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Impact of Cluster Strength Training Versus Eccentric Oriented Strength Training on Anterior Cruciate Ligament Reconstruction with a Hamstring Tendon Graft

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ABSTRACT:

BACKGROUND: Anterior cruciate ligament reconstruction using a hamstring tendon graft is one of the commonest procedure for Anterior cruciate ligament injury patients to restore strength, stability, balance and functional performance. Rehabilitation program play a major role in muscular adaptation, neuromuscular control and risk of reinjury.

OBJECTIVE: the objective of the study is to compare the effectiveness of cluster strength training versus eccentric oriented strength training on anterior cruciate ligament reconstruction with a hamstring tendon graft.

METHODS: A quasi-experimental study was conducted on sixty participants aged between 18 to 30 years with anterior cruciate ligament reconstruction with a hamstring tendon graft. The participants were divided into two groups, group A received cluster strength training and group B received eccentric oriented strength training. The outcome measures were one repetition maximum and y-balance test.

RESULTS: The one repetition maximum showed improvements in both the groups with comparably higher changes in group b(14.6 ± 0.99) compared to group a(12.1 ± 0.93). In post-test of both group a and group b, anterior reach was increased in group b(71.03cm) compared to group a(65.33cm), the posteromedial reach showed greater in group b(93.71cm) than in group a(85.81cm) and posterolateral reach of 68.25cm in group a was lesser than 77.48cm in group b.

CONCLUSION: The Study Concluded That Group B(Eccentric Oriented Strength Training) Showed Significantly Higher Improvement Compared To Group A(Cluster Strength Training) In Anterior Cruciate Ligament Reconstruction With Hamstring Tendon Graft.

INTRODUCTION

Anterior cruciate ligament (ACL) is composed of two functional bundles, namely the anteromedial and posteromedial which was named by their attachment in tibial bone.^[1] The annual incidence of anterior cruciate ligament tears with age was 68.6 per 100,000 person-years. Age and gender related anterior cruciate ligament tear was observed with highest incidence among male aged 19-25 years (241.0 per 100,000 persons-years) compared to females aged 14-18 years (227.6 per 100,000 persons-years).^[2] Approximately one-third of athletes who return to sports following an ACL injury experience a subsequent ACL injury, with nearly 50% of these mainly occurring within the first two months after returning to sport.^[3] Anterior cruciate ligament reconstruction remains one of the most commonly performed surgical procedures in orthopaedic sports medicine.^[4] The anterior cruciate ligament reconstruction graft choice is very important and it depends on several factors such as age, gender, orthopaedic surgeon preferences and sports participation.^[5] Despite advances in ACL reconstruction, the graft failure rates are higher among younger and more active population with ranges from 6% to 39% with most failures occurring within 2 years after graft surgery.^[6] ACLR can be reconstructed with both allograft and autograft, but autograft showed reduced graft rupture rate compared to allograft particularly in younger patients.^[7] Graft selection plays an important role in postoperative knee stability, as hamstring tendon autografts have been associated with greater residual anterior and rotational knee laxity compared to patellar tendon autograft.^[9] Particularly, the semitendinosus and gracilis tendon plays a defined role in reducing excessive knee valgus and thereby minimally contributing to stability of knee joint.^[10] Whereas bone patellar tendon bone autograft is more evident and associated with higher donor-site morbidity problems, such as anterior knee pain, kneeling pain and extension loss compared to hamstring tendon autograft.^[11] However, knee stability and functional performance was re-established only after the post-operative rehabilitation, as ACL reconstruction often associated with muscle atrophy and neuromuscular inhibition, particularly in the muscles of thigh.^[12] Traditional rehabilitation protocols have predominantly emphasized on concentric exercises, whereas focusing on eccentric type of exercises provide greater improvement in muscular hypertrophy, strength, balance, neuromuscular adaptation and functional independence.^[13] Eccentric training offers significant benefits by improving muscular capacity to control movement during deceleration, a critical component of dynamic sporting activities such as jumping mechanics and rapid changes in direction.^[14] Eccentric training facilitates muscle tendon adaptation, lowers the risk of re-injury, and supports a more rapid return to activity, thus plays a crucial role in progression of rehabilitation.^[15] Studies suggested that eccentric exercises promote higher activation of type II muscle fibers and stimulate satellite cell proliferation, thus improves muscle repair, hypertrophy and tendon remodelling.^[16] While existing evidence suggested the benefits of strength training and their adaptations with anterior cruciate ligament reconstruction, limited research has directly compared the rehabilitation effects with response to type of graft. Therefore, the objective of this study is to evaluate the effectiveness of cluster strength training and eccentric-oriented strength training on muscle strength, functional performance, and rehabilitation outcomes in individuals who underwent anterior cruciate ligament reconstruction using a hamstring tendon graft.

METHODS

A quasi-experimental study was conducted on Pre Test and Post Test Experimental Design. In Mahatma Gandhi Medical College and Hospital, Puducherry. The sample size was calculated as 60 based on confidence level of 95%, effect size of 0.5 and degree of accuracy of 0.05. The participants were selected based on convenient sampling and allocated on odd and even method. The inclusion criteria included both male and female, age group of 18 to 30, post anterior cruciate ligament reconstruction patients referred for physiotherapy by orthopaedic department, chronic phase from 8th week, using hamstring tendon graft.

transplantation method, Range of motion - Knee flexion(60°-120°). Knee Extension (120°-10°). Underwent sutures after accompanying cartilage injury, Deep vein thrombosis, Elite athletes, not willing to participate, Co-existing injuries, Vascular injuries, Previous anterior cruciate ligament injuries, Sever chondral defects, Surgery with bone patellar tendon or other tendon autograft. The study protocol will be explained and informed consent will be obtained from each participant. The participants will be selected based on selection criteria. The baseline assessments such as name, age, gender, type of graft, post operative day, pain assessment, muscle range of motion and power will be assessed before the training protocol. The participants were divided into two groups. Group A received cluster strength training and Group B received eccentric oriented strength training. The intervention such as cluster strength training and eccentric oriented strength training were listed below in table (1.1 and 1.2). The frequency, intensity and duration of the intervention were listed in table 2. The outcome measures were one repetition maximum (hamstring curl) and y-balance test (Y-balance anterior, y-balance postero-medial and y-balance postero-lateral). The pre-test were evaluated one day before the initiation of intervention and post-test were evaluated 2 days after the completion of intervention.

TABLE 1.1- Cluster Strength Training

EXERCISES	1 st WEEK	2 nd WEEK	3 rd WEEK	4 th WEEK	5 th WEEK	6 th WEEK
Half squat (Quadriceps)	4rep×4set	4rep×4set	5rep×5set	5rep×5set	6rep×6set	6rep×6set
Copenhagen eccentric (Core)	4rep×4set	4rep×4set	5rep×5set	5rep×5set	6rep×6set	6rep×6set
Romanian deadlifts (Hamstring)	4rep×4set	4rep×4set	5rep×5set	5rep×5set	6rep×6set	6rep×6set
Hip thrust (Gluteus)	4rep×4set	4rep×4set	5rep×5set	5rep×5set	6rep×6set	6rep×6set
Eccentric Swiss ballcurl (Hamstring)	4rep×4set	4rep×4set	5rep×5set	5rep×5set	6rep×6set	6rep×6set
Bulgarian squats (Quadricep)	4rep×4set	4rep×4set	5rep×5set	5rep×5set	6rep×6set	6rep×6set

TABLE 1.2 – Eccentric Oriented Strength Training

EXERCISES	1 st WEEK	2 nd WEEK	3 rd WEEK	4 th WEEK	5 th WEEK	6 th WEEK
Half squat (Quadriceps)	6rep×2set	8rep×2set	10rep×2set	8rep×3set	9rep×3set	10rep×3set
Copenhagen eccentric (Core)	6rep×2set	8rep×2set	10rep×2set	8rep×3set	9rep×3set	10rep×3set
Romanian deadlifts (Hamstring)	6rep×2set	8rep×2set	10rep×2set	8rep×3set	9rep×3set	10rep×3set
Hip thrust (Gluteus)	6rep×2set	8rep×2set	10rep×2set	8rep×3set	9rep×3set	10rep×3set
Eccentric Swiss ballcurl	6rep×2set	8rep×2set	10rep×2set	8rep×3set	9rep×3set	10rep×3set

(Hamstring)						
Bulgarian squats	6rep×2set	8rep×2set	10rep×2set	8rep×3set	9rep×3set	10rep×3set
(Quadriceps)						

TABLE 2

Variable	Cluster Strength Training (CST)	Eccentric-Oriented Strength Training (EOST)
Frequency	3 sessions/week	3 sessions/week
Intensity	70–85% 1RM with intra-set rest intervals (15–30 s between clusters)	80–100% of concentric 1RM during eccentric phase
Time (Duration)	45–60 min/session	45–60 min/session
Type	Resistance exercises performed using cluster sets (Half Squat, Romanian Deadlift, Hip Thrust, Bulgarian Squat, Copenhagen Eccentric, Swiss Ball Curl)	Eccentric-focused resistance exercises (Half Squat, Romanian Deadlift, Hip Thrust, Bulgarian Squat, Copenhagen Eccentric, Swiss Ball Curl) emphasizing controlled lowering phase (3–5 s)

RESULTS

A Welch two sample t-test was used for analysis of variables. Descriptive statistics will be used to describe all continuous variables via means and standard deviations. To evaluate the longitudinal progress and performance changes over time within each training cohort (Group A and Group B), a paired t-test will be applied to compare the pre- and post-intervention data. To assess baseline equivalence prior to training and to determine which intervention yielded superior adaptations afterward, an unpaired t-test will be utilized to compare the data between the two independent groups at both the pre-test and post-test milestones. Additionally, Cohen's *d* effect sizes will be calculated to determine the standardized magnitude and practical significance of both the within-group improvements and the between-group final differences.

TABLE 3 Age Distribution of group A and group B

AGE CATEGORY	MEAN±SD
GROUP A	24.0 ± 3.48
GROUP B	23.87±3.64

Table 1: The mean age of the participants at enrolment was 24.0 ± 3.48 in group A and 23.87±3.64 in group B.

TABLE 4 Intragroup Pre and Post Test Values of Repetition Maximum of groups

SI No	Group	Pre Test	Post Test	T Value	P Value
1	A	7.50±0.59	12.1±0.93	-40.176	7.309×10 ⁻¹⁶
2	B	7.20±0.59	14.6±0.99	-44.223	<2.2×10 ⁻¹⁶

TABLE 2 showed the intergroup pre and post test values of repetition maximum. The group B(14.6±0.99) showed higher improvement in post test values compared to group A (12.1±0.93).

TABLE 5 Intergroup Pre and Post Test Values of Y-balance Test of Groups

Group	Reach Direction	Pre-Test Mean (Cm)	Post-Test Mean (Cm)	T-Value	P-Value
A	Anterior	59.30	65.33	- 62.3	$<2.2 \times 10^{-16}$
A	Posteromedial	77.33	85.81	-36.4	2.8×10^{-15}
A	Posterolateral	61.17	68.25	-63.9	$<2.2 \times 10^{-16}$
B	Anterior	61.40	71.03	-70.6	$<2.2 \times 10^{-16}$
B	Posteromedial	79.85	93.71	-69.1	$<2.2 \times 10^{-16}$
B	Posterolateral	63.25	77.48	-58.5	$<2.2 \times 10^{-16}$

Table 3 presented the within group comparison of pre-test and post-test Y-Balance test scores for group A and B in the anterior, posteromedial and posterolateral reach directions. In group A, the mean anterior Reach distance increased from 59.30cm at pre test to 65.33cm at post test, with a highly significant difference ($t = -62.3$, $p < 2.2 \times 10^{-16}$). Similarly, the posteromedial reach distance improved from 77.33cm to 85.81cm ($t = -36.4$, $p = 2.8 \times 10^{-15}$), while the posterolateral reach distance increased from 61.17cm to 68.25cm ($t = -63.9$, $p < 2.2 \times 10^{-16}$). In group B, the mean anterior Reach distance increased from 61.40cm at pre test to 71.03cm at post test, with a highly significant difference ($t = -70.6$, $p < 2.2 \times 10^{-16}$). The posteromedial reach distance improved from 79.85cm to 93.71cm ($t = -69.1$, $p = 2.2 \times 10^{-16}$), and the posterolateral reach distance increased from 63.25cm to 77.48cm ($t = -58.5$, $p < 2.2 \times 10^{-16}$).

FIGURE 1. Graphical Representation of Post-Test Values of Repetition Maximum and Y-Balance Test Between Group A and Group B

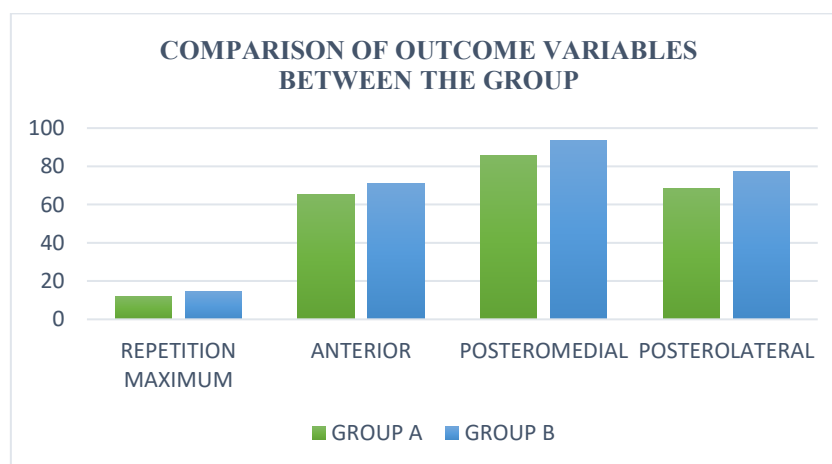


FIGURE 1 Graphically represented the post-test outcomes of Repetition Maximum and Y-Balance Test for both groups. The graphical analysis demonstrated a greater increase in performance among participants in Group B compared to Group A, supporting the findings that Group B showed better improvements in muscular strength and dynamic balance following the intervention.

DISCUSSION

The present study evaluated the effects of cluster strength training versus eccentric oriented strength training on muscular strength and balance in individuals with Anterior Cruciate Ligament Reconstruction on a Hamstring Tendon Graft.

The baseline age distribution showed homogeneity within the group A (24.0 ± 3.48) and group B (23.87 ± 3.64). The similarity in age characteristics suggested that incidence of Anterior cruciate ligament reconstruction was predominantly higher within the defined age group. The one repetition maximum showed improvements in both the groups with comparably higher changes in group B (14.6 ± 0.99) compared to group A (12.1 ± 0.93) with a effect size of -2.5 with a confidence interval of 95% [-3.5, -1.5]. Similar study was done on ACLR patients with either eccentric or concentric isokinetic training for 6 weeks and evaluated peak torque of quadriceps and hamstring,

single leg hop test and ability to return to sport and found that eccentric isokinetic training was more effective on strength, functional performance compared to concentric isokinetic training.^[17] Thus, the current study suggested that the eccentric oriented strength training group provided superior neuromuscular adaptation, recruitment of motor unit potential, improved muscle activation and force generating capacity. According to studies, the Hamstring autograft provided better functional outcome on Lachman and pivot-shift tests, Tegner activity score, Lysholm knee score, and IKDC score and synovial coverage on second-look arthroscopy.^[8] Balance was evaluated using y-balance test demonstrated significant improvements in both the groups throughout all reach directions. In post-test of both group A and group B, anterior reach was increased in group B (71.03cm) compared to (65.33cm). The posteromedial reach showed greater in group B (93.71cm) than in group A (85.81cm). The posterolateral reach of 68.25cm in group A was lesser than 77.48cm in group B. The composite score of y-balance test was 91.42. In a similar type of quasi experimental study, eccentric strength training was given for ACL reconstructed patients and reported that greater improvements were observed in muscular strength, dynamic balance and functional performance.^[18] Thus, the present study demonstrated significant improvement in anterior, posteromedial and posterolateral reach directions in group B compared to group A and indicated that eccentric oriented strength training enhanced lower extremity stability, joint proprioception, neuromuscular control and coordination. Several limitations of the study included a relatively smaller sample size. The characteristics such as duration of intervention can be increased. The outcome variables related to functional performances and quality of life were not evaluated. Factors influencing intervention outcome such as nutritional intake, sleep quality, physical activity level were not controlled. This study failed to include follow up assessment after completion of intervention. Future recommendations can be done on various rehabilitation strategies and evaluation of injury prevention, reoccurrences and return-to-sport performances. The study concluded that both the intervention showed effective in improving muscular strength, and dynamic balance among anterior cruciate ligament reconstruction with hamstring tendon graft. Among which, group B (eccentric oriented strength training) showed significantly higher improvement compared to Group A (cluster strength training) in anterior cruciate ligament reconstruction with hamstring tendon graft.

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