The Influence of Anterior Cruciate Ligament Rupture and Ankle Sprain on Static Postural Control Among Soccer Players

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Abstract

Purpose: The objective of this study was to compare the influences of AS and ACLR on static postural control among amateur athletes.

Materials and Methods: Ten subjects having ACLR with mean age, height and body mass of (23.9yrs ± 4.4yrs), (1.77m ± 0.06m) and (81.6kg ± 12.95kg) respectively, were selected as experimental group I. Another 10 subjects who were injured by AS with mean age, height and body mass of (24.4yrs ± 4.4yrs), (1.79m ± 0.08m) and (74.63kg ± 11.48kg), respectively were served as experimental group II. Also, 10 able-bodied subjects were selected as control group. A Kistler force plate was used to record the sway of the feet center of pressure (COP). Six different conditions including a) standing on the injured foot, b) standing on the uninjured foot, and c) standing on both feet, in both closed and open eyes conditions were used for balance evaluations. For statistical analysis Repeated Measure (GLM) technique with Tukey post-hoc test and α<0.05 was used.

Results: In eyes open condition, COP sway was similar in all groups (p=0.364). Closed eyes resulted in a significant increase in the COP sway which was differently distributed among groups (p = 0.04). This study reveals that ACLR and AS injuries have minimal effects on static standing postural control in eyes open condition. Single-limb standing without visual inputs resulted in a significantly greater COP sway in soccer players with ACLR and AS injuries, implying a proprioception deficit. Postural control on standing over the intact foot showed greater COP sway than that of the injured foot.

Conclusion: It is recommended to repeat this study in dynamic conditions to have a better understanding of this issue.

Keywords: Ankle sprain (AS), anterior cruciate ligament rupture (ACLR), Postural sway, Proprioception.

Introduction

In most physical activities and athletic performances, an optimal level of static and dynamic balance maintenance is essential. Individuals with poor postural control and/or balance deficits might be in a greater risk of ankle and knee injuries during vigorous physical activities which involved running and turning, jumping and landing activities(Reimer and Wikstrom, 2010). The rate of this injury is also high in elderly and sedentary population (Chun-Man et al., 2011; Santos et al., 2008; Stephen et al., 1999). Generally, in more challenging sports such as soccer, volleyball, basketball and handball, knee and ankle injuries are common (14%) (Sefton et al., 2009). It has also a high rate of recurrence (Hertel and Olmsted-Kramer, 2007; Lee and Lin, 2008).

Ankle joint supports the body weight in standing position and during push off in gait cycle or running. Therefore, any injury to this joint, may greatly affect the force produced in ankle joints as well as the static and dynamic balance (Hertel, 2002; Santos et al., 2008; Van Cingel et al., 2006). To maintain body balance, central nerve system (CNS) integrates the information about the spatial position of different body segments received
from visual, vestibular and proprioception systems (Lehart et al., 1997) based on which a suitable muscle activity command is released to control the posture. In still-standing position, generally, the ankle strategy is active (Suarez et al., 2007). In this strategy, the ankle proprioception system plays an important role. When body sway is beyond 5 degrees, the hip strategy becomes important (Blackburn et al., 2000; Shumway-Cook and Woollacott, 2007), consequently, the hip proprioception plays a greater role.

For better understanding of the balance mechanism in different conditions, various studies have been conducted in healthy and various clinical populations as well as in athletic groups (Anderson and Behm, 2005; Yamada, 1995). However, the effects of ACLR and AS injuries on postural control are not well understood yet. AS and ACLR may alter the functional stability of the joint and reduce the patient’s capabilities on physical activities (Zouita Ben Moussa et al., 2009a). Anatomical and mechanical changes of the joint after the sprain may affect the related proprioception performance leading to balance deficits (Lysholm et al., 1998; Smolen, 2004). It is usually very hard to recover the joint’s full function after the surgery (McKeon and Hertel, 2008; Sefton et al., 2009; Zouita Ben Moussa et al., 2009b).

McGuine et al. (2000) and Tropp et al. (1985) concluded that muscle weakness and balance deficit are among the prime causes of damage to the ankle, being most prevalent in basketball and football players. Rehabilitation of ACLR and AS based on balance training was addressed by Amaral De Noronha and Borges (2004), Cumps et al. (2007), Reimer and Wikstrom (2010), Roi (2010), Stracciolini et al. (2007), and Sefton et al. (2009), Koshida et al. (2010) also explained the mechanism of ACL.

Cumps et al. (2007) examined the efficacy of a sports specific balance training program on the incidence of ankle sprains among basketball players and concluded that balance training reduces the risk of ankle sprain. Souissi et al. (2011) also recommended that 4 to 6 months post-ACLR, 2 physical training sessions per week (4hrs/week) of intensive training are more beneficial than 3 sessions a week (6hrs/week) of relatively low intensity training. However, the mechanism of balance performance in the injured athletes after rehabilitation needs more explanation. The objective of this study was to explain how the ACLR and AS alter the balance performance.

Materials and Methods

Participants

From amateur soccer players population in north west of Iran, 10 subjects with grade (II) ACLR and another 10 subjects with grade (II) AS were selected as experimental groups (I) and (II) respectively. Also, 10 able-bodied subjects were chosen as control group. The mean age, height and mass of all groups are illustrated in table 1.

Table 1: Main characteristics of subjects in different groups.

<table>
<thead>
<tr>
<th>Variables</th>
<th>Experimental I</th>
<th>Experimental II</th>
<th>Control</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age (years)</td>
<td>23.90± 4.4</td>
<td>24.40± 4.5</td>
<td>22.40± 3.3</td>
</tr>
<tr>
<td>Height (m)</td>
<td>1.77±0.06</td>
<td>1.79±0.08</td>
<td>1.79±0.08</td>
</tr>
<tr>
<td>Body mass (Kg)</td>
<td>81.6±12.95</td>
<td>74.63±11.48</td>
<td>74.63±11.48</td>
</tr>
</tbody>
</table>

ACLR patients were waiting for operation. Patients with AS were also being treated with the conservative treatment. Subjects were fully informed about the aim and protocol of the study and signed an informed consent. The research plan was approved by the research council of the Hamedan branch of Islamic Azad University.

Data collection

A Kistler force plate (EA 9281) was used to record the position of the center of foot pressure (COP) with 200HZ during each test. Subjects stood barefoot on the force plate for 20 seconds in anatomical up-right standing position with their feet 10cm apart from each other and medial border of the foot was oriented externally by 15°. Before starting the tests, each subject had a 10 minute warm-up exercise. The experimental design consisted of two factors: a) vision with two levels (open and closed eyes) and b) standing position with three levels (left foot standing, right foot standing, standing on both feet). This design came up with six testing conditions.

In the eyes open condition the subject was asked to keep eyes looking at a black point marked on a white paper sheet located in a three meters distance from the subject. While standing on a single leg, the other leg was held in a 90° flexed knee position (Figure 1). Hands were held akimbo all through the tests. The test was ignored if the subject’s foot was displaced, his hands fell off the hips or the knee’s 90° flexion was varied. Each test was repeated three times and the average value of the three repetitions was used in statistical analysis. COP sway was recorded for anterior-posterior (AP) and medial-lateral (ML) directions.
Statistical analyzing

For statistical analysis Repeated Measure (GLM) technique with Tukey post-hoc test and α<0.05 was used in SPSS-16 environment were used.

Results

Overall average of all of the tests for COP sway were (1.01cm± 0.11cm), (1.08cm ±0.11cm) and (0.86cm ± 0.11cm), for experimental groups (I and II) and control group respectively. Though the control group showed a slightly less sway than the experimental groups, the differences between groups were not statistically significant (F=1.051, df=2, P= 0.364). Figures 2 and 3 show the COP sway in AP and ML directions in eyes open testing conditions for all groups.

In eyes open condition, there wasn’t any significant difference on between groups and within groups comparisons of COP sway. COP sway of standing on the right foot was similar to that of the left foot standing in all groups. Symmetrical balance performance in patients implies that both injured and uninjured feet had similar performance.

As was expected, double support standing resulted in smaller values of COP sway in all groups (P≈ 0.000, F≈ 4.911). Regardless of any testing conditions, COP sway in AP direction (1.055± 0.068) was significantly greater than in ML direction (0.911± 0.064), (P=0.000, F=3.681). There wasn't any significant interaction between the sway direction factor with other factors such as injury (between group factor) and vision (closed eyes & open eyes).

Factor analysis revealed a significant effect of Vision factor on COP sway. Regardless of other factors, the overall mean for open eyes and closed eyes conditions were 0.70± 0.05 and 1.26± 0.09 respectively. Therefore, closing eyes increased the COP sway by 1.8 times (P≈0.000, F≈5.552). There was a significant interaction
between vision and injury factors. In experimental groups, closing eyes increased the COP sway of standing over the injured limb, uninjured limb and double limbs by 1.8, 1.9 and 1.2 times respectively. This shows that postural control when standing on the intact foot is affected more than the injured foot (Figure 4 and 5).

**Discussion and Conclusion**

The objective of this research was to examine the influences of ACLR and AS on the static balance performance in both the eyes open and closed conditions. The balance performance was measured using a stationary Kistler force plate during standing on single-limb (injured and uninjured feet) and double limb standing positions by means of COP sway in AP and ML directions. The results of this study showed that with presence of visual inputs, the COP sway in people with ACLR and AS injuries were similar to able-bodied subjects.

The results of few similar studies on AS including (Douglas and Richie, 2001; Hertel and Olmsted-Kramer 2007; Hopper et al., 2009) are in agreement with our results. While, Lysholm et al (1998), Negahban et al (2009), Zatterstrom et al (2000) and Gauffin et al (1990) found that subjects with ACLR have greater posture sway compared to healthy people. Conversely, several studies have indicated that in AS, balance performance of single-limb standing on both injured and uninjured feet are affected (Lysholm et al., 1998; Zouita Ben Moussa et al., 2009b). This discrepancy was also observed in the athletes who had ACLR (Henriksson et al., 2001; Shiraishi et al., 1996). It is accepted that the proprioception system provides the CNS with useful information about body’s spatial position. When injury occurs it is more likely that the proprioception system will be affected, so that the segment fails to send accurate inputs to the brain. Therefore it is expected to have a poorer balance performance in injured people compared to the normal group.

Care must be taken about interpreting our results since the balance measurements in our experiment were performed between 3-6 months after the injury occurrence. Therefore, the normal balance performance of the patients in our study might partially be due to healing of the injury or some kind of neuromuscular adaptation. Our results could have two possible interpretations. The first interpretation is that the ACLR and AS injuries do not affect the static balance performance, especially when visual inputs are available. In static balance performance there is minimal perturbations to proprioception. Besides, visual cues can compensate the possible minor proprioception deficits in these populations. The second interpretation is that even if AS and ACLR alter the proprioception performances, these deficits have been recovered after 3-6 months (Negahban et al. 2009) has concluded that the increased COP sway due to the ligament injury is associated with a deficit on the related proprioceptive performance. It is well documented that rehabilitation has satisfactory results on balance performance of people with AS and ACLR (Henriksson et al., 2001).

In our study, when the eyes were closed, there was a significant difference between injured and able-bodied groups on single-limb standing. In eyes closed condition, the proprioception is maximally involved and proprioceptive information is the major source of inputs of the balance systems. On the other hand, single-limb standing is a more challenging balance performance where a higher level of balance performance is required. Therefore, the postural control deficit becomes more obvious. We suggest repeating the same experimental design with minimum delay between the injury occurrence and balance test.

This study reveals that ACLR and AS injuries have minimal effects on static standing postural control in eyes open condition. Single-limb standing without visual inputs resulted in a significantly greater COP sway in soccer players with ACLR and AS injuries, implying a proprioception deficit. Postural control on standing over the intact foot showed greater COP sway than that of the injured foot. This implies that injury on a single foot
affects both limbs’ balance performance. It is recommended to repeat this study in dynamic conditions to have a better understanding of this issue.

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References


