DOI: https://doi.org/10.53350/pjmhs2216514

ORIGINAL ARTICLE

Comparison of effects of open kinetic chain exercises with closed kinetic chain exercises on quadriceps strength and knee functional activity level after ACL reconstruction - a randomized controlled trial

NIMRA NADEEM[1], HAFIZ MUHAMMAD UZAIR ASGHAR[2], ISHRAT FATIMA[3], MUHAMMAD IRFAN FAZAL[4], AHMAD HUMAYUN SARFRAZ[5], SANIA MAQBOOL[6]

[1]*Physiotherapist at Khadija Polyclinic/hospital Sheikhupura.*
[2]*Lecturer at Lahore college of physical therapy-LMDC, Lahore*
[3]*Demonstrator at Akhtar Saeed College of Rehabilitation Sciences ACRS, Physiotherapist at Johar Medicare Complex, Lahore*
[4]*Assistant Professor at Mayo Hospital, Lahore*
[5]*Assistant Professor of Orthopedic Surgery, King Edward Medical University, Mayo Hospital, Lahore.*
[6]*Demonstrator at University of Management and Technology, Lahore*
Correspondence to Nimra Nadeem Email: nadeemnimra26@gmail.com Tel. 0333-4857673

ABSTRACT

Aim: To compare open kinetic chain exercises with closed kinetic chain exercises on strength of quadriceps and knee functional activity level after reconstruction of ACL.

Methods: The study design is randomized controlled trial. Data of 36 patients was collected with subjective consent: 36 patients were distributed in 3 groups and each group had 12 patients with age limit from 17-39 years, treatment was given for 6 weeks including 3 days a week with conventional RICE therapy, conventional treatment with open kinetic chain exercises and conventional treatment with closed kinetic chain exercises.

Results: SPSS 21 is used to generate results. Significant p value for post treatment ONE WAY ANOVA showed for knee injury and osteoarthritis outcome score is less than 0.05 which means the treatment technique is effective in reducing pain and disability in patients after ACL reconstruction. Significant difference was showed by ONE WAY ANOVA post treatment values for strength of all the muscles of quadriceps and knee functional activity in GROUP A, GROUP B and GROUP C. Vastus Medialis muscle showed p value 0.000, vastus lateralis muscle showed p value 0.000, vastus intermedius and rectus femoris both muscles showed p value 0.000 which are less than 0.05 showing significant difference between three groups.

Conclusion: Closed kinetic chain exercises are conclusively better in improving quadriceps strength and Functional status of patients suffering from Anterior cruciate ligament reconstruction than open kinetic chain exercises.

Keywords: Open Kinetic chain Exercises, Closed Kinetic chain Exercises, Anterior Cruciate Ligament.

INTRODUCTION

Reconstruction of Anterior cruciate ligament (ACLR) brings about decline of quadriceps muscle strength. The current examination explored the impact of ACLR on the thickness of muscles of quadriceps and coursing biomarker identified with muscle decay and hypertrophy[1]. Notwithstanding the expanded data and development in reconstructive medical procedure of the anterior cruciate ligament (ACL) in recent decades, joint inefficiency and leftover knee laxity remains a problem[2]. Anterior cruciate ligament (ACL) injury is a typical physical problem that antagonistically influences both mechanical and tangible capacity of knee joint. Careful remaking of the ACL is an efficient treatment of ACL injured people where the objective is to diminish side effects and reestablish normal knee dependability and capacity[3].

The chances of twisting injury after reconstruction of anterior cruciate ligament have been concentrated by a few creators in the previous 10 years[4]. The ACL is a focal ligament of the knee. The principle practical job of the ACL is to give protection against anterior tibial translation (ATT) and inward pivot. A typical and regular physical issue system is non-contact consolidated valgus- and inward revolution injury. Along these lines, ACL wounds are regularly connected with different ligamentous wounds, for example, a (fractional) crack of the medial collateral ligament (MCL) or the menisci[5]. Anterior cruciate ligament (ACL) injury is a genuine physical issue in patients who are normally youthful and physically dynamic, with potential long-haul difficulties including practical constraint, posttraumatic osteoarthritis of the knee, and disabled personal satisfaction. ACLR is currently viewed as the highest quality level of treatment for recapturing strength and improving knee work[6]. Security can be characterized as an insignificant risk of a re-injury or an ensuing related physical issue for the time being and with diminished risk of osteoarthritis in the long haul[7].

Received on 11-10-2021
Accepted on 22-04-2022

Patients have been accounted for to have exclusive requirements on the general state of the knee joint a year after an ACL reproduction, particularly more youthful patients, patients without past knee medical procedure, and profoundly dynamic patients[8]. Injury of the anterior cruciate ligament is a typical physical issue that generally influences young, truly dynamic patients and can prompt interminable risk of injury[9].

Even though ACLR can reestablish mechanical dependability to the knee, quadriceps quality deficiencies and useful restrictions regularly keep on enduring long after medical procedure. Moreover, the pace of come back to the pre-injury movement level is lower than predicted, and the occurrence of accessory ACL wounds is high after ACLR[10]. An effective come back to the pre-injury functional level and a low frequency of optional knee injuries after ACLR are desired outcomes; notwithstanding, such results are at present not exactly ideal[11].

Mostly, anterior cruciate ligament (ACL) injuries occur with associated injuries to different structures in the knee joint, for example, the menisci, collateral ligaments, and articular ligaments[12]. To decide exactly the hour of the subject's re-visitation of full physical wellness, the quality of their knee joint flexors and extensors ought to be observed routinely, as indicated by a previously characterized plan[13]. Every muscle of quadriceps femoris has a particular part in development; thus, to examine the quality of each quadriceps muscle individually is important for useful outcomes[14].

This study was aimed for the comparison of open chain kinetic exercises with closed chain kinetic exercises on strength of quadriceps muscles and knee functional activity level after ACL reconstruction.

This study is supported by hypothesis that closed kinetic chain exercises are more effective as compared to the open kinetic chain exercises and conventional treatment (RICE and knee range of motion exercises) in patients with anterior cruciate ligament reconstruction. There is very little evidence to prove the effect of

closed kinetic chain exercises as compared to open kinetic chain exercises and conventional treatment program.

METHODOLOGY

This study was Randomized controlled trial and was carried out in Physiotherapy outpatient door of Mayo Hospital Lahore after Ethical Committee permission. The time duration of this study was 6 months and was conducted in 2019-20. 36 subjects were assessed as a sample, each group having 12 patients by means of the use of G Power 3.10 with values of Effective size f: 0.48, α err prob: 0.50, Power (1-β err prob): 0.950. The number of groups used in this study were 3 and 3 number of measurements were taken. 10% Attrition rate of 33 having value of 3 was added. Purposive Non-probability sampling technique was used.

Criteria used for patients inclusion involves age limit of 17-39 years, diagnosed cases of ACL reconstruction managed and stable post operatively after 3 weeks, having positive results of pain and instability on any one of these three ACL tear tests: anterior drawer test, the pivot shift test and Lachman test. The exclusion criteria for this study includes concomitant surgery limiting an accelerated rehabilitation protocol (meniscal repair or transplant, microfracture, osteotomy, matrix autologous chondrocyte implantation or autologous cartilage implantation[15].

The patients were referred to Department of Physiotherapy by orthopedic surgery OPD of Mayo Hospital. Those who were fulfilling the eligible criteria had been considered for this study. Patients didn't know about their randomization in interventional groups, while the treating physiotherapist was not blinded to treatment allocation but blinding of the assessing physiotherapist was ensured for group allocation, to reduce bias. The intervention was given by experienced and designated physiotherapists while, a physiotherapist who was not involuted during the process of assessment had given the treatment sessions. Inclusion and exclusion criteria for treatment of anterior cruciate ligament reconstruction was considered while conducting this research study. Before starting the treatment of patients their consent had been taken through consent forms. Examination data (subjective and objective) and demographic data involving age, past medical and surgical history, gender, socioeconomic status, educational status, onset, severity, and duration of symptoms had been recorded. Group A included 12 patients of 3 weeks post operative with anterior cruciate ligament reconstruction and were given conventional treatment including R.I.C.E therapy including: Rest, Icing of effected knee joint (For 10-15 minutes) in circular motion around the knee joint, Compression therapy (pressure stockings were used by the patients for maximum of time), Elevation (knee joint was elevated at 45 degrees), and range of motion exercises for knee joint (passive, active and active assisted). The group B involved 12 patients and were treated with open kinetic chain exercises: (isometrics knee exercises, isotonic knee exercises, knee flexion-extension stretching exercises) and conventional treatment. The Group C of 12 patients were given closed kinetic chain exercises (standing weight shift exercise, Wall sits exercise, Squatting lunges exercise) and conventional treatment.

The interventional protocol was divided into two different phases: In Phase ONE of 1–3 weeks, patients were given the physiotherapy treatment of 3 sessions per week which was based on group-specific active physiotherapy treatment, each exercise was repeated 5 times with 10 seconds' hold; during Phase TWO of 3–6 weeks, patients were given a treatment plan of progressive nature with increasing time duration and repetitions in number. The patients were advised not to perform any activity that can aggravate their symptoms with a prescription to follow the conventional treatment plan at home twice daily to relief pain.

Data was managed and analyzed using SPSS 21. Percentages and table of frequency were used to show qualitative data. While the Quantitative data e.g., age was shown as mean ±SD. Normality of the data was assessed by Shapiro Wilk test. The difference within all clinical parameters (KOOS, MMT) was determined by Repeated Measure ANOVA. Difference between the three groups was assessed by One way ANOVA. If p-value is <0.05 than it indicated the significance of results while p value >0.05 showed that the results were not significant.

RESULTS

Table 1: Between groups descriptive statistics of KOOS

		Pretreatment			Post-treatment		
		N	Mean	St. deviation	N	Mean	St. deviation
Koos pain	Group A	12	36.0833	5.90005	12	42.7500	8.58249
	Group B	12	43.2500	12.57794	12	67.9167	12.52240
	Group C	12	43.8333	19.32419	12	75.7500	12.58516
Koos symptoms	Group A	12	39.0000	8.15754	12	44.6667	6.74649
	Group B	12	42.7500	8.92519	12	61.4167	10.61267
	Group C	12	48.5000	19.55180	12	67.0000	12.10560
Koos adls	Group A	12	38.6667	5.05125	12	46.5000	10.98346
	Group B	12	42.7500	11.82543	12	68.1667	13.69030
	Group C	12	52.0000	20.59126	12	80.9167	12.73833
Koos sports	Group A	12	40.8333	8.21123	12	49.5833	13.04857
	Group B	12	36.2500	13.33570	12	66.2500	15.09440
	Group C	12	42.5000	15.73935	12	75.8333	11.64500
Koos qol	Group A	12	39.8333	6.67197	12	48.0833	10.73193
	Group B	12	39.1667	11.24790	12	64.2500	7.65299
	Group C	12	38.6667	12.27217	12	69.4167	10.50072

Table 2: ANOVA test of KOOS between and within groups *ANOVA*

	Pretreatment				Post-treatment			
	Sum of squares	Mean square	F	p- value	Sum of squares	Mean square	F	p- value
Koos pain between groups	2.722	1.361	.005	.995	7134.889	3567.444	27.523	.000
Within groups	9955.583	301.684			4277.417	129.619		
Total	9958.306				11412.306			
Koos between symptoms groups	264.500	132.250	.470	.629	3242.056	1621.028	15.961	.000
Within groups	9286.250	281.402			3351.583	101.563		
Total	9550.750				6593.639			
Koos between groups	684.500	342.250	1.039	.365	7266.056	3633.028	23.173	.000
Within groups	10866.250	329.280			5173.583	156.775		
Total	11550.750				12439.639			
Koos between ports groups	312.500	156.250	.696	.506	4234.722	2117.361	11.902	.000
Within groups	7406.250	224.432			5870.833	177.904		
Total	7718.750				10105.556			
Koos qol between groups	2.000	1.000	.007	.993	2972.667	1486.333	15.700	.000
Within groups	4705.000	142.576			3124.083	94.669		
Total	4707.000				6096.750			

Table 3: Descriptive statistics of muscles of quadriceps for strength between groups

		Pretreatment			Post-treatment		
Quadricep muscles		**N**	**Mean**	**St. deviation**	**N**	**Mean**	**St. deviation**
Vastus medialis	Group A	12	2.7500	.45227	12	3.3333	.65134
	Group B	12	2.6667	.49237	12	4.0000	.00000
	Group C	12	2.5833	.51493	12	4.0000	.00000
Vastus lateralis	Group A	12	2.7500	.45227	12	3.3333	.65134
	Group B	12	2.6667	.49237	12	4.0000	.00000
	Group C	12	2.5833	.51493	12	4.0000	.00000
Vastus intermedius	Group A	12	2.7500	.45227	12	3.3333	.65134
	Group B	12	2.6667	.49237	12	4.0000	.00000
	Group C	12	2.5833	.51493	12	4.0000	.00000
Rectus femoris	Group A	12	2.7500	.45227	12	3.3333	.65134
	Group B	12	2.6667	.49237	12	4.0000	.00000
	Group C	12	2.5833	.51493	12	4.0000	.00000

Table 4: ANOVA test for strength of muscles of quadriceps between and within groups

	Pretreatment				Post-treatment			
	Sum of squares	**Mean square**	**F**	**p- value**	**Sum of squares**	**Mean square**	**F**	**p- value**
Vastus between medialis	.167	.083	.351	.707	3.556	1.778	12.571	.000
Groups within groups	7.833	.237			6.667	.141		
Total	8.000				8.222			
Vastus between lateralis	.167	.083	.351	.707	3.556	1.778	12.571	.000
Groups within groups	7.833	.237			6.667	.141		
Total	8.000				8.222			
Astus between Intermedius	.167	.083	.351	.707	3.556	1.778	12.571	.000
Groups within groups	7.833	.237			6.667	.141		
Total	8.000				8.222			
Rectus between femoris	.167	.083	.351	.707	3.556	1.778	12.571	.000
Groups Within groups	7.833				6.667	.141		
Total	8.000	.237			8.222			

DISCUSSION

Knee extensor quality declines following ACLR is a typical issue which has been accounted for in past studies. In 2015, research was conducted by Palmier-Smith et al., revealed decline quality of extensor muscle of knee, extending somewhere in the range of 24% and 40.5%, a half year after ACLR, while another detailed a remaining, deficiency in quadriceps quality of 10% to 27%, a year after ACLR. Besides, long haul negative results of knee work for sports exercises and in any event, during day-by-day exercises. Consequently, the recuperation of muscles of quadriceps strength is one of the most significant factors after ACLR[16]. According to this study the strengthening plan proved more effective which concluded closed kinetic chain exercises.

Knee activities after ACL reconstruction surgery have been accounted in literature. In any case, these examinations researched knee movement at various time focuses after the medical procedure. In 2016, a study conducted by Gao et al. considered the step kinematics of the knee inside 1 year of activity. Hosseini et al. revealed ACL reconstruction knee kinematics a half year after the medical procedure. Scanlan et al. explored the connection between top knee expansion at heel strike of strolling and the area of thickest femoral ligament following 2 years of activity. All in all, these investigations detailed that ACL reconstruction essentially improved knee activities, yet couldn't reestablish useful knee kinematics to normal[17].

A study conducted in 2015 showed another purpose behind a decline in muscle action on the harmed side could be muscle shortcoming, regularly revealed after ACL injury, particularly in quadriceps and hamstrings in which a quadriceps quality deficiency of 20% preoperatively and furthermore 1 year after ACL reproduction is accounted for[18].

Clinicians and patients could be consented with nonsurgical treatment (dynamic recovery alone) for female patients after an ACL injury and has better knee work ahead of schedule after the injury. Knee capacity can be surveyed either previously or after a time of recovery, however various measures are expected to evaluate knee work at the 2 time focuses[19].

Research on early rehabilitation in 2017 gave evidence on execution of weight-bearing activity too soon could harm the local ligament because of joint insecurity or imbalanced muscle quality, while commencement of activity past the point of no return could have no useful impacts because of an inadequate development microenvironment[20].

In previously conducted studies, different kinds of supporting were assessed, including knee immobilization, recovery propping, and utilitarian supporting. While no support or length of support wear showed a bit of tolerance over another sort of support, another term of propping, or no propping by any means. Supporting doesn't give any profit and isn't vital. Quickened restoration has demonstrated no pernicious impacts, and likely patients are convenient to start prompt weight-bearing postoperatively, move the knee from 0° to flexion of 90°, and perform closed kinetic chain exercises. Unusual muscle of quadriceps reinforcing, and isokinetic hamstring muscle fortifying were securely consolidated three weeks after medical procedure; they might be sheltered sooner, yet further examination is required. Locally established restoration can be viable[21]. This study showed significant differences among different exercise programs concluding closed kinetic chain exercises as more effective treatment plan.

CONCLUSION

All of three exercise groups with conventional treatment, open kinetic chain exercises and closed kinetic chain exercises showed results of improvement in strength with reduced disability and pain. Between all three groups, GROUP C patients having closed kinetic chain exercises showed the best results with better strength and pain reduction and disability as compared to Group A and Group B with conventional treatment and open kinetic chain exercises respectively. In comparison with Group A and Group B, the patients with open kinetic chain exercises showed better strength and reduction in pain as compared to patients with conventional treatment program.

Conflict of interest: Nil

REFERENCES

1. Uçar M, Koca I, Eroglu M, Eroglu S, Sarp U, Arik HO, et al. Evaluation of open and closed kinetic chain exercises in rehabilitation following anterior cruciate ligament reconstruction. J Phys Ther Sci. 2014;26(12):1875-8.
2. Snaebjörnsson T, Hamrin Senorski E, Svantesson E, Westin O, Persson A, Karlsson J, et al. Graft Fixation and Timing of Surgery Are Predictors of Early Anterior Cruciate Ligament Revision: A Cohort Study from the Swedish and Norwegian Knee Ligament Registries Based on 18,425 Patients. JB & JS open access. 2019;4(4):e0037.

3. Filbay SR, Grindem H. Evidence-based recommendations for the management of anterior cruciate ligament (ACL) rupture. Best practice & research Clinical rheumatology. 2019;33(1):33-47.
4. Kiapour AM, Murray MM. Basic science of anterior cruciate ligament injury and repair. Bone & joint research. 2014;3(2):20-31.
5. Domnick C, Raschke MJ, Herbort M. Biomechanics of the anterior cruciate ligament: Physiology, rupture and reconstruction techniques. World journal of orthopedics. 2016;7(2):82-93.
6. Krause M, Freudenthaler F, Frosch KH, Achtnich A, Petersen W, Akoto R. Operative Versus Conservative Treatment of Anterior Cruciate Ligament Rupture. Deutsches Arzteblatt international. 2018;115(51-52):855-62.
7. Hamrin Senorski E, Samuelsson K, Thomeé C, Beischer S, Karlsson J, Thomeé R. Return to knee-strenuous sport after anterior cruciate ligament reconstruction: a report from a rehabilitation outcome registry of patient characteristics. Knee surgery, sports traumatology, arthroscopy : official journal of the ESSKA. 2017;25(5):1364-74.
8. Beischer S, Hamrin Senorski E, Thomeé C, Samuelsson K, Thomeé R. Young athletes return too early to knee-strenuous sport, without acceptable knee function after anterior cruciate ligament reconstruction. Knee surgery, sports traumatology, arthroscopy : official journal of the ESSKA. 2018;26(7):1966-74.
9. Kiapour AM, Fleming BC, Murray MM. Biomechanical Outcomes of Bridge-enhanced Anterior Cruciate Ligament Repair Are Influenced by Sex in a Preclinical Model. Clinical orthopaedics and related research. 2015;473(8):2599-608.
10. Delahunt E, Chawke M, Kelleher J, Murphy K, Prendiville A, Sweeny L, et al. Lower limb kinematics and dynamic postural stability in anterior cruciate ligament-reconstructed female athletes. Journal of athletic training. 2013;48(2):172-85.
11. Nawasreh Z, Logerstedt D, Cummer K, Axe MJ, Risberg MA, Snyder-Mackler L. Do Patients Failing Return-to-Activity Criteria at 6 Months After Anterior Cruciate Ligament Reconstruction Continue Demonstrating Deficits at 2 Years? The American journal of sports medicine. 2017;45(5):1037-48.
12. Hamrin Senorski E, Svantesson E, Beischer S, Grassi A, Krupic F, Thomeé R, et al. Factors Affecting the Achievement of a Patient-Acceptable Symptom State 1 Year After Anterior Cruciate Ligament Reconstruction: A Cohort Study of 343 Patients From 2 Registries. Orthopaedic journal of sports medicine. 2018;6(4):2325967118764317.
13. Czaplicki A, Jarocka M, Walawski J. Isokinetic Identification of Knee Joint Torques before and after Anterior Cruciate Ligament Reconstruction. PloS one. 2015;10(12):e0144283.
14. Cheon S, Lee JH, Jun HP, An YW, Chang E. Acute Effects of Open Kinetic Chain Exercise Versus Those of Closed Kinetic Chain Exercise on Quadriceps Muscle Thickness in Healthy Adults. International journal of environmental research and public health. 2020;17(13).
15. Janssen RPA, van Melick N, van Mourik JBA, Reijman M, van Rhijn LW. ACL reconstruction with hamstring tendon autograft and accelerated brace-free rehabilitation: a systematic review of clinical outcomes. BMJ Open Sport Exerc Med. 2018;4(1):e000301.
16. Kim DK, Hwang JH, Park WH. Effects of 4 weeks preoperative exercise on knee extensor strength after anterior cruciate ligament reconstruction. J Phys Ther Sci. 2015;27(9):2693-6.
17. Lin L, Li JS, Kernkamp WA, Hosseini A, Kim C, Yin P, et al. Postoperative time dependent tibiofemoral articular cartilage contact kinematics during step-up after ACL reconstruction. J Biomech. 2016;49(14):3509-15.
18. Trulsson A, Miller M, Hansson G, Gummesson C, Garwicz M. Altered movement patterns and muscular activity during single and double leg squats in individuals with anterior cruciate ligament injury. BMC musculoskeletal disorders. 2015;16:28.
19. Grindem H, Wellsandt E, Failla M, Snyder-Mackler L, Risberg MA. Anterior Cruciate Ligament Injury-Who Succeeds Without Reconstructive Surgery? The Delaware-Oslo ACL Cohort Study. Orthopaedic journal of sports medicine. 2018;6(5):2325967118774255.
20. Chang NJ, Shie MY, Lee KW, Chou PH, Lin CC, Chu CJ. Can Early Rehabilitation Prevent Posttraumatic Osteoarthritis in the Patellofemoral Joint after Anterior Cruciate Ligament Rupture? Understanding the Pathological Features. Int J Mol Sci. 2017;18(4).
21. Kruse LM, Gray B, Wright RW. Rehabilitation after anterior cruciate ligament reconstruction: a systematic review. The Journal of bone and joint surgery American volume. 2012;94(19):1737-48.