ORIGINAL ARTICLE

The Effectiveness of Backward Walking Post Anterior Cruciate Ligament Reconstruction- Results of a Randomised Controlled Trial

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ABSTRACT

Introduction: Rehabilitation of Anterior cruciate ligament reconstruction involves both open and closed chain exercises. Backward walking is an easy technique and is used in few rehabilitation protocols. This study aims to assess the effectiveness of backward walking post anterior cruciate ligament reconstruction

Materials and methods: 30 subjects were randomly allotted into the two groups: experimental group and control group. Pre intervention assessment was done in terms of strength, proprioception and gait parameters (step length, stride length, cadence). The control group received conventional rehabilitation program. Experimental group received backward walking in addition to the conventional rehabilitation program. The intervention was given for 4 weeks. Post intervention assessment was done in terms of strength of quadriceps and hamstrings, proprioception, and gait parameters (step length, stride length, cadence). Strength of the quadriceps and hamstrings was measured by 10 repetition maximum (RM) with the help of weight cuffs. Proprioception at the knee was measured at different angles by active positioning test. Gait parameters were assessed by foot print analysis method.

Results: Within group analysis revealed that there was statistically significant improvement in the 10 RM of quadriceps and hamstrings; proprioception and gait parameters in both experimental and control groups ($p < 0.05$). Between the groups: 10 RM of quadriceps and hamstrings, and gait parameters improved substantially in the experimental group as compared to the control group, but statistically there was no significant difference in the improvement of proprioception with respect to both the groups.

Conclusion: Physiotherapy rehabilitation program post anterior cruciate ligament reconstruction is effective in the improvement of the strength, proprioception and gait parameters. Inclusion of backward walking in the rehabilitation program results in the better improvements in various parameters.

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INTRODUCTION:

Traumatic injuries of the knee are common in all the levels of sports as well as in daily life.[1-3] Injuries affecting the knee joint cause considerable disability and time off sport. They are common in all the sports that requires twisting movements and sudden changes in the direction especially football, basketball, netball etc.[1,3] Damage to any knee structure leads to pain, stiffness, oedema, instability, difficulty in carrying out activities of daily living such as walking, squatting, staircase climbing etc.[1-3] Among the acute knee injuries, the greatest concern is of tear of anterior cruciate ligament (ACL). The ACL injuries are most commonly found between the age group of 20-40 years.2 The ACL injuries can be treated conservatively or operatively. Surgical management of the ACL deficient knee includes open or arthroscopic reconstruction.[1,2,4] After surgical intervention there are various modes of the rehabilitation such as strength training Isokinetics, training pool therapy, forward cycling, graded walking etc. which helps to reduce pain, swelling, stiffness, instability, and also helps in returning to normal functional activities.[2]

After ACL reconstruction early rehabilitation that incorporates early joint motion is beneficial for reducing pain, minimizing capsular contractures, decreasing scar formation that can limit joint motion. The studies show that immediately after ACL reconstruction, weight bearing is possible without producing an increase in the anterior knee laxity as it reduces the incidence of patello-femoral pain.[2] Rehabilitation with the closed chain exercises results in antero posterior knee laxity values close to normal and earlier return to normal daily activities compared to rehabilitation with open kinetic chain exercises.[5]Closed kinetic chain exercises can be given in the form of mini squats, lunges, step ups, backward walking, cycling etc. Thus ACL rehabilitation includes both open as well as closed chain exercises.[6,7] In this, the use of backward walking is of increasing interest in the current rehabilitation.

Since backward walking is one of the form of functional activity, including it in rehabilitation results in functional training. Backward walking does not need any specific equipment thus it is cost effective and easy mode of rehabilitation. Backward walking once done under supervision can be done as a home exercise program. There is however lack of studies stating quantitative effect of

backward walking on various functional impairments such as strength, proprioception, range of motion gait etc and activity limitation following ACL reconstruction. Thus, this study is undertaken to know its additive effect in rehabilitation.

AIM AND OBJECTIVES:

Aim of the study is to study the effectiveness of backward walking post anterior cruciate ligament reconstruction. The objectives are to study the effect of backward walking on dynamic power {10RM} of quadriceps and hamstrings group of muscles, proprioception at the knee post ACL reconstruction, spatial and temporal variables of gait (step length, stride length, cadence)

MATERIALS AND METHODS:

Weight cuffs for measurement of 10RM, 15 inches wide and 40 feet long paper sheet, stamp pad ink, inch tape, scale, pen and pencil, stopwatch, goniometer, velcrostraps were used. Pilot study for the duration of backward walking and Goniometer measurement for the proprioception was done prior to the study. The permission to carry out the study was obtained from the concerned authority, eligibility criteria were met and subjects were taken for the study with prior consent and explanation of the study to each subject. A total of 30 subjects were selected for the study as per inclusion criteria. Subjects were randomly allotted to the two groups: experimental group and control group. Both the groups were checked for homogeneity, experimental group: 15 subjects, control group: 15 subjects. Intervention was started when subject was allowed to weight bear 100% on the involved limb without an assistive aid. Pre- intervention assessment was done by the therapist for 10 RM of quadriceps (picture 2a) and hamstrings (picture 2b), proprioception (picture 3a, 3b) and gait parameters (step length, step length, cadence) (picture 1).Treatment protocol was started according to the groups. Control group received conventional rehabilitation program (picture 5) and experimental group received backward walking in addition to the conventional rehabilitation program. The conventional rehabilitation program common to both the groups included ankle pumping exercises, static quadriceps and hamstring exercises, hip and knee ROM exercises, strengthening of the hip and knee musculature by various closed and open chain exercise , gait training , proprioceptive training. Frequency of the treatment for both the groups was once a day for the morning session. Duration of the entire treatment for the conventional rehabilitation program was 20 min. For the backward walking, a pilot study was done for the duration of backward walking wherein 3 subjects were considered. The subjects were given backward walking in a fixed distance till the subjects felt some discomfort in the operated knee. According to the readings to start with the protocol 10 min duration was taken. Progression was done every week by 2 min. The supervised intervention was given for 4 weeks, since it is the maximum duration required for the adaptation in the muscle to occur.[2, 12] Post intervention assessment was done, final readings were noted and data was analysed. Measurement of 10 RM of quadriceps and hamstrings, proprioception at the knee was measured according to the standard measurement methods given in the books.[19, 20]. The study includes the subjects between the age group of 20-40 years having ACL injuries, undergone arthroscopic reconstruction for ACL and allowed for 100%weight bearing on the operated limb without any assistive aid. The study excludes knees with associated other soft tissue involvement like MCL,LCL, and lateral meniscus, associated fractures, associated muscle involvement like quadriceps tear, hamstring tear, surgical intervention done for the involved limb in the previous 1 year(open surgical intervention).

STATISTICAL ANALYSIS

Statiscal analysis was carried out using Microsoft excel 2003and SPS12.

Within group analysis for 10 RM of quadriceps and hamstrings was done by using paired "t" test, level of significance was set at $p<0.05$,between group analysis for 10RM of quadriceps and hamstrings was done by using independent t test level of significance was set at $p<0.05$.

Within group analysis for proprioception at all the three angles was done by using paired "t" test, level of significance was set at $p<0.05$, between group analysis for proprioception at all the three angles was done by using independent "t" test, level of significance was set at $p<0.05$.

Within group analysis for gait parameters was done by using paired t test, level of significance was set at $p<0.05$,between group analysis for gait parameters was done by using independent t test, level of significance was set at $p<0.05$

Table 1: **RESULTS**

SR NO	TEST	BASELINE	PRETEST		POST TEST		P VALUE
			MEAN	SD	MEAN	SD	
1	QUADRICEPS	EXP	1.6	0.47	3.63	0.6	<0.001
	10RM	CONTROL	1.3	0.5278	2.9	0.7606	<0.001
2	HAMSTRINGS	EXP	1.53	0.3994	3.73	0.623	<0.001
	10 RM	CONTROL	1.43	0.4577	3	0.5	<0.001
3	PROPRIOCEPTION	EXP	9.8	3.3209	2.2	2.4842	<0.001
	30	CONTROL	9.4	2.9713	4.26	2.9873	<0.001
4	PROPRIOCEPTION	EXP	9.6	3.9964	2.2	2.9391	<0.001
	60	CONTROL	9.8	2.426	4.3	2.4103	<0.001
5	PRPRIOCEPTION	EXP	9.33	3.266	2.26	2.0391	<0.001
	90	CONTROL	9.93	3.3693	3.86	3.8423	<0.001
6	STEP LENGTH	EXP	40.46	1.5225	42.89	1.9095	<0.001
	NON AFFECTED	CONTROL	40.41	1.4726	42.44	2.161	<0.001
7	STEP LENGTH	EXP	38.14	1.8719	40.75	1.8404	<0.001
	AFFECTED	CONTROL	37.77	1.5618	39.43	1.6798	<0.001
8	STRIDE LENGTH	EXP	77.02	5.7219	78.59	5.3169	<0.001
	NON AFFECTED	CONTROL	73.45	5.4656	76.48	5.4365	<0.001
9	STRIDE LENGTH	EXP	78.41	2.5615	79.86	2.5662	<0.001
	AFFECTED	CONTROL	75.56	2.633	77.15	2.6471	<0.001
10	CADENCE	EXP	78.33	4.3698	87.8	5.1713	<0.001
		CONTROL	79.86	4.32236	88.46	4.7339	<0.001

Table 2; RESULT

SR NO	TEST	EXPERIMENTAL		CONTROL		P VALUE
		SD	MEAN	SD	MEAN	
1	Age	4.43	25.46	3.47	25.86	
2	Height	4.16	158.8	3.95	157.7	
3	10 RM Quadriceps	0.62	2.1	0.45	1.6	0.017
4	10RM Hamstrings	0.57	2.2	0.44	1.6	0.003
5	proprioception30	3.26	7.26	2.38	5.13	0.52
6	proprioception60	4.3	7.13	2.53	5.46	0.201
7	proprioception 90	2.57	7.2	3.43	6.06	0.307
8	step length(NA)	0.79	2.69	0.47	1.89	0
9	step length(A)	0.45	2.6	0.54	1.71	0.001
10	stride length(NA)	0.39	1.69	0.46	1.52	0.048
11	stride length(A)	0.76	2.84	0.54	1.61	0
12	Cadence	2.22	9.46	1.32	8.88	0.041

RESULTS:

Within group analysis revealed that there was statistically significant improvement in the 10 RM of quadriceps and hamstrings, proprioception and the gait parameters in both experimental and control groups ($p < 0.05$). Between the groups: 10 RM of quadriceps and hamstrings and gait parameters improved substantially in the experimental group as compared to the control group. But there was no statistically significant difference in the improvement of proprioception with respect to both the groups.

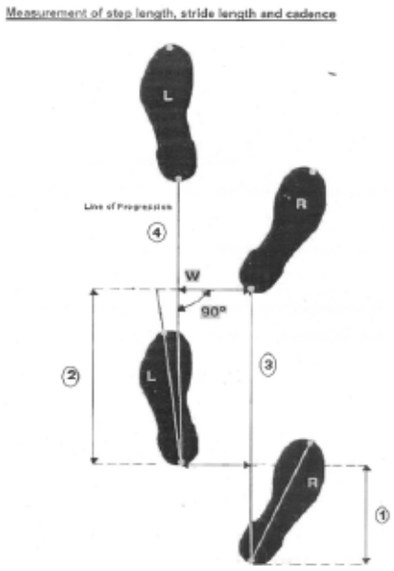
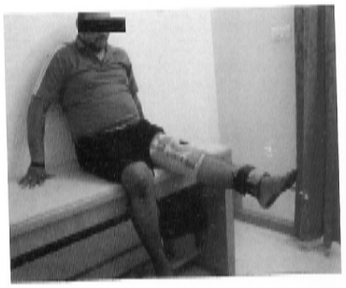
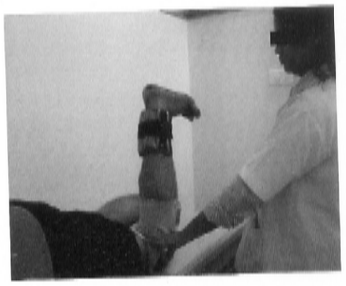


Figure 1 : Assesmont of steplength stridelength and cadence.



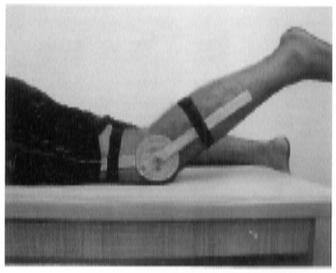
Picture 1a

10 RM Quadriceps



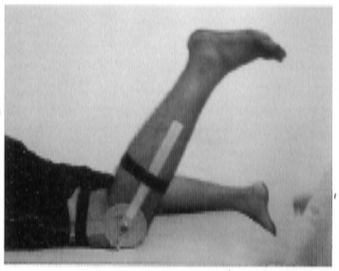
Picture 1b

10RMHamstrings



Proprioception at 30 degrees

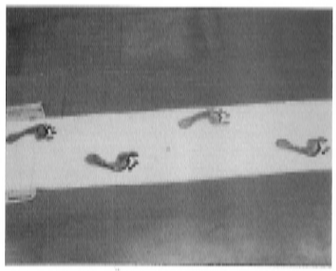
Picture 3a



Picture 3b

Proprioception at 60 degrees

Footprints



Footprints

Picture 4 ab

Picture 5

DISCUSSION:

The present study was undertaken to evaluate the effectiveness of backward walking post ACL reconstruction. The results suggests that there was statistically significant improvement ($p<0.05$) within both the groups with respect to the 10RM of quadriceps and hamstrings. The reason of improvement in the strength of quadriceps and hamstrings in both the groups can be attributed to the rehabilitation program. The rehabilitation program which was given to both the groups included: strength training of the hip knee musculature in closed chain as well as open chain pattern.

The strength improvement seen in the quadriceps and hamstrings is attributed to the physiological adaptations which occur in the skeletal muscle (skeletal and neural adaptation)post strengthening program which was given for 4 weeks.[2,16] Post training, there is a hypertrophy of the muscle fibre incorporated with hyperplasia. Fibre composition is changed from type 2b to type 2a.According to the size principle, low force muscle action activates only few motor units but with the strength training there is a higher force requirement progressively. So there is addition of more number of motor units to increase the muscle force due to which motor unit firing increases. Synchronization and the rate of firing improves by strength training, also there is an increase in the inhibitory function of the central nervous system because of decrease in the sensitivity of golgi tendon organ or changes at the myoneural junction of motor unit.[2, 16, 21]

There was a statistically significant difference in the 10RM of quadriceps and hamstrings in between the groups post intervention where as experimental group showed better improvement in the strength of quadriceps and hamstrings as compared to the control group. This can be attributed to the addition of backward walking to the conventional rehabilitation program. Backward walking has different biomechanics as compared to the forward walking. The studies show that in the backward stance toes contact the ground first and the heel is lifted off the ground last .The foot impact on the ground in the early stance is accompanied by activity of the knee extensors and ankle planter flexors. The backward thrust is provided by hip and knee extensors. The pattern of muscle synergies will be different as the knee flexors are reciprocally activated with knee extensors in backward walking.[9-14] Backward walking tends to decrease both swing and stance duration. The hip, knee and ankle angles are more in backward walking as compared to forward walking decrease in the stride length, increases the cadence as the frequency of quadriceps and hamstring firing increases.[14] Backward walking relies less on the momentum that also

leads to increase in the muscle activity and practice of repeated bouts of backward walking leads to more efficient recruitment of the motor units.[10, 13, 14] In the backward walking, quadriceps are active in the swing phase to control the foot placement prior to touch down, also concentric activity of quadriceps is needed to assist the knee extension in the stance phase.[14] Thus, all this results in better activity of quadriceps and hamstring group of muscles. So in addition to the conventional rehabilitation program, backward walking resulted in increase in the muscle activity and thus better improvement in the strength

Both the groups showed statistically significant improvement in the proprioception of the knee at all the three angles. The result can be due to closed kinetic chain exercises and early weight bearing which was included in both the groups. There is proprioceptive deficit post ACL reconstruction since there are large numbers of proprioceptors found in the ACL.[1,3,4] Closed chain exercises addresses the integration of the proprioceptors. These receptors during rehabilitation slowly adapt and continue to send impulses to the CNS as long as the neurological stimulus is present enhancing the proprioceptive input. Closed chain exercises use body's natural movements like squatting, standing and walking in all the planes. Thus, all the proprioceptors are stimulated together to some extent.[17, 25] The rehabilitation program includes mini squats which will stimulate GTO and muscle spindle as they respond to the muscle tension and the stretch. The subjects were allowed to weight bear immediately post ACL reconstruction. This results in the stimulation of the golgi mazzoni corpuscles which are present in the capsule and the tendons which respond to the perpendicular axial loading. They will be stimulated only with the closed chain exercises and not the open chain exercises. Early weight bearing allowed all the proprioceptors to stimulate increasing the sensory input to the CNS. This resulted in the improvement of the proprioception and the joint sense. Closed chain exercises allowed inherent joint stability thus allowing more span of pain free work out.[25]

There was improvement in the step length, stride length, cadence within both the groups which is statistically significant pre and post intervention. The improvement was seen in affected as well as non affected extremity. There is decreased stance time on the affected extremity due to pain, apprehension and impaired proprioception. This results in decreased step length, stride length of the non affected extremity. The gait variables of the affected extremity are also affected because of pain reduced range strength deficits.[8, 24] Both the groups underwent strength training, range of motion exercises, early weight bearing program. This resulted in the improvement of the range and strength of the muscles of the affected extremity. Early range of motion exercises resulted in the decrease pain and improved gait pattern. This resulted in the improved stance time on the affected extremity due to which even gait parameters of the non affected side improved.

There was a statistically significant difference in the mean of the experimental and control group with respect to the gait parameters post intervention. This can be due to the addition of backward walking in the experimental group. Addition of backward walking resulted in the improvement in strength of the affected extremity. Since backward walking requires more angles at the hip, knee and ankle there was improvement in the range at all the three angles. This also reflected in the gait pattern, thus use of backward walking in the rehabilitation resulted in the improvement in the range strength of the affected extremity thus minimizing pain and improve the weight acceptance on the affected extremity. This helped in normalising the gait pattern. The improvement in the experimental group was seen since backward walking is one form of gait training including gait parameters. The study did not measure the range of motion at the knee, Isokinetic strength, and long term follow up could not be maintained.

The study concluded that rehabilitation program post anterior cruciate ligament reconstruction is effective in the improvement of strength, proprioception and gait parameters. Inclusion of backward walking in the rehabilitation program results in better improvement of the quadriceps and hamstrings strength and gait parameters (step length, stride length, cadence) which is clinically and statistically significant. Backward walking did not have any additional effect in the improvement of proprioception post anterior cruciate ligament reconstruction

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