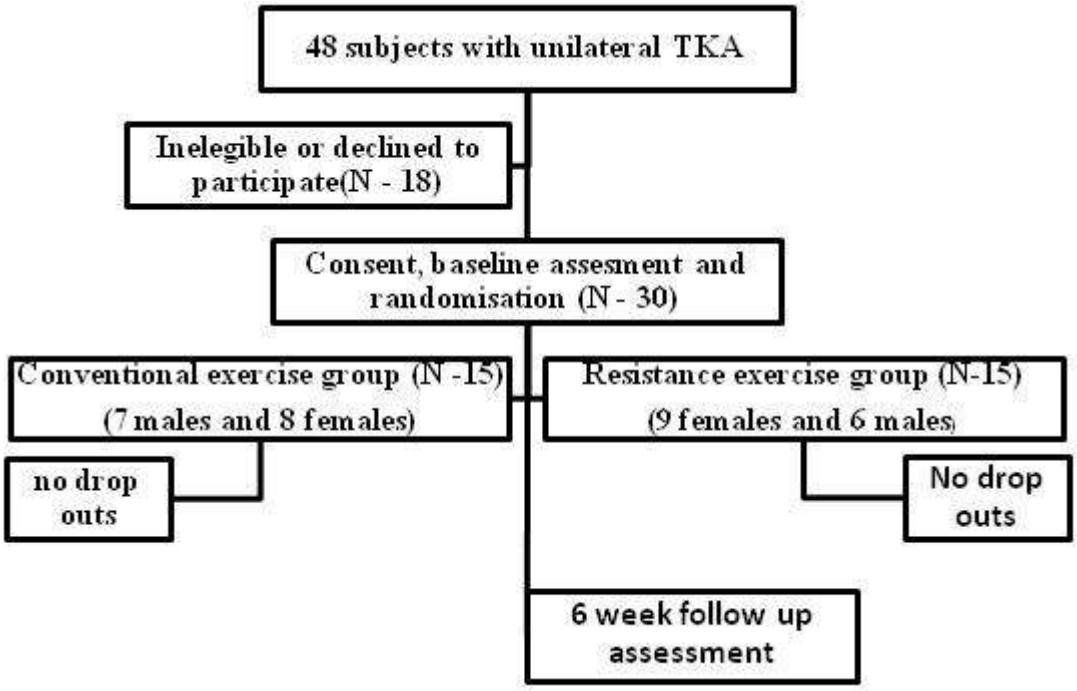

Figure 1: Study protocol

Alva's Health Center rehabilitation protocol after TKA
Phase I (Immediate post operative to 3rd post operative day)
● Cryotherapy ● Patient education about positioning and turning to side lying ● Ankle pumps ● Isometrics to quadriceps, hamstrings and gluteals ● Unilateral pelvic bridges ● Supine straight leg raises ● Supine hip abduction and adduction ROM exercise ● Side lying hip abduction ● Transfers training ● Gait training with walker support ● Start knee ROM from 3rd post operative day and achieve 90 degree by 1st week ● Hamstring stretches ● Supine knee hangs with pillow under heel to achieve full knee extension ● VMO strengthening ● Stair climbing ● Hamstring curls in standing and prone lying ● Achieve 110 degrees of knee flexion by 2 weeks
Phase II (2 weeks – 4 weeks)
● Continue same exercises as mentioned in phase I ● Achieve more than 125 degrees knee flexion ● Start gait with single elbow crutch or sticks ● Stationary cycling or pool walking ● Strengthening: Gluteals, quadriceps, gastro-soleus and Hip external rotators ● Stretching: Hamstrings, Quadriceps, Illopsoas, Gastro-soleus and ITB. ● Balance and Proprioception activities ● Normalise gait pattern and wean off assistive device at the end of 4 weeks

TABLES

Table 1: Total Knee Arthroplasty rehabilitation protocol

Variable	Conventional exercise group (SD)	Eccentric exercise group (SD)	P value
Pain	63.5	43.9	0.01
Circumferential measurement of thigh	46.6	47.0	0.87
Active knee Flexion ROM	93.5	94.8	0.08
Active knee extension ROM	2.1	2.4	0.87
Quadriceps extensor strength	1.49	1.31	0.99

Table 2: Baseline demographics

Variable	**Mean difference between groups**	**p value**
Pain	-2.707	0.678
Circumferential measurement of thigh	-3.662	0.847
Active knee Flexion ROM	1.657	0.116
Active knee extension ROM	1.880	0.045
Quadriceps extensor strength	0.27	**0.001**

Table 3: Baseline to 6 week comparison between groups