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Research Article

Comparison of Knee Proprioception between Athletes with Anterior Cruciate Ligament Injury and Healthy Athletes

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ABSTRACT

Introduction: In addition to the instability of the knee joint, injury to the anterior cruciate ligament (ACL) leads to a functional deficit in the form of diminished proprioception of the knee joint. The purpose of this study was to compare knee proprioception in athletes with an ACL injury and healthy athletes.

Materials and Methods: The participants in this cross-sectional study were 26 athletes with an ACL injury and 24 healthy athletes who were selected from the orthopedic clinic at Baqiyatallah Hospital in 2019, Tehran City, Iran. Cooper or non-Cooper subjects with ACL injury were identified via the knee injury and osteoarthritis outcome score (KOOS). The knee proprioception of all participants was recorded using a system consisting of digital photography, non-reflective markers, and Digimizer software.

Results: The results showed that there was no significant difference between groups in the absolute error of knee joint reconstruction at both 45° and 90° angles.

Conclusion: The data of the study showed that in comparison with healthy athletes, the knee joint proprioception of athletes with an ACL injury is not different and has the same function.

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1. Introduction

Proprioception is a sensation that involves understanding the position and movement of the joints. The mechanoreceptors provide the proprioception of neural feedback for positioning in space and are crucial for three-dimensional interaction [1]. Proprioceptive inputs from the joints and limbs arise from mechanoreceptors in the tendons, ligaments, and muscles [2, 3]. The knee joint has a wide range of movements and proper neuroanatomical organization is very important for knee stability. In addition to the muscles, the knee ligaments, including the anterior cruciate ligaments (ACL), along with the tendons and meniscus of the knee, provide knee stability [4, 5]. The presence of these mechanoreceptors in the ACL suggests a possible protective role. Stimulation of these receptors may initiate a reflex arc that may stabilize muscle contractions [6]. An ACL injury can be caused by improper functioning of mechanical receptors. Therefore, the instability of an athlete due to the ACL rupture may not only be due to the loss of an important structure but also because of the loss of proprioception [7]. An ACL injury may decrease the sensory input from mechanoreceptors to the central nervous system, which results from a decrease in the number of mechanoreceptors or alteration of their properties due to ACL injuries, that not only lead to mechanical instability but also leads to proprioception disturbance and reduces sensitivity, impaired ability to detect movement, and inhibits motor neurons around the joint [8, 9].

Although the ACL plays a significant role in knee proprioception, the effect of ACL injury on knee proprioception is unclear. Studies have also shown that ACL injury causes damage to the knee proprioception sense [5, 7]. ACL injury not only causes mechanical instability but also leads to functional impairment, including a decreased sense of proprioception of the knee joint [5]. A decrease in proprioception can have a negative effect on the activities of daily living, balance, and quadriceps muscle strength and increase the risk of new knee injuries [10].

Given that the effect of ACL injury on knee proprioception is somewhat unclear, we were prompted to conduct this study. Therefore, the purpose of this study is to compare the proprioception of the knee in athletes with an ACL injury and healthy athletes.

2. Materials and Methods

Participants

In this cross-sectional study, subjects were selected from the orthopedic clinic at Baqiyatallah University of Medical Sciences in 2019. The sample size estimation was performed through single proportion formula with a 95% confidence interval and the calculated sample size was 50 people. Twenty-six subjects had an ACL injury and 24 were healthy controls, and out of subjects with an ACL injury, 22 subjects were Cooper type according to the knee injury and osteoarthritis outcome score (KOOS). Because of the small sampling size, all subjects with ACL injuries were placed in a group. The main criterion for being qualified as Cooper was a complete return to exercise and the absence of knee instability. Non-Cooper patients were those who failed to return to pre-injury levels of activity and had at least one knee instability during the past six days. In addition, Cooper patients had a KOOS score above 80 and non-Cooper patients below 80 [11]. The diagnosis for ACL injury or no injury was made by an orthopedist. The inclusion criteria were as follows: 1) six months after an ACL repair, 2) lack of cognitive, visual, and hearing impairment [wearing glasses was permitted], 3) no systemic neuromuscular disease [diabetes] and rheumatism, 4) ACL injury during exercise, 5) no drug or alcohol addiction or any other disorder that disturbs balance (vestibular disorders, stroke, etc.), and 6) no limb length difference. The exclusion criteria were as follows: 1) reluctance to cooperate and 2) musculoskeletal injury during the study.

Procedure

At the beginning of the study, the implementation process was explained to the subjects and the participants were fully informed. Informed consent was obtained from all subjects. The demographic characteristics of the subjects were recorded. In both groups, objective angle reconstruction in standing posture was used to evaluate joint position sense. A system consisting of skin marking and digital photography (Canon EOS 1300D) was used to measure the target angle and reconstruction angles [12]. For marking, each person wore shorts with no other garments worn on lower limbs. Three colored circular markers were attached to the exterior part of the test limb at three points by the following method: The first marker was in the upper 1/4 line between the large trochanter and the middle part of the outer knee line, the second marker was attached to the upper part of the lateral malleolus. The person was then seated on the edge of the bedstead, and in a knee flexion position

of about 90°, the third marker was attached to the upper portion of the popliteal fossa along the upper edge of the patella (Figure 1). During all stages of the study, the camera was positioned on a tripod and perpendicular to the knee motion plane at all distances of 185 cm from the individual and 65 cm from the ground so that the lens was completely in line with the knee joint [12, 13]. Then the individual was positioned in a standing position (complete extension of the knee joint) and was asked to start a non-dominant leg test (a ball-hit test was used to determine the dominant leg). The subject made contact with the ground so that he can only maintain its balance easily [12]. The subject was also asked to keep his head straight and not to bend the trunk backward or forward. Then, while the tester's eyes were closed, he was asked to bend his knee joint. When the knee was flexed to 45° and 90°, (measured by a goniometer), a stop was ordered and the person was required to keep that angle for 5 seconds and remember this position [12]. After a 10-second rest, the individual was asked to reconstruct the angle and declare it. For greater precision, the angle reconstruction test was repeated three times, with a rest of 10 seconds between each repetition, with the individual announcing the reconstruction status. Photos were taken from every angle of testing and reconstruction. The photograph was taken and analyzed by Digimizer software, version 5.3.4. [14, 15] (Figure 2). The angle of test and reconstruction was considered an absolute error and recorded (i.e. absolute error, the deviation from the target angle in the reconstruction of the angles of motion without considering the direction of the deviation [+ or –]). In the present study, the knee joint proprioception in the standing position and weight tolerance were evaluated. All assessments were done by a master of occupational therapy.

Statistical analysis

The data of this study were analyzed using SPSS software, version 22. Knee joint proprioception was assessed at 45° and 90° angles using the Mann-Whitney U test and $P \leq 0.05$ was considered significant.

3. Results

Table 1 shows the demographic data of the subjects. As shown, 26 people had an ACL injury and 24 were healthy controls, and out of subjects with an ACL injury, 22 subjects were Cooper type according to the knee injury and osteoarthritis outcome score (KOOS). Table 2 and Figure 3 show that the absolute error rate in knee joint reconstruction was 45° with P=0.861 and 90° with P=0.823. There was no statistically significant difference between the two groups.

Figure 1. Marker placement used in this study

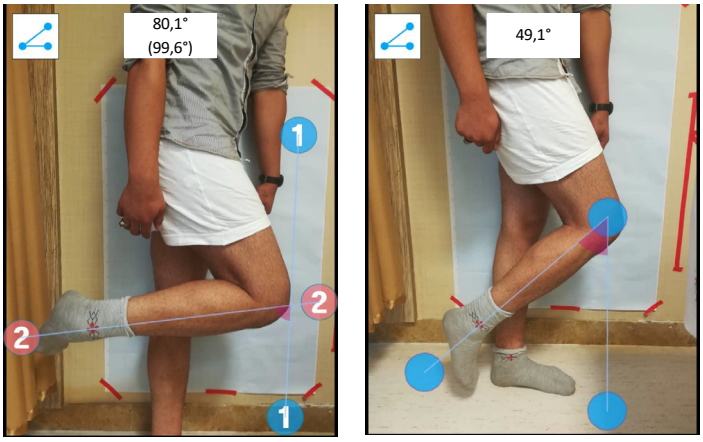

Figure 2. The photograph taken and analyzed by Digimizer software

Table 1. Demographic characteristics of the participants (n=50)

Group	Cooper	Non-Cooper	Mean±SD		
			Age (y)	Height (m)	Weight (kg)
Athletic with ACL injured	n=22	n=4	23.61±2.21	171.7±5.48	70.34±6.38
Healthy athletics			21.45±1.88	173.6±7.15	66.16±5.25

Abbreviations: ACL: Anterior cruciate ligament; SD: Standard deviation.

Table 2. Knee flexion angle reconstruction error in two groups

Variables	Mean±SD		P
	ACL Injured	ACL Uninjured	
Knee joint proprioception in 45™ angle	10.07±7.93	10.00±7.24	0.861
Knee joint proprioception in 90™ angle	11.34±11.36	9.52±5.44	0.823

ACL: Anterior cruciate ligament; SD: Standard deviation.

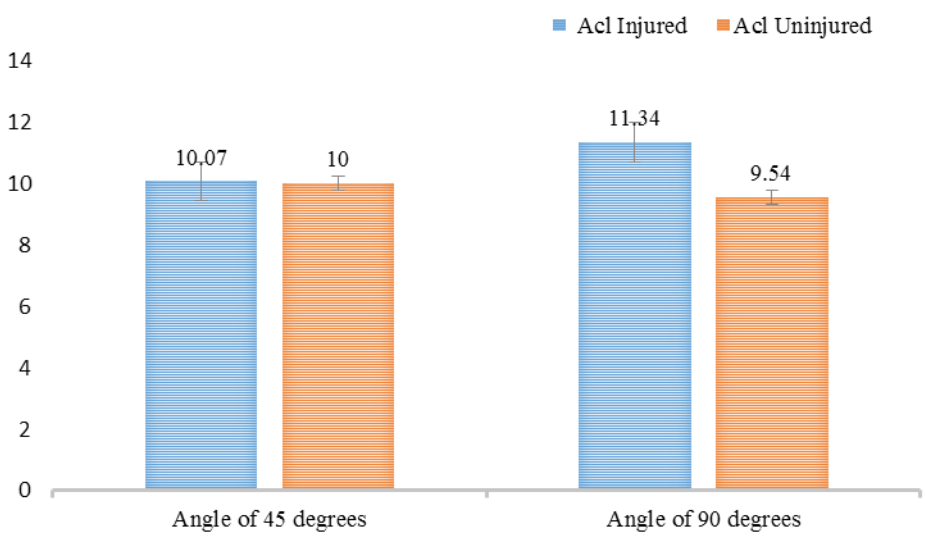

Figure 3. Comparison of mean proprioception error at two angles of knee in two groups

4. Discussion

The purpose of this study was a comparison of knee proprioception between athletes with an ACL injury and healthy athletes. The data showed that in the group with an ACL injury, the amount of error in knee joint reconstruction at both 45° and 90° angles was not statistically significant compared to the healthy group. However, there was no statistically significant difference between the no-injury group at 45° and 90° angles. In a study, Zhang reported that damage to the ACL decreased the number of proprioceptors in monkeys and ultimately decreased their proprioception [14]. Also, in a study aimed at investigating abnormalities after ACL injury and loss of proprioception following ACL injury, Ralph reported that after ACL reconstruction, proprioception sensation in subjects with ACL injury compared to healthy subjects was weaker [15]. In some studies, symptoms of a decrease in proprioception and instability in the lower extremity joints have been reported after ACL injury [9, 5, 15].

After the ACL is injured, a small number of receptors remain in the articular capsule, which leads to the loosening of the joint. Upon reconstruction, by restoring mechanical stability, some of the mechanoreceptors are improved and lead to decreased joint laxity, especially at larger physiological movement domains, but does not completely eliminate this defect [16]. On the other side, following the elimination of the afferents and rupture of the ligament, it can be said that spinal reflexes that lead to motor nerves and muscle spindles, as well as the cortical pathways necessary to consciously and unconsciously understand the proprioception and joint motion sense become disrupted and feedback and feedforward control experience a disturbance which cannot be compensated even after the reconstruction [17] muscle receptors like muscle spindles and Golgi apparatus can play an important role in proprioception. Anterior cruciate ligament injury and lack of afferent information from ACL mechanoreceptors lead to poorer balance [18].

The results of the above study are not in line with the present study [14, 15]. One reason for the inconsistency of the results of these two studies is the measurement of knee joint proprioception in these two studies. In the above study [14], knee proprioception was measured six months after reconstruction, but the present study was performed before reconstruction. Another reason could be related to the differences between the statistical samples and the level of activity of the subjects in these two studies [14, 15].

The result of our study is inconsistent with the study by Gokeler [9] which suggests that anterior cruciate ligament injury causes proprioception impairment, and this disagreement can be attributed to the selection of participants. The participants in that study had non-Cooper anterior cruciate ligament injury which reduces the proprioception [19], but in the present study, 22 subjects in the ACL group were Cooper-type, which according to the studies of the kinematic and kinetic changes in those Cooper athletes who were able to fully return to pre-injury level of exercise, did not show any noticeable difference in quadriceps torque, which is very similar to that of normal subjects [20]; therefore, it seems natural that including Cooper participants in the study, dismissed a significant difference in proprioception between the two groups. This observation is consistent with the study by Pap et al. [21] confirming that muscle spindles play an important role in the detection of movements and quadriceps tendon suppression can be helpful in knee function in people with an ACL injury and associated with proprioception [22]. The data showed that the knee joint proprioception of athletes with an ACL injury after reconstruction of the ACL was not different compared to the healthy athletes.

Our study had its limitations. The small size of patients and lack of proper cooperation of subjects can be considered as a limitation of our study.

5. Conclusion

The results of the study showed that in comparison with healthy athletes, the knee joint proprioception of athletes with an ACL injury is no different and has the same function. The lack of difference between the two groups is thought to be because the athlete with ACL was mostly Cooper. For this reason, it is recommended that this study be performed on non-Cooper athletes as well.

Ethical Considerations

Compliance with ethical guidelines

The study was approved by the Ethics Committee of Baqiyatallah University of Medical Sciences (Code: IR.BMSU.REC.1396.521). All study participants were informed about the study objectives and those agreeing to participate signed the informed consent forms.

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Authors' contributions

All authors equally contributed to preparing this article.

Conflict of interest

The authors declare no conflicts of interest.

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