

Hip Extensor Weakness and Hip Displacement Angle During Gait in Post Anterior Cruciate Ligament Reconstruction Subjects: A Correlativestudy

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Abstract:-

➤ *Background and Purpose of the Study:*

The anterior cruciate ligament reconstruction (ACLR) subject's exhibit altered hip moment pattern during early stance suggesting that the hip doesn't re-establish normal joint moment characteristics at 3 months post-surgery. Weak hip extensors and quadriceps of the injured leg could lead to reduced hip extension and therefore a reduced hip displacement angle (HDA), and step length.

➤ *Method:*

An observational correlative study was conducted at HOSMAT Hospital physiotherapy OPD with a Sample size of 30. Outcome measures used were Hip extension (HE), Hip extensor strength (HES) and Hip Displacement Angle (HDA).

➤ *Results:*

30 subjects with a Mean (SD) age of 28.27 (± 5.85) yrs. 1 female and 29 males were included. There was statistical significant difference in all 3 outcome measures (HE, HES and HDA) in affected side compared to un-affected side, using paired "t" test. Correlations among the normalized outcome measures were done using pearson's correlation co-efficient. $r = 0.450$ ($p = 0.013$) for HE and HES, $r_s = 0.346$ ($p = 0.061$) for HES and HDA, $r_a = 0.328$ ($p = 0.077$) for HDA and HE. This study showed a weak correlation among the outcome measures.

➤ *Conclusion:*

In this study significant difference was appreciated in all the 3 outcome measures between affected and unaffected side. HE and HES was decreased in affected side compare to unaffected side after 3 weeks of ACLR and increase in HDA in the affected side. Statistical correlation among the outcome measures showed very weak correlation among them.

Keywords:- Anterior Cruciate Ligament Reconstruction, Hip Extension, Hip Extensor Strength, Hip Displacement Angle, Gait.

I. INTRODUCTION

The anterior cruciate ligament (ACL) is one of the 4 major ligaments in the knee. Two typical mechanisms of ACL injury includes shearing of ACL with sudden shift between tibia and femur and hyperextension of the knee causing failure of the ligament.¹ In ACLR grafts commonly used include bone patella tendon bone (BPTB) graft or hamstring (semitendinosus / gracilis) graft.¹ It has been suggested that, after surgery, the ability to perform functional activities and balance may be decreased 5–10%. Deficits have been found in the muscular and sensory processes after reconstructive surgery. Specifically, after ACLR with the BPTB procedure, strength deficits of 5% to 34% have been reported in the involved extremity compared with the contra lateral limb after rehabilitation.⁴ Reports of prolonged hip extensor moments have been common after ACLR.^{1,7} The ACLR subjects exhibit altered hip moment pattern during early stance suggesting that the hip doesn't re-establish normal joint moment characteristics at 3 months post- surgery.^{2,3,4,5}

Weak hip extensors and quadriceps of the injured leg could lead to reduced hip extension (HE) and therefore a reduced step length and velocity.⁶ Studies have suggested that the hip extensors, knee extensors, and ankle plantar flexors all help to control hip and knee extension during the stance phase of normal gait.⁷ The hip displacement angle (HDA) is the difference in hip angle between the leading and trailing leg at heel strike (HS) and is theorized to represent the functional hip range of motion at this time of point. HDA, leg length and to a lesser degree knee joint angle all contribute to step length. HDA reflects the hip joint influence on step length without any contribution from the knee joint.¹ The purpose for conducting this study was to check co-existence of hip extensor weakness and corresponding reduction in hip extension (HE) and hip displacement angle (HDA) during gait.

II. METHOD

30 subjects who underwent ACL reconstruction surgery at Hosmat hospital were included in the study after ruling out the inclusion and exclusion criterias. Inclusion criterias were 1) 3weeks Post ACL reconstruction. 2) Age 18-40 yrs .3) Gender: Both males and females. 4) Subjects

visited physiotherapy department as outpatient. Exclusion criterias were: 1) Infection (local or general). 2) Subjects complained of pain level more than 6 on VAS while weight bearing. 3) Apprehensive to walk. 4) Dependence on assistive aids. 5) Menisci tear along with ACL. 6) Associated fractures. 7) Multiple ligament failure. 8) Flexion deformity $>100^\circ$. 9) Profound swelling post operative. 10) Limb length discrepancy ≥ 29 . 11) Hip contractures. 12) Gastrocnemius and Soleus tightness.

Outcome measures included were 1) Hip extensor strength. (KgF). 2) Hip extension. (Degree). 3) Hip displacement angle during gait (Degree).

Pain intensity while weight bearing was evaluated by means of a visual analogue scale (VAS), ranging from 0 cm to 10 cm, wherein the subjects had marked a point according to their pain level, a higher pain score correspond to more intense pain.

➤ Figures:



Fig 1 Measurement of Hip Extension

For HE, subjects were instructed to lie prone on the couch. The fulcrum was aligned with the greater trochanter of the femur.[Fig. 1] The stationary arm was positioned along the lateral midline of the abdomen, using the pelvis for reference, the moving arm along the lateral midline of the femur. The subject was instructed to lift the leg off the couch. The active range of motion (AROM) of hip extension was measured from the reading of goniometer. The procedure was repeated three times on affected and

unaffected extremity. The average of the readings was considered for data analysis.



Fig 2 Measurement of Hip Extensor Strength (HES)

For the assessment of HES, the Isometric dynamometer (Modified handgrip dynamometer) was attached to a specially designed portable and adjustable hand hold bar which examiner was stabilized during the test. On applying pressure, the measurement of Kg force (KgF) exerted was recorded on the control pad. To ensure accuracy of this measurement, the pelvis and contra-lateral leg was fully stabilized by belts with the couch. The dynamometer was secured onto the specially designed hand hold bar and stabilized by the examiner, so that motion and force artefacts can be minimized during the test.(Fig 2)

(Fig: 2) The subjects were lying down prone on the couch; the dynamometer with the portable and adjustable hand hold bar was fixed 5 cm over the back of the thigh and stabilized by the examiner. The pelvis and contra-lateral leg was stabilized on the couch with stabilizing belts. The testing leg was extended approximately till 70° (to isolate Glutei hip extension) and were supported by an assistant and subjects were asked to do extension of the hip and create pressure on the dynamometer with the back of the thigh as much as possible [Fig 2]. Three readings were taken and the average of all the three readings was used for data analysis. Measurement was taken on unaffected leg first and then affected leg. In case of the readings falling in between two marked value in the dynamometer, the higher value was consider for data analysis.

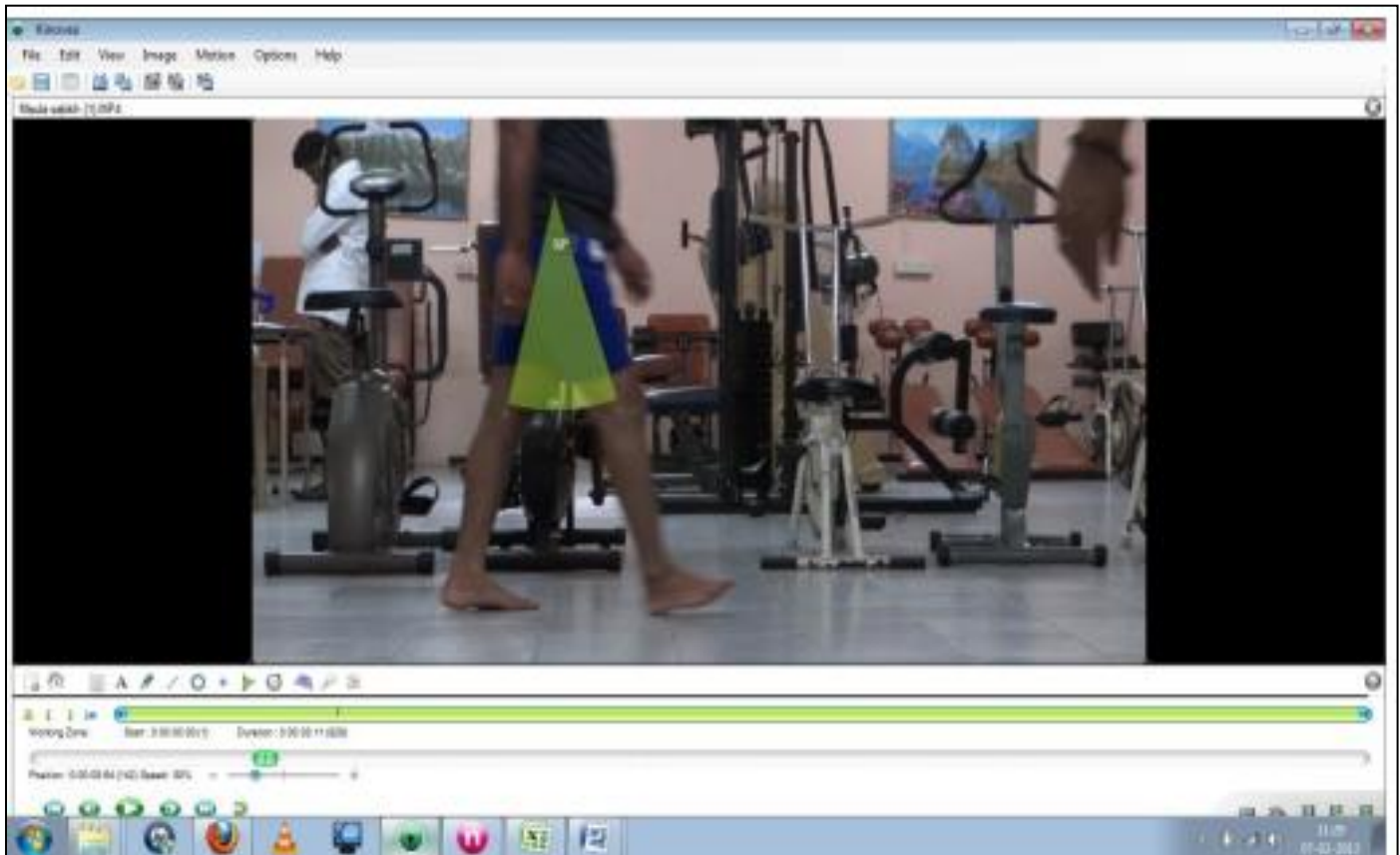


Fig 3 Measurement of Gait Parameters:

The subjects were instructed to wear shorts during walking session. A digital SLR with Full HD movie recording (SONY DSC-HX100V) was placed 6 m away from the walkway, on a 2.5 feet high fixed platform, perpendicular to the direction of movement. Subjects were instructed to move at their comfortable speed along the length of the walkway. Two trials were taken, two in either direction. Individual AVI files were saved for each gait trial. These were then analyzed frame by frame until the frame corresponding to Heel Strike was discovered for both the injured and non injured legs using Kinovea 0.8.15. Individual frames corresponding to events of interest was saved from the video and stored as JPEG files.

➤ *Method used to Obtain Joint angle Measurements*

Hip displacement angle was measured using Kinovea software. Electronic goniometer was placed along the length of both femurs till the level of femoral condyles. Angle was measured at intersection point on pelvis during heel strike on forward limb and heel off on backward limb. Affected HDA (A_HDA) means when angle measured, when affected limb was forward during gait and Unaffected HDA

(UA_HDA) means when angle was measured while forwarding the unaffected limb during gait cycle.

A computerized goniometry tool (Kinovea 0.8.15) was aligned over specific landmarks to obtain the joint angles. HDA reflects the hip joint influence on step length without any contribution from the knee joint.

III. RESULT

The demographic data age and POD assessment data was described by Median and Range. Hip extension (HE), Hip extensor strength (HES) and Hip displacement angle (HDA) for both affected and unaffected side scores was described by Mean m and SD and checked for normal distribution for the same data. Affected verses Un-affected comparison was done using paired t-test. The correlation between HE and HES, HE and HDA, HES and HDA was analyzed by pearson's correlation co-efficient.

➤ *Demographic Data:-*

Table 1 Demographic data: [M – Male, F – Female, R – Right side, L – Left side, Hams – Hamstring, POD – Post Operative day]

Serial No.	Subjects Parameters	Frequency
1.	Age in years – [Mean ($\pm$ SD)]	28.27 ($\pm$ 5.85)
2.	Gender [M / F]	29 / 1
3.	Side affected [R/L]	15 / 15
4.	Graft [BPTB / Hams]	28 / 2
5.	POD – [Median (Range)]	24 (21 - 26)

➤ *Comparison of means of affected and Unaffected Side with Paired 't'-Test:-*Table 2 Descriptive data: [HE – Hip extension, HES – Hip extensor strength, HAD – Hip displacement angle, KgF – Kilogram force, SD – Standard Deviation] * $p < 0.05$, $df = 29$

	HE	HES	HDA
AFFECTED SIDE	27.754 ± 2.295	30.355 ± 5.429	32.266 ± 4.438
UNAFFECTED SIDE	29.91 ± 1.543	36.976 ± 5.844	26.98 ± 3.89
Comparison of means with paired "t" test	8.273*	18.925*	-11.785*

Normalization of data was done taking ratio of mean of all 3 outcomes; HE, HES and HDA of affected side with unaffected side and its shown in Table No. 3; so that data can be compare with each other.

Correlations among the normalized outcome measures were done using pearson's correlation co-efficient. It

showed a very weak correlation among the data. $r_e = 0.450$ ($p=0.013$) for HE and HES, $r_s = 0.346$ ($p=0.061$) for HES and HDA, $r_a = 0.328$ ($p=0.077$) for HDA and HE; shown in Table No 3.

➤ *Normalizaion of Data:-*

Table 3 The mean (SD) ratio of HE, HES, HDA

Outcome measures	Symmetrical ratio between sides (Mean ± SD)
HE ratio (A/UA)	0.927 ± 0.050
HES ratio (A/UA)	0.821 ± 0.047
HDA ratio (UA/A)	0.837 ± 0.067

Table 4 Correlation between HE and HES; HES and HDA; HDA and HE using Pearson's Correlation coefficient:- * Correlation is significant at the 0.05 level (2tailed).Correlation between outcome measures.

Outcomes	Correlative co-efficient
HE and HES	$r_e = 0.450^*$
HES and HDA	$r_s = 0.346$
HDA and HE	$r_a = 0.328$

IV. DISCUSSION

The aim of this study was to examine HES after ACLR and HDA during normal gait and correlation between HE, HES and HDA during gait. A total of 30 subjects were recruited for the study. Mean age of the subjects was 28.27 ± 5.85 years ranging from 17 to 43 years. This age group was taken for study as they are more prone to ACL injury and wants to undergo ACLR surgery, to get back to their recreational activities.¹ There were 29 male subjects and 1 female subjects participated in the study, due to their personal reasons. There were 7 traumatic ACL injury, 1 professional sports injury, 21 recreational sports injury and 1 domestic injury. There were 15 right sided and 15 left sided ACLR subjects who participated. Out of them 28 subjects were reconstructed with BPTB graft and 2 were reconstructed with hamstring tendon graft. Assessment was done in between 21st to 26th OPD with a median 24 POD. The result of this study demonstrated that there was significant decrease in HE and HES in affected side compared to unaffected side, which could be due to no focus during initial rehabilitation phase on HE and HES. Also while doing hip extension, length of quadriceps muscles could be a limiting factor as maximum subjects were reconstructed with BPTB graft. Also subjects were apprehensive towards movement of knee. The results may be attributed to weakness of Gluteus maximus on affected side in comparison to unaffected side which may lead to reduction in hip extension in open kinematic chain.¹⁰ There

was significant increase in HDA in affected side compare to unaffected side after 3 weeks of ACLR surgery. This could be explained as, stance duration is longer in non-operated leg compare to operated leg, and so affected leg step length is longer compared to unaffected side step length. The results are accordance with a previous study.¹² Decrease in step length and HDA on the operated leg could also be due to pain¹⁰, fear avoidance¹³ and alteration of extensor mechanism¹². Underlying cause of the reduced unaffected HDA may have been weak hip extensor along with quadriceps of operated leg. Reduced unaffected HDA would contribute to knee stability by reducing the single leg support time and biomechanical load on the operated leg during gait.¹ Previous study stated reduced unaffected HDA in ACLR was found to be positively correlated to gait velocity.¹⁴ Correlation among outcome measures (HE, HES and HDA):- Poor correlation was found among the Normalized outcome measures. This may be due to various reasons. This study only concentrates on hip parameters mainly HE and HES. But gait depends on other factors like knee musculature (mainly quadriceps and hamstring) and hip, knee and ankle kinematics or may be fear avoidance³³. In a previous study the multi joint accelerations induced by muscles during single limb stance confirmed that the gluteus maximus, vasti and soleus make substantial contributions to hip and knee extension during normal gait⁷. Clinical factors that could have caused altered kinematics and gait parameters like effects of swelling, ROM of knee, physiotherapy sessions, activity levels and some underlying

pathology are considered minimal, although difference have not been tested statistically¹. Weak hip extensor along with quadriceps weakness of the operated leg could lead to reduced hip extension during stance phase of operated leg and therefore a reduced HDA and step length.⁷ Also subjects were taken in 3rd week of POD after ACLR, they were dominated by pain and fear avoidance¹³ and were weaning from assistive aids promoting full weight bearing. Previous investigation reported that Chronic ACL deficient patients tend to develop a quadriceps avoidance gait pattern.¹⁴ Devika et al reported that ACLR subjects walked with approximately 10° higher flexion at the knee joint 3 weeks after surgery, which may reduce hip extension and HDA during gait; however no differences were observed 6 months later compared to uninjured controls.

V. LIMITATION OF THE STUDY

- Smaller sample size.
- Ratios of female subjects were very less. So difficult to generalized the results.
- Measurement error might come while measuring HES and HDA, as dynamometer was not fixed in a stable fixed platform as it was stabilized by the examiner. There were no proper anatomical landmarks on the subjects while measuring HDA in video tape using kinovea software, so accuracy could be biased.
- This study only focused on hip strength and hip kinematics during gait but gait is affected by many other factors.
- Only one dimension of gait analysis was focused in this study.
- *Further Recommendation:-*
 - ✓ Larger sample size to generate better data analysis.
 - ✓ Further studies should include knee and ankle kinematics along with hip kinematics.
 - ✓ Other outcome measures of knee to be considered for data analysis.

VI. CONCLUSION

In this study significant difference was appreciated in all the 3 outcome measures between affected and unaffected side. HE and HES was decreased in affected side compare to unaffected side after 3 weeks of ACLR and increase in HDA in the affected side.

➤ Implications on Physiotherapy Practice:

Hip extensor muscles should also be prioritized during ACL rehabilitation as considering only knee joint muscles leads to change in gait pattern of post ACL construction patients. Complete recovery and getting back to pre surgery functional level will be difficult for patients if hip muscles are not considered part of ACL rehabilitation protocol.

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