Isokinetic performance of ankle evertor and invertor muscles in adolescent female volleyball athletes

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Abstract — Aims: This study aimed to analyze the muscular performance of evertor and invertor ankle muscles of adolescent volleyball athletes. Methods: The information provided by database concerning the isokinetic evaluation of ankle muscles from 20 female volleyball players between the ages of 14-17 years old were analyzed. The isokinetic dynamometer was used in a concentric-concentric mode for the ankle evertor and invertor muscles at angular velocities of 60°/s, and 180°/s. Results: Seven athletes had suffered ankle sprains (6 affected the non-dominant limb and all were lateral ankle sprain) in the one year prior to the isokinetic evaluation. The isokinetic results demonstrated that the mean peak torque values for eversion of the non-dominant limb were significantly lower in comparison to the dominant limb at 60°/s. Moreover, although no difference was observed in the average values of the evertor/invertor ratio between the limbs, the ratios were below the values suggested by the literature. Conclusion: We believe that although the athletes reported no ankle injury and no pain in the previous assessment month, the isokinetic results of the non-dominant limb seemed to be directly related to previous ankle sprains injuries in inversion of this limb. The athletes had similar results to those of subjects clinically diagnosed with ankle joint instabilities despite their being active in sports at the moment of the assessment.

Keywords: team sport; strength, biomechanics.

Introduction

Volleyball is one of the most practiced sport worldwide and is characterized by short, intense, and explosive movements; such as jumps, attack hits, blocks, services, passes, and lateral shuffling1. However, the most important actions observed during the volleyball practice are the offensive movements (services, blocks, and attack hits) which requires many muscle and joint demands2. Since it is a sport with no physical contact and the opponents are separated by a net, volleyball is considered to be a safe sport, and, consequently, there is a low incidence of musculoskeletal injuries when compared to other sports3,4. Nevertheless, previous studies have shown that the most frequent injury which affect volleyball players is the ankle sprain2,3,5 and that according to a recent meta-analysis by Doherty, Delahunt, Caulfield, Hertel, Ryan, Bleakley6 and females have higher chances of ankle sprains.

The main factor related to ankle sprains is the high impact after a vertical jump, which is a fundamental movement and is considered a differential for better performance by the athletes during services, blocks and attack hits7. Nevertheless, just the impact intensity alone does not justify the occurrence of these injuries, and the malfunctioning of the structures that comprise this joint, such as the ankle muscles, also justify the high occurrence of ankle sprains8.

The study of the ankle muscles is of great importance as it is related to the good performance during volleyball practice and since it is involved in the mechanism of jumping and landing on a single foot, making the ankle one of the most injured joints8. The comparison between limbs’ strength is important to determine muscular balance because bilateral asymmetries indicates a higher risk of musculoskeletal injuries10. Thus, the isokinetic testing, which is an assessment method of high effectivity and trustworthiness, can be used to compare bilateral and agonist/antagonist muscle strength of the athletes11.

Although many studies have used the isokinetic testing in the muscular study of different sports populations, and joints, there are few studies directed to adolescent volleyball athletes, and, especially, to the ankle joint. Therefore, this study aimed to analyze, through information from a database, the muscular performance and differences between the dominant and non-dominant limbs of the evertor and invertor muscles of the ankle in adolescent female volleyball players.

Methods

This quantitative, cross-sectional and retrospective study was conducted at the Instituto de Medicina do Esporte e Ciências Aplicadas ao Movimento Humano da Universidade de Caxias do Sul (IME-UCS) in the city of Caxias do Sul, Rio Grande do Sul, Brazil. It was approved (protocol number 967.527) by the Ethical Research Committee of the Faculdade Cenecista Bento Gonçalves (Bento Gonçalves, Rio Grande do Sul, Brazil), and conducted according to the 2012 Law N° 466 of the National Health Council, which approves the guidelines and rules for...
The athletes performed three sub-maximal repetitions (50% of pelvis, and thigh (1/3 distal) were stabilized with belts to avoid dorsum of the food held it against the foot plate and the torso, was positioned at 10-15° plantar. Two straps cross-crossing the position 70°, hips and knees flexed at 90° and the ankle joint. The athletes sat on the dynamometer chair with their torsos at resistance at moderate velocity (70-80 revolutions per minute).

The isokinetic evaluations were made with the institution’s isokinetic dynamometer (Biodex System 4®, Biodex Medical Systems, Shieley, New York, USA). To verify the normality of the data distribution, the Shapiro-Wilk test was used, and the mean values for the DL and NDL tests were evaluated with paired version of student’s T test at the significance level of 0.05. Bilateral asymmetry between DL and NDL was also evaluated using a specific equation. To calculate the bilateral asymmetry of the PT, the difference between the PT of the DL and NDL was divided by the PT of DL and multiplied by 100. The Evertor/Invertor ratio’s bilateral asymmetry was calculated by dividing the difference between the flexor/extensor ratio of the DL and NDL with the flexor/extensor ratio of the DL and the result was multiplied by 100 (flexor/extensor DL – flexor/extensor ratio NDL * 100)\(^{13-14}\).

### Results

The concentric isokinetic data results of the PT of the DL and NDL are presented in Table 1. At an angular velocity of 60°/s, the average values for PT ankle evertor muscle showed significant differences between the limbs.

### Table 1. Mean and standard deviation values for peak torque of the evertors and invertors of the dominant limb and the non-dominant limb’s ankle.

<table>
<thead>
<tr>
<th>Angular Velocities</th>
<th>PT Ankle Evertors (N•m)</th>
<th>Bilateral Asymmetry (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>DL</td>
<td>NDL</td>
</tr>
<tr>
<td>60°/s</td>
<td>25.08 (±5.54)</td>
<td>19.96 (±6.62)*</td>
</tr>
<tr>
<td>180°/s</td>
<td>19.52 (±4.95)</td>
<td>17.77 (±5.66)</td>
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<thead>
<tr>
<th>Angular Velocities</th>
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</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>DL</td>
<td>NDL</td>
</tr>
<tr>
<td>60°/s</td>
<td>27.88 (±8.03)</td>
<td>25.90 (±10.77)</td>
</tr>
<tr>
<td>180°/s</td>
<td>20.62 (±5.75)</td>
<td>19.89 (±7.17)</td>
</tr>
</tbody>
</table>

DL = dominant limb, NDL = non-dominant limb, PT = peak torque, * = p < 0.05.
Table 2 shows that there was no significant difference between the DL and NDL average value results of the evertor/invertor ratio for the angular velocities of 60°/s, and 180°/s.

Table 2. Mean and standard deviation values for the evertor/invertor ratio of the dominant limb and the non-dominant limb’s ankle.

<table>
<thead>
<tr>
<th>Angular Velocities</th>
<th>Evertor/Invertor ratio (%)</th>
<th>Bilateral Asymmetry (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>DL</td>
<td>NDL</td>
<td>“p”</td>
</tr>
<tr>
<td>60°/s</td>
<td>89.35 (±19.37)</td>
<td>90.49 (±27.09)</td>
</tr>
<tr>
<td>180°/s</td>
<td>97.68 (±29.73)</td>
<td>90.61 (±27.49)</td>
</tr>
</tbody>
</table>

DL = dominant limb, NDL = non-dominant limb.

Discussion

The purpose of this study was to analyze the peak torque (PT) and the evertor/invertor ratio (Ever/Inver ratio) of the ankle joint in adolescent female volleyball athletes through an isokinetic test. In the analysis of the mean PT values, the NDL presented mean PT values of the evertor muscles significantly lower than the DL at angular velocity of 60°/s. In the analysis at 180°/s, despite the tendency (p = 0.067), there was no statistically significant difference in mean PT values between the limbs as well as in the analysis of the invertor muscles at both velocities. An additional investigation was performed and the results were similar to the statistical analysis. In the bilateral asymmetry analysis, the PT of the evertor muscles at 60°/s was the only result where the difference between the limbs were higher than 15% (20.41%). Although there is no consensus about the values, it has been reported that bilateral differences higher than 10% or 15% indicates imbalances between the limbs and may increase the risk of injuries and reinjuries in sports. Even though studies about bilateral asymmetry of ankle’s muscles are rare, it is an important parameter for the rehabilitation process and injury prevention.

Two classic studies on the isokinetic assessment of healthy subjects of both genders with no previous ankle sprain performed at angular velocities of 30°/s, 60°/s, and 120°/s, demonstrated no PT differences for evertor and invertors, except for the evertors at 30°/s in the study by Wong, Glashen-Way, Andrews. More recent, study by Lin, Liu, Hsieh, Lee also found no statistically significant differences in healthy subjects. Interestingly, the 7 episodes of ankle sprains reported by the athletes were sprains in inversion and 6 of them affected the NDL – factors which might be directly related to the isokinetic testing results. The assessed athletes indicated that ankle sprain was the most common injury, representing 50% of the reported injuries in the previous year. This result corroborates with findings from other studies that have also shown a high rate of ankle injuries representing approximately half of the musculoskeletal injuries in female volleyball athletes.

The athletes reported that these sprains occurred laterally; an injury mechanism which can be defined as a traumatic injury resulted from an excessive inversion of the ankle. During the inversion of the ankle, a reflexive contraction of the evertor muscles occurs proving the important role of this muscle group in the dynamic stabilization of this joint against the inverting forces. However, the systematic review by de Oliveira Menacho, Pereira, de Oliveira, Chagas, Toyohara, Cardoso demonstrated that after an episode of ankle sprain there is a decrease of the neuromuscular reflex; resulting in a significantly lower PT of the evertor muscles when compared to not injured joints. Perron, Moffet, Nadeau, Hébert, Belzile showed that after only one episode of inversion ankle sprain, the evertor weakness persists up to 6 months after the injury.

Regarding the Ever/Inver ratio, which represents the proportion of strength of the ankle evertors in relation to the invertors, the results showed no statistically significant differences and no bilateral asymmetry between DL and NDL at both angular velocities. The assessment of healthy subjects with no previous ankle injury also showed no difference between limbs in relation to the Ever/Inver ratio. However, mean values of the Ever/Inver ratio in this study range from 89.35% to 97.68%, values below 100% suggested by literature. Other studies on healthy subjects demonstrated mean values of the Ever/Inver ratio ranging from 103% to 120% also showed no difference with no previous ankle injury. Nevertheless, values below 100% were also found in the assessment of healthy women. Mean values above 100%, besides demonstrating that the evertor muscles have PT values higher than the invertor muscles, also indicate that the evertor muscles have a greater functional capacity of stabilizing the ankle joint. According to Ersoz, Atalay, Kumbar, Akyuz, although the investigation of the PT mean values is important, the analysis of the Ever/Inver ratio is the most essential parameter to be assessed and it might easily demonstrate the imbalance and the impaired muscle group.

The asymmetry of the PT mean values between limbs and the Ever/Inver ratio below normality suggested by the literature might be explained due to various factors, mainly due to an previous ankle sprain. Ankle sprains in inversion predisposes subjects to other consequent sprains which can be twice more frequent when compared to a subject with no previous injury. According to a literature review by Calatayud, Borreani, Colado, Flandez, Page, Andersson, the increased risk of new sprains often results from remaining structural and functional alterations from prior injury. Among the functional factors, small strength deficits of the evertor muscles weakness can alter the dynamic joint stabilization. If structural and functional recovery do not occur, new sprain episodes will lead to functional instability or chronic instability of the ankle joint, and, consequently, will further accentuate the evertor muscles weakness. In addition to the evertor muscles deficits, alterations in proprioception, in neuromuscular control, and in postural control may be involved in functional deficits of the ankle. In order to recovery the muscle strength and
proprioception, professionals of rehabilitation has to focus on evertor muscle after an ankle sprain.

**Conclusion**

This study demonstrated that the evertor muscles of NDL had lower PT values than DL and mean values of Ever/Inver ratio were below normality for both limbs. Although the athletes reported no ankle injury and no pain in the previous assessment month, the isokinetic results of the non-dominant limb seemed to be directly related to previous lateral ankle injuries that affected 6 athletes' non-dominant limbs. The results has a great clinical importance since it was possible to show the athletes and the team staff about the importance of enhancing muscular performance during and after the rehabilitation process. It is important in order to reach the bilateral balance between the limbs, both for athletic performance and for minimizing chances of subsequent ankle sprains. However, new studies with larger samples performed at different angular velocities and different types of muscular contractions are necessary to contribute with scientific knowledge concerning the evertor and invertor ankle muscles performance.

**References**


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