Variation in Joint Position Sense in the Contralateral Knee Following Unilateral ACL Injury

Abstract

The anterior cruciate ligament is one of the four major ligaments that stabilize the knee joint. Its function is to control anterior translation and medial rotation of the tibia in relation to the femur. ACL injuries are most often a result of low-velocity, non-contact, deceleration injuries and contact injuries with a rotational component. Cross limb transfer refers to the contralateral effects of the one limb. Alternative terms of this phenomenon include cross education, cross training or cross exercise. Cross limb transfer was first reported in scientific literature by Scripture et al. 1894. Recent literature has continued to suggest the importance of proprioception in maintaining normal joint kinematics in the knee, as well as in other joint. In addition, a greater appreciation of the process in both the normal and abnormal joint has been facilitated.

Question: To find whether there is any variation in joint position sense in the contralateral knee in unilateral ACL injury patients, when compared with the normal control group. This study is to find out the "Variations in the joint position sense on the contralateral knee following unilateral ACL injury". Since the nervous system is constructed with bilateral symmetry and crossed representation, the need for a study has aroused to assess the variations in joint position sense in the contralateral knee in a unilateral ACL injury.

Design: Comparative Study design.

Participants: The subjects for this study were 15 athletes with unilateral ACL injury and 15 normal individual.

Intervention & outcome measures: Joint Position Sense (JPS) of ACL injured knee and the contralateral knee were recorded. Also, JPS from the knee of healthy subjects were taken as the control. This was performed with the subject sitting on a chair with arm and back supported. Legs hanging in 90° flexion vertically. The therapist has to passively position the knee in pre-determined angles of 30°, 45°, 60° and hold this position for 5 seconds to sense the position. Then the patient is asked to return the leg actively to the starting position to reproduce the same angle with closed eyes. Measurements were repeated three times with three different targeted angles. Measures were taken by using goniometer and readings were noted in the chart and average values were recorded.

Conclusion: In this study, it has been found that proprioception is also affected in the contralateral knee following unilateral ACL injury when compared with the healthy knee. In addition, the proprioceptive devices are normal in the contralateral knee but due to the cross limb transfer phenomenon, mechanism of proprioception is altered in the unaffected contralateral limb. Therefore, encouraging proprioceptive training in the contralateral knee should be considered in the rehabilitation protocol that can enhance the healing of affected limb thereby improving the performance and reducing the risk of recurrent injury. Based on the statistical analysis and the discussion, t "there is a significant variation in the joint position sense in the contralateral knee following unilateral ACL injury compared with control knee".

Keywords: Anterior cruciate ligament; Knee; Rehabilitation; Joint position

Research Article

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Introduction

The knee joint is one of the most complex joints in the human body. Being a uniaxial hinge joint, it is structured to perform flexion and extension. The anterior cruciate ligament is one of the four major ligaments that stabilize the knee joint. Its function is to control anterior translation and medial rotation of the tibia in relation to the femur. ACL injuries are most often a result of low-velocity, non-contact, deceleration injuries and contact injuries with a rotational component. Contact sports also may produce injury to the ACL secondary to twisting, valgus stress or hyper extension all directly related to contact or collision.

A greater prevalence of ACL injury is found in females than males, accompanied by mensical injuries in 50% of the ACL injuries. The prevalence of ACL in general population has been estimated as an incidence of 1 case in 3500 people. The average tensile strength of ACL is 2160N.

The importance of the ACL has been emphasized in athletes who require stability in running, cutting and kicking. Injury to the ACL not only causes mechanical instability, but also leads to a functional deficit in the form of diminished proprioception of the knee joint.

Functional anatomy

By 14 weeks of gestation, the ACL and posterior cruciate ligament have divided; both having a functional blood supply, derived from the middle geniculate artery. ACL is intra capsular and extra synovial. It courses anteriorly, medially, distally as it runs from the femur to tibia.ACL receives nerve fibers from the posterior branch of the posterior tibial nerve. The main functions are proprioception, providing the afferent arc for postural changes during motion and ligament deformation.

Proprioception

The term proprioception was first coined in 1906 by Sherrington. The presence of neuro-receptor in the human knee joint was described by Rauber in 1874. Awareness of the posture, balance or position due to the reception of stimuli, produced within the body, stimulates the receptors within the muscles, tendon, joints and the vestibular apparatus of the inner ear. It is neural arc mediated and it has been demonstrated that a significant number of mechanoreceptors exist in the fibers of the ACL. These receptors play an important role in the complicated neural network of proprioception. Depending on the amount, location in the body, and the type of proprioreceptor, where the input is coming from, determines whether the information will be made conscious or processed unconsciously.

Impulses arising in the ligament are transmitted through the central nervous system, then processed and depending on the state of muscle there, commands are sent back to the effector muscles. This allows for maintenance of normal, smooth, coordinated movement of joint and the abnormally strong impulses such as those initiated when a ligament is over stretched, will result in contraction of allied muscle groups, thereby protecting further injury and subluxation of the knee.

Proprioception has three components:

i. Joint Position Sense - Static awareness of joint position

ii. Kinesthesia - Awareness/detection of movement and acceleration

iii. A closed loop afferent activity which starts reflex response and regulate muscle activation

There are various peripheral receptors, which detect specific signals and major sensory afferent pathways which carry the information from the spinal cord up to the cortex. Special type of sensations originates by stimulation of specialized nerve ending referred to as mechanoreceptors. These specialized end organs function as a transducer, converting mechanical energy of physical deformation into electrical energy of a nerve action potential.

Cross limb transfer

Cross limb transfer refers to the contralateral effects of the one limb. Alternative terms of this phenomenon include cross education, cross training or cross exercise. Cross limb transfer was first reported in scientific literature by Scripture et al. 1894.

The reason why cross-transfer happens is poorly understood. Reserchers believe that neuroanatomical basis for cross-transfer may exist. For instance, about 85% to 90% of the cortico spinal tract crosses in the medulla so that the left primary motor cortex controls the right voulantary muscles and the right primary motor cortex controls the left voluntary muscles (Barr & Kiernan,1993) while 10% to 15% of the axon that do not cross and continue to travel through medulla. Hence, motor impulses arising from one of the cerebral hemispheres innervates both the contralateral and the ipsilateral sides. Effect of cross limb transfer has been observed in different muscle including large limb muscle and small hand muscles and in response to different kind of training such as isometric, dynamic, concentric or eccentric exercise.

The nervous system is constructed with bilateral symmetry and crossed representation. Spinal nerve neurons receive afferent information from both ipsilateral and contralateral limbs. In the cerebral motor cortex, cross connection between contra lateral limbs contributes to the concurrent learned responses. This phenomenon has been exploited in rehabilitation of patients with head injury in whom training the opposite limbs improves function in weaker limb. Disruption of the afferent input from a knee with an ACL injury could theoretically affect the contra lateral limb. Hypothesis to explain cross limb transfer can be classified into two broad categories. The first category is the hypothesis in which it has been proposed that motor engrams developed in the dominant hemisphere can be assessed by the opposite hemisphere via the corpus callosum to facilitate task performance with the unilateral limb [1-10].

The second category of possible mechanism of the cross activation hypothesis, the bilateral cortical activity produced by unilateral training leads to adaptation in both hemisphere. Thus unilateral training causes task specific changes in the organization of motor circuits normally associated with control of the opposite homologous muscle.

There are also parallel pathways, some of which serve conscious proprioception and others that serve subconscious proprioception.

Recent literature has continued to suggest the importance of proprioception in maintaining normal joint kinematics in the knee, as well as in other joint. In addition, a greater appreciation of the process in both the normal and abnormal joint has been facilitated [11-13].

Aim, Statement and Need of The Study

To find whether there is any variation in joint position sense

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in the contralateral knee in unilateral ACL injury patients, when compared with the normal control group. This study is to find out the "Variations in the joint position sense on the contralateral knee following unilateral ACL injury".

Since the nervous system is constructed with bilateral symmetry and crossed representation, the need for a study has aroused to assess the variations in joint position sense in the contralateral knee in a unilateral ACL injury [14].

Materials and Methods

Materials

I. Arm rest chair

II. A universal 360° double arm Goniometer

III. Blind fol

Assessment tools

I. Assessment chart

Methodology

Study design

This study was conducted as a comparative study design, which describes the joint position sense in the contralateral knee in unilateral anterior cruciate ligament injured athletes and are compared with the healthy subjects in terms of their interesting features of cross limb transfer. Therefore, this study design brings out the striking features in the variation of joint position sense in the contralateral knee in unilateral ACL injury patient.

Study setting

Place of study: The study was conducted at Nehru stadium, Coimbatore.

Subjects: The subjects for this study were 15 athletes with unilateral ACL injury and 15 normal individual.

Study duration: The study was conducted over a period of 3 months.

Sample size: 30 patients were assigned into two groups of each 15.

A. Group 1: Athletes with Unilateral ACL injury (Experimental group)

B. Group 2: Healthy individual's "normal" knees (Control group)

I. Inclusion criteria

a. Patient with unilateral ACL injury

b. Grade 1 & 2 unilateral ACL injury

c. Patient with unilateral anterior cruciate ligament reconstruction.

d. Age between 18 -35

e. Both sexes were included

II. Exclusion criteria

a. Recent fractures of lower limb

b. Prolonged immobilization of lower limb

c. Any inflammatory pathology pertaining to knee joint.

d. Any neuro muscular problems

e. Decreased range of motion in the knee

f. Meniscal tears

g. Neurological disease

Parameters

Joint Position Sense (JPS) of ACL injured knee and the contralateral knee were recorded. Also, JPS from the knee of healthy subjects were taken as the control. This was performed with the subject sitting on a chair with arm and back supported. Legs hanging in 90° flexion vertically. The therapist has to passively position the knee in pre-determined angles of 30°, 45°, 60° and hold this position for 5 seconds to sense the position. Then the patient is asked to return the leg actively to the starting position to reproduce the same angle with closed eyes. Measurements were repeated three times with three different targeted angles. Measures were taken by using goniometer and readings were noted in the chart and average values were recorded [15-20].

Statistical tools

i. This study is based on the comparative study design in which the variation in the joint position sense in the unilateral and contralateral knee joint is evaluated.

ii. This requires the use of paired t test.

iii. Further, to assess the variation between contra lateral knee and the control knee, independent t-test is used which allows inferring the significance in the differences between the two groups.

The results are interpreted based on the calculated t-value and the level of significance.

Data Presentation and Statistical Analysis

The following data was collected from the subjects that included 15 unilateral ACL injury patients and 15 control group. Joint position sense of these two groups was measured at a predetermined extension angle of 30°, 45° and 60° passively; and the difference between the predetermined angle JPS and perceived (actively performed) degree of angle is noted. The primary data is as follows [21-25].

Interpretation

From the above data analysis, it is clear that there is no significant difference in the joint position sense in the affected and contralateral knee. The values of Table 1-4 show that Group 1 (i.e. Affected and unaffected knee) has no significance at all three angles. The results can also be confirmed with the values in the Table 1-4, in which the variation in the joint position sense significantly differs from the experimental injured group compared to the control normal group (Figure 1 & 2).

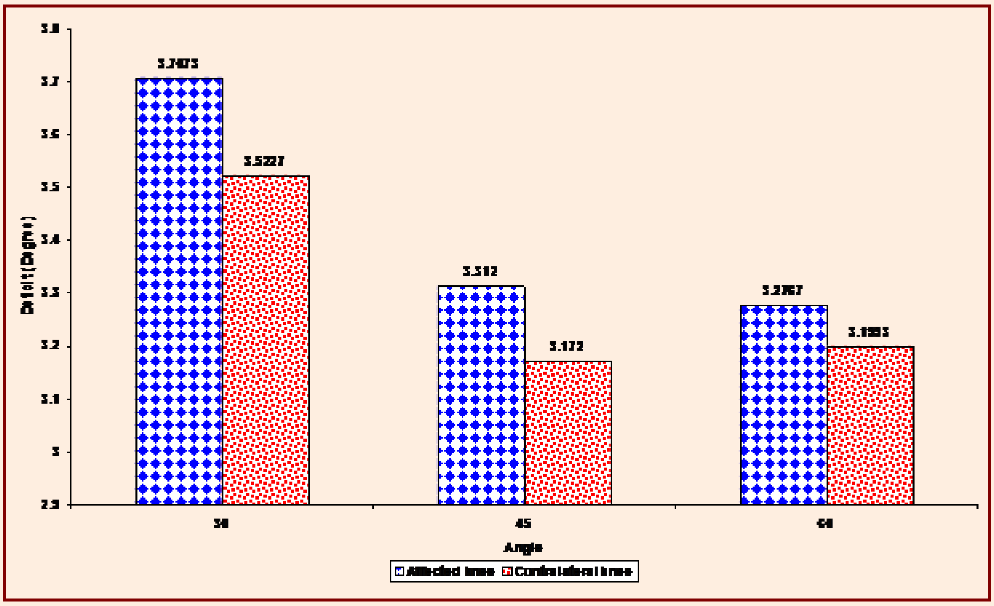

Figure 1: Mean value of joint position sense of affected and contralateral knee (30°,45°and 60°).

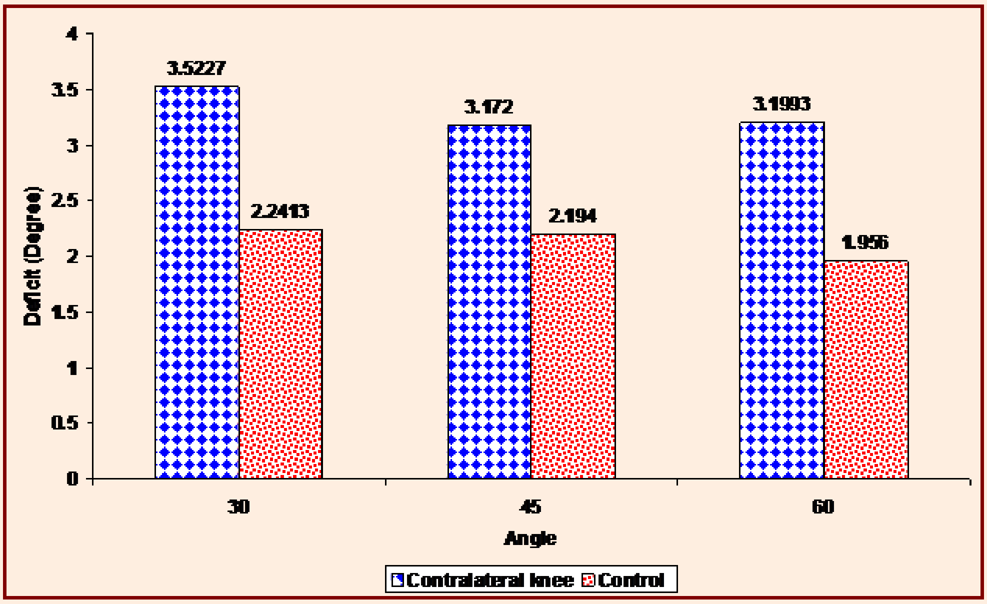

Figure 2: Mean value of the joint position sense between contralateral knee and control knee (30°,45°and 60°).

Table 1: Demographic Data.

Age Group	ACL injured knee		Control knee	
	Male	Female	Male	Female
18-26	6	3	5	3
26-35	4	2	3	4

Table 2: Joint position sense tested at 30° of knee joint extension from starting position (90°).

Sl. No	Angle tested	Experimental		Control
		Affected knee	Unaffected knee	Control knee
1	30	3.75	4.1	2.11
2	30	3.71	4	2.5
3	30	4.01	4.4	2.72
4	30	3.1	3.5	2.01
5	30	2.9	3.23	2.2
6	30	2.85	3.06	2.08
7	30	3.12	3.48	2
8	30	3.12	3	2.1
9	30	2.73	3.01	2.81
10	30	2.65	3	2.23
11	30	3.31	3.83	2.01
12	30	3.21	4.01	2
13	30	2.9	3.07	2.17
14	30	3.01	3.36	2
15	30	2.94	3.17	2.15
	Mean	3.7073	3.5227	2.2413
	Standard Deviation	0.50863	0.51727	0.29093
	Total Value	-1.141		

Table 3: Joint position sense tested at 45° of knee joint extension from starting position (90°).

S. No	Angle tested	Experimental group		Control group
		Affected	Unaffected	Control knee
1	45	3.7	3.1	1.61
2	45	4.19	3.54	1.7
3	45	4.57	3.4	1.36
4	45	3.95	3.09	2.42
5	45	3.39	2.68	1.32
6	45	4.42	3.19	2.83
7	45	4.02	3.18	2.01
8	45	4.01	2.95	2.91
9	45	3.72	3.02	2.08
10	45	3.21	3.26	2
11	45	3.27	3.06	2.89
12	45	4.08	3.32	1.09
13	45	3.21	2.31	2
14	45	4.14	3.08	2.31
15	45	4.2	3.29	2.18
	Mean	3.3120	3.1720	2.1940
	Standard Deviation	0.26617	0.28884	0.82645
	Total Value	1.278		

Table 4: Joint position sense tested at 60° of knee joint extension from starting position (90°).

S.No	Angle tested	Experimental Group		Control Group
		Affected	Unaffected	Control knee
1	60	3.12	3.5	1.82
2	60	3.12	3.42	1.6
3	60	3	3.4	1.21
4	60	3.09	3.58	1.84
5	60	3.01	3.22	1.65
6	60	3.11	3.58	1.8
7	60	3	3.81	1.85
8	60	3.01	3.58	1.87
9	60	3.33	3.48	1.8
10	60	3.49	4.15	2.78
11	60	3.01	3.87	1.81
12	60	3.49	3.28	2
13	60	3.41	4.06	2.8
14	60	3	3.99	2.03
15	60	3.8	4.18	2.48
	Mean	3.2767	3.1993	1.9560
	Standard Deviation	0.17274	0.24647	0.2852
	Total Value	-1.058		

Discussion

ACL is the most commonly injured ligaments in the knee. Athletes, who are involved in contact sports, have a high risk of ACL injury. As a known fact, injury to the ACL leads to a deficit in proprioception of the injured knee. This study attempts to find whether there is a proprioception deficit in the contralateral knee due to the "cross limb transfer" phenomenon.

The above table shows the average values of joint position sense of experimental and control group. It is clear that the values in the affected and unaffected knee (experimental group) is almost similar whereas the control knee shows significant difference in the values. This shows that there is a cross limb transfer phenomenon, which alters the proprioception in the contralateral knee [26-32].

Conclusion

In this study, it has been found that proprioception is also affected in the contralateral knee following unilateral ACL injury when compared with the healthy knee. In addition, the proprioceptive devices are normal in the contralateral knee but due to the cross limb transfer phenomenon, mechanism of proprioception is altered in the unaffected contralateral limb. Therefore, encouraging proprioceptive training in the contralateral knee should be considered in the rehabilitation protocol that can enhance the healing of affected limb thereby improving the performance and reducing the risk of recurrent injury. Based on the statistical analysis and the discussion, "there is a significant variation in the joint position sense in the contralateral knee following unilateral ACL injury compared with control knee" [33-38].

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