Neuromuscular efficiency of the vastus medialis obliquus and postural balance in professional soccer athletes after anterior cruciate ligament reconstruction

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Summary

The purpose of this study was to evaluate the neuromuscular efficiency of the vastus medialis obliquus (VMO) and postural balance in professional soccer athletes after anterior cruciate ligament (ACL) reconstruction, compared to the uninvolved leg. A cross-sectional study was conducted with 22 male professional soccer players after ACL reconstruction (4-12 months postoperatively). The athletes were submitted to functional rehabilitation with an accelerated protocol on the soccer team. They were evaluated using isokinetic dynamometer, surface electromyography and electronic baropodometer. There was no decrease or difference between neuromuscular efficiency of the VMO when comparing both the limbs after ACL reconstruction in the professional soccer athletes under treatment. The same result was found in postural balance. It can be concluded that the NME of the VMO in the involved member and postural balance were successfully re-established after the reconstruction procedure of the ACL in the sample group studied.

Key words: soccer, anterior cruciate ligament, electromyography, torque, postural balance.

Introduction

Rupture of the anterior cruciate ligament (ACL) is a recurrent injury in soccer athletes, with a high prevalence in high-performance athletes. On average, one ACL is injured every 2000 hours of sport practice, 14% of knee sprains injure this structure and each club disputes 12.8 games before losing a team member because of the rupture of this ligament¹. After partial or total rupture of the ACL the individual may have a deficit in conscious joint positioning², deficiency in the perception of change in position during passive movement³ and a decrease in latency of reflex hamstring contraction⁴.

These proprioceptive alterations inhibit the action of the motor units in the knee extensors, decreasing the strength and the muscle power and tending to decrease the amplitude of the active movement in this articulation⁵. One way to evaluate neuromuscular performance is quantifying the responsiveness of the contractile elements to an electric stimulus of the sarcolemma and, consequently, establishing a relationship with force production. Thereby, the individual is considered more efficient that requires lower activation to produce a given force. This ratio of myoelectrical activation, given by the average of the positive EMG signal (Root Mean Square - RMS), divided by the peak torque value generated by the muscle is called Neuromuscular Efficiency (NME)⁶, ⁷.

Another physical valence which can be affected by ACL injury is postural balance, which can be harmed by the loss of information supplied by mechanoreceptors in the knee joint⁸. These sensory receptors are responsible for providing information about knee position and the movements performed by this joint⁹. When there is rupture of this ligament the neural feedback mechanism is stopped and the motor control of the knee is damaged¹⁰. In addition to the consequences mentioned there is also a mechanical restraint to excessive movement in this joint¹¹. These factors may harm the postural balance of the individual¹².

Reconstruction of the ACL is indicated to restore the mechanical stability of the knee and allow a return to high-intensity functional activities, as required by soccer athletes¹³. The literature does not offer consensus on somatosensory activity restoration after this ligament reconstruction, with questions remaining about the restoration of postural balance after surgery¹⁴.

The purpose of this study was to evaluate the neuromuscular efficiency of the vastus medialis obliquus (VMO) and postural balance in high-performance soccer athletes after anterior cruciate ligament (ACL) reconstruction, between 4 and 12 month post-operation, comparing to the unaffected limb.
Materials and methods

Sample
This study was approved by the committee of ethics in research of the Universidade Federal of Ceará (COMEP-UFC), protocol number 230/2011, and participants signed a free and informed consent form, confirming their voluntary participation on research. The collection happened at the Human Movement Analysis Lab, in 2011. A sample of twenty-two men were selected, all high-performance soccer players from three professional soccer teams in Brazil and within four to twelve months postoperative for ACL reconstruction. All individuals were undergoing functional rehabilitation on an accelerated protocol. The athletes were referred spontaneously by the rehabilitation department of the teams to which they belonged. Athletes were allowed to participate in the research who did not present changes in their cardiovascular system, such as uncontrolled hypertension, angina pectoris or arrhythmia and athletes were excluded who had acute musculoskeletal pain before or during testing (Analogs Pain Scale less than 70 mm), untreated injuries or any other factor that affected the athlete’s performance during the evaluation.

Procedures

Evaluation protocol

Stabilometry
The first stage of evaluation was stabilometry, which aims to evaluate postural balance. The procedure was performed on an electronic baropodometer, trademark Diagnostic Support Italy, in a 3.2 m-long platform and composed of 4800 pressure sensors arranged continuously at a distance of 1.6 m in the center platform. This equipment, composed of electronic sensors which recognize oscillations in the center of gravity, permits the analysis of static equilibrium through a stabilometric test, which was carried out in both bipodal and monopodal forms. For the bipodal evaluation, the athlete was instructed to remain in a standing position with feet put into a triangular shape, which accompanies the appliance, at an external rotation of 15°, along with arms at their sides, gaze directed to the horizon, and keep their temporomandibular joint relaxed (open mouth) for 51 seconds. For the monopodal test, the individuals were supported by their left foot, keeping the right foot elevated with the knee flexed and then reversed, holding each position for 5 seconds. All tests were performed twice, first with open eyes and the second with closed eyes.

Isokinetic evaluation and neuromuscular efficiency
The second stage of evaluation was the evaluation of neuromuscular efficiency, which was performed in the Human Movement Analysis Lab, in 2011. A sample of twenty-two men were selected, all high-performance soccer players from three professional soccer teams in Brazil and within four to twelve months postoperative for ACL reconstruction. All individuals were undergoing functional rehabilitation on an accelerated protocol. The athletes were referred spontaneously by the rehabilitation department of the teams to which they belonged. Athletes were allowed to participate in the research who did not present changes in their cardiovascular system, such as uncontrolled hypertension, angina pectoris or arrhythmia and athletes were excluded who had acute musculoskeletal pain before or during testing (Analogs Pain Scale less than 70 mm), untreated injuries or any other factor that affected the athlete’s performance during the evaluation.

The athlete warmed up freely for 5 minutes. The isokinetic chair of the dynamometer was positioned so that the subject’s hip stayed at 85° of flexion and the movement axis of the equipment was aligned with the knee joint line. Next, the subject sat in the dynamometer chair and their position was stabilized with the use of seat belts on the trunk, abdomen and the unevaluated thigh, to prevent accessory movements. The lever arm of the equipment was fixed 2 centimeters above the medial malleolus. Preparation of the skin to collect the electromyography signal involved shaving, cleaning and abrasion of the skin surface of the individual with paper towel moistened with 70% alcohol, following standardization of the SENIAM. The electrodes were placed in the region of the vastus medialis obliquus muscle, with 20mm distance between the centers, and the reference electrode was placed at the lateral epicondyle of the humerus. The analog signal was converted to digital signal by sensor SDS500. Meditrace conducting electrodes for adults were used for the electrocardiogram in this research. The collection date was transmitted to the dynamometer computer by USB connection. The software used was Miograph, which accompanied the equipment.

Electromyographic signal processing
In the post-collection phase, for analysis of EMG data, an interval of 1 second before the onset of contraction and 1 second after the end of contractions was duplicated and filtered. A digital filter was applied to the signal: Butterworth-type 4th-order band pass and cutoff frequencies between 20 and 450 Hz.

Statistical Analysis
Descriptive measurements were used to describe the sample characteristics, such as the measure of central tendency (mean) and dispersion (standard deviation). To compare the mean variables between the various treatments we used the Student-t test for independent sample analysis to com-
The sample had a mean age of 21.77±4.45 years, mean weight 76.41±7.99 kg, mean height 1.79±0.06 m and mean body mass index 23.70±1.54 Kg/m². Amongst the athletes assessed, 54.5% were right-handed and 31.8% had the dominant limb involved in the procedure (Tab. 1).

Table 1. Descriptive sample data.

<table>
<thead>
<tr>
<th>Sample data</th>
<th>Values</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age</td>
<td>21.77±4.45 years*</td>
</tr>
<tr>
<td>Weight</td>
<td>76.41±7.99 kg*</td>
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<tr>
<td>Height</td>
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</tr>
<tr>
<td>Body mass index</td>
<td>23.70±1.54 Kg/m²*</td>
</tr>
<tr>
<td>Right-handed</td>
<td>54.5%</td>
</tr>
<tr>
<td>Dominant limb involved in the procedure</td>
<td>31.8%</td>
</tr>
</tbody>
</table>

* Mean ± Standard deviation

The NME showed no statistical difference at the different speeds assessed. At 60°/s, the involved limb showed a mean of 0.7±0.1 μV/N.m and the uninvolved member of 0.6±0.1 μV/N.m p=0.14, while at 300°/s the involved limb had a mean of 1.2±0.3 μV/N.m and the uninvolved limb, 1.0±0.2 μV/N.m, p=0.27 (Fig. 3).

Figure 1. Myoelectric activity at speeds of 60°/s and 300°/s of the VMO in the involved limb (I) and uninvolved limb (UN). The values are expressed as means and standard deviation. * - p<0.05 Student-t Test

Figure 2. Peak torque at speeds of 60°/s and 300°/s of the quadriceps in the involved limb (I) and uninvolved limb (UN). The values are expressed as means and standard deviation. * - p<0.05 Student-t Test

Figure 3. Neuromuscular efficiency at speeds of 60°/s and 300°/s for the VMO in the involved limb (I) and the uninvolved limb (UN). The values are expressed as means and standard deviation. * - p<0.05 Student-t Test
Postural balance
Comparing the two members in unilateral support for the oscillation surface with eyes open (165.8 ± 21.80 mm² for the involved member and 151.3 ± 23.67 mm² for the uninvolved member, p = 0.66) and oscillation surface with closed eyes (1157.8 ± 1314.3 mm² for the involved member and 1090.4 ± 801.6 mm² for the uninvolved member, p = 0.86), it can be observed that there was no statistical difference (Fig. 4A).

The same happens in the anteroposterior variables mean displacement velocity with open eyes (15.8 ± 4.6 mm/s for the involved member and 16.9 ± 5.6 mm/s for the uninvolved member, p = 0.55) and with closed eyes (36.3 ± 4.5 mm/s involved member and 35.5 ± 2.6 mm/s for the uninvolved member, p = 0.87) and lateral-lateral mean displacement velocity with eyes open (10.4 ± 3.9 mm/s involved member and 10.6 ± 3.3 mm/s for the uninvolved member, p = 0.69) and eyes closed (15.6 ± 29.4 mm/s for the involved member and 28.7 ± 11.2 mm/s for the uninvolved member, p = 0.88).

When comparing the variables in bipodal support, surface oscillation with eyes open (70.3 ± 7.2 mm²) and eyes closed (51.79 ± 63.6 mm²) p = 0.42 (Fig. 4B), mean anteroposterior displacement with eyes open (4.14 ± 1.5 mm/s) and eyes closed (3.7 ± 0.9 mm/s) p = 0.31 and average lateral-lateral speed with eyes open (4.9 ± 1.8 mm/s) and eyes closed (4.1 ± 1.3 mm/s) p = 0.17, it can also be noted that these data showed no statistical difference.

Using the Romberg Index, no significant difference was found between the involved limb (832.1 ± 1074.2) and the uninvolved one (929.7 ± 813.7) for unipodal support (p = 0.77).

Discussion
This study had the purpose of evaluating peak torque of the knee extensor muscles, myoelectric activity and neuromuscular efficiency of VMO, and postural balance of soccer players who underwent ACL reconstruction. To compare the variables, the averages of the athletes’ own uninvolved members were used. This procedure has been used in several studies. Male soccer players were chosen to compose the sample owing to the high prevalence of ACL injuries in this sport. The reason for choosing the VMO was the fact that this is one of more susceptible muscles to atrophy after ACL rupture. The NME is a rare topic in literature. The evaluation of this valence is a strategy for evaluating neuromuscular performance and success of the rehabilitation process of injured athletes. The restoration of postural balance and muscle strength after anterior cruciate ligament reconstruction are issues much discussed in the literature, and therefore, are evaluated in this study.

In terms of myoelectrical activation, no statistical difference was observed when comparing the two members of the individual. This result differs from that found in a study in which thirteen individuals in a post-surgical period after ACL ligamentoplasty showed a significantly higher rate of myoelectrical activation of the vastus medialis and vastus lateralis in the affected limb when compared to the unaffected one.

The peak torque in the involved limb performed better than the uninvolved one. Another study, which accompanied the rehabilitation of twenty patients for twelve weeks after surgery for ACL reconstruction showed that the difference in peak torque at a speed of 180°/s between the two members was 38%. After isokinetic exercises for 20 minutes for 12 weeks, at a speed of 240°/s in the first six weeks and 180°/s in the last six weeks, there was an average 23.8% reduction in the difference between the peak torque of the two members. This result confirms what was found in another study that assessed the same variable in eighteen soccer players, where the authors evaluated the peak torque before surgery and four months after rehabilitation, concluding that this deficit, especially in knee extensors muscles, was still great four months after surgery. Other authors have demonstrated in their study that the deficit of the peak torque was maintained only at a slower speed, indicating that power was restored, but not force.

By comparing the difference in percentage of the peak torque of the two members, it was found that the member subjected to the procedure showed 88% of strength and 90% of power of the control member, and the difference recommended for patient discharged is 80%. This result does not corroborate with findings in a study of 120 patients undergoing the same procedure for 6 months, showing that only half of competitive athletes had achieved this result. This difference must be a functional target reached.
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months after surgery. In postural balance, there were no significant differences in any analyzed variable, at any posture adopted. One study compared 19 healthy subjects between 18 and 30 years of age and 19 patients with unilateral ACL injury on the postural control with unilateral support, alternating the sides and the opening and closing of the eyes. The results showed that balance is changed in unilateral support on both sides after unilateral ACL rupture, which is more evident in the affected limb.

According to the results presented and discussed, the accelerated rehabilitation protocol appears effective at restoring myoelectric activity, neuromuscular efficiency and postural control in subjects who underwent anterior cruciate ligamentoplasty.

For this research, it was not possible to monitor neuromuscular performance and fitness of athletes who comprised the sample, because this was done in the rehabilitation department of each team. Due to the difficulty to isolate the activity of a single quadriceps muscle, it was necessary to evaluate the myoelectric activity of the vastus medialis obliquus and peak torque of the quadriceps, to calculate the values of neuromuscular efficiency. Ideally, however, data would be collected related to the muscle that was studied, in this case, the vastus medialis obliquus.

This study used laboratory equipment of high technology in data collection, such as isokinetic dynamometer. Although this is an important tool to evaluate dynamic muscle work, the isokinetic test is not sensitive and specific to analyze functional movements and sports skills as one leg hop test, co-contraction test, shuttle run test, carioca test. Thus it is important to combine information from laboratory tests with functional performance tests as a criterion for return to sport. For future studies it is suggested that the rehabilitation of the sample be monitored and there be periodic assessments to compare the results at different cutoff points in the rehabilitation phases.

Conclusion

According to the results we can conclude that the NME of the VMO of the limb involved in the procedure of ACL ligamentoplasty was reestablished with the protocol used to rehabilitate the patients studied. For postural balance the result was the same, no significant difference between unilateral support for the two members, suggesting that the protocol used was adequate to restore the equilibrium variables analyzed.

References


