Profile of Ankle Isokinetic Strength and Proprioception in Elite Female Handball Players

Perfil de Fuerza Isokinética del Tobillo y Propiocepción en Jugadoras de Balonmano de Élite

Nebahat Eler; Serdar Eler; Gamze Cobanoglu; Gökhan Mehmet Karatay & Nevin A. Güzel


SUMMARY: The evaluation of the invertor and evertor muscle strength and proprioception are important in terms of determining the risk of injury in handball players. The aim of this study was to determine the isokinetic strength and proprioception profile of the ankle invertor and evertor muscles of elite female handball players. Fifteen elite female handball players were included. Ankle invertor and evertor muscle strength and proprioception were evaluated using the isokinetic system. The isokinetic strength test was performed in concentric mode at 30°/s (5 repetitions) and 120°/s (10 repetitions). Proprioception sense was evaluated as active joint position sense. There was no statistically significant difference between the dominant and nondominant sides in terms of invertor and evertor muscle strength, evertor/invertor (Ever/Inver) ratio, and active joint position sense at both angular speeds (p>0.05). The Ever/Inver ratio on both sides was lower than normal values. It was concluded that the female handball players showed bilateral symmetry in the invertor and evertor muscles. However, the fact that the Ever/Inver strength ratio was lower than normal values on both sides suggested that caution should be exercised in terms of risks such as ankle sprain or chronic ankle instability. Pre-season evaluations should be made and it would be beneficial to add strengthening exercises to related muscle groups in training programs to normalize the unilateral ratios in these athletes.

KEY WORDS: Ankle muscles; Strength ratio; Joint position sense; Proprioception.

INTRODUCTION

Handball is an Olympic team sport that requires muscle strength, power, speed, and endurance. Handball players have a wide range of physical skills that include throwing, blocking, and ball control (González-Ravé et al., 2014). The incidence of ankle injuries in handball players ranges from 0.4 to 1.6 per 1000 exposure hours and it is the most common time-wasting injury. Ankle sprains can be seen in 18% of handball ankle injuries (Fritz et al., 2020). Acute ankle sprains have a high recurrence rate, which is associated with the development of chronic ankle instability (Herzog et al., 2019). Chronic ankle instability (CAI) can be caused by mechanical ankle instability (MAI) or functional ankle instability (FAI) (Sarcon et al., 2019). While MAI is caused by ligament laxity (Sarcon et al., 2019), the factors that cause functional chronic ankle instability include: lack of dynamic muscle strength balance, impaired neuromuscular control (postural control), delayed reaction time, deficits in joint position sense (proprioception), and peroneal weakness (Hertel, 2008). A comparison between limbs is important to monitor muscle balance, as bilateral asymmetries indicate a higher risk of musculoskeletal injuries (Bonetti et al., 2008). Since many authors have identified co-activation of the antagonistic muscle group as a factor affecting dynamic joint stability, it has been emphasized that the evertor / invertor (Ever / Inver) strength ratio is an important indicator for evaluating patients with chronic ankle instability (Baumhauer et al., 1995; Cho et al., 2019). Ankle proprioception is very important in sports that require balance and control. Ankle proprioception provides information that allows adjustment of ankle positions following upper body movements. This phenomenon helps facilitate the complex motor activity required in sports (Wilkinson et al., 1997; Madkhali & Nuhmani, 2021). Proprioception includes joint position sense, kinesthesia, and force sense. It has been
claimed that the components constituting proprioception may be impaired after ankle sprain and that impaired proprioception may also cause CAI (Sausa, 2017).

Evaluation of invertor and evertor muscle strength, Ever / Inver strength ratio, and proprioception in handball players is very important in terms of identifying athletes who are predisposed to acute ankle sprain and CAI, and preventing injuries and re-injuries. When we look at the literature, there are studies on the isokinetic strength profile of the ankle invertor and evertor muscles in basketball, volleyball, and football players. There are many studies on muscle strength and strength ratios in handball players using the isokinetic system. However, these studies usually focus on the muscles around the knees and shoulders (Andrade et al., 2010; González-Ravé et al., 2014; Risberg et al., 2018). Although there are few studies comparing the ankle invertor and evertor muscle strength ratios in handball players with and without CAI history, there exist no study in this branch evaluating the invertor and evertor isokinetic muscle strength, strength ratio, and proprioception in healthy individuals. Therefore, the aim of this study was to determine the invertor and evertor muscle strength, power ratio, and proprioception profile of elite female handball players.

MATERIAL AND METHOD

Subjects. Fifteen professional female handball players, aged between 18 and 35, who did not have pain in the ankle region in the previous 6 months, and who did not have ankle injury or surgery in the previous 6 months were included in the study. Before the study, the purpose and content of the study were explained to the participants and an Informed Consent Form was signed to indicate that they will participate voluntarily.

Procedures. Age, gender, and the dominant limb information of the athletes were recorded. The dominant side was determined by identifying the jumping leg. Before the test, the athletes warmed up for 5 minutes on a bicycle. The isokinetic system was used to evaluate the strength of the ankle invertor and evertor muscles and the proprioception sense of the athletes. The sense of proprioception was evaluated by the sense of active joint position. All tests were performed by the same physiotherapist.

Measurements. The strength of the ankle invertor and evertor muscles of the athletes was evaluated in a modified sitting position using the isokinetic system (Cybex NORM®, Humac, CA, USA). Participants were seated on the dynamometer chair with the hip joint flexed at approximately 80° and the knee joint at 110°, so that the tibia was placed horizontally on the floor. The ankle was placed in the foot adapter with 10° plantar flexion and secured with two Velcro straps. The isokinetic test was performed for ankle inversion and eversion in concentric mode at 30°/s (5 reps) and 120°/s (10 reps) (Gonosova et al., 2018). The test range was set to 30°–35° for ankle inversion and 25°–30° for ankle eversion (Wang et al., 2021). Three trials were performed before each test. A rest period of 20 seconds was given between the trial and the test, and a 90-second rest period was given between the two sets. Instant verbal and visual feedback was provided to encourage the athletes to give their maximum effort. After testing one lower limb, testing of the other lower limb was repeated with the same procedure. The order of the tested limbs was randomized. Peak torque/body weight values at both angular velocities and Ever / Inver strength ratios of both lower limbs were recorded.

The ankle proprioception sense of the athletes was measured in the isokinetic system (Cybex NORM®, Humac, CA, USA) in the modified sitting position. Proprioception was assessed by active joint position sense. The athletes were positioned in the same way as the isokinetic strength test. Each athlete was blindfolded so that no visual information would interfere with the test. Inversion at 15° was selected as the target angle (Sausa et al., 2017). The athletes were asked to move to the target angle three times, starting from the neutral position, and to learn this angle by concentrating on this angle for 5 seconds. Afterwards, they were asked to find the target angle as accurately as possible, and when it was thought that they had reached that angle, they were asked to stop and indicate it accordingly. Absolute error was used for evaluation. Absolute error was calculated as the absolute value difference in degrees between the test position angle and the position chosen by the athlete. The test was repeated for both limbs and the tested limb was randomly selected.

Statistical analysis. SPSS 22 was used in the analysis of the data. The conformity of the variables to the normal distribution was examined using visual (histogram and probability graphs) and analytical methods (Kolmogorov-Smirnov test). For descriptive statistics, mean ± standard deviation or median and interquartile range of values were calculated. The Paired t-Test was used in the comparison of the difference between the dominant and non-dominant limbs of the athletes when there was a normal distribution and the Wilcoxon Test was used in cases where the normal distribution was not met. Any p value less than 0.05 was considered statistically significant.
RESULTS

Demographic information of the handball players participating in the study is given in Table I. Athletes had a mean sports history of 13 years. They were also Super League players for a mean of 8 years. The mean weekly training hours were 9 hours.

Table I. Demographic characteristics in elite female handball players.

<table>
<thead>
<tr>
<th>Female Handball Players (n=15)</th>
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</thead>
<tbody>
<tr>
<td>Age (years)</td>
<td>24 ± 3</td>
<td></td>
</tr>
<tr>
<td>Height (cm)</td>
<td>173 ± 5</td>
<td></td>
</tr>
<tr>
<td>Weight (kg)</td>
<td>64.8 ± 7.2</td>
<td></td>
</tr>
<tr>
<td>BMI (kg/cm²)</td>
<td>21.53 ± 2.18</td>
<td></td>
</tr>
<tr>
<td>Dominance</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Right</td>
<td>10 (66.66)</td>
<td></td>
</tr>
<tr>
<td>Left</td>
<td>5 (33.33)</td>
<td></td>
</tr>
</tbody>
</table>

BMI: Body Weight Index.

When the analysis results were examined, it was seen that there was no statistically significant difference between the dominant and non-dominant sides of elite female handball players in terms of invertor muscle strength in both angular velocities, evertor muscle strength, Ever / Inver strength ratio, and active joint position sense (p>0.05 and Table II).

DISCUSSION

This study aimed to determine the profile of ankle isokinetic strength and proprioception sensation in elite female handball players. Ever / Inver muscle strength deficit is an important risk factor for lateral ankle sprain. Bilateral ankle strength imbalance was also suggested as a risk factor for injuries in athletes (González-Ravé et al., 2014). Although there is no consensus on the values, it has been reported that bilateral differences of more than 10 % or 15 % indicate an imbalance between the limbs and may increase the risk of injury in sports. Although studies on bilateral asymmetry of the ankle muscles are rare, it is an important parameter for injury prevention and rehabilitation process (Wang et al., 2021). It was observed in the present study that the ankle evertor and invertor muscles did not show an asymmetry in elite female handball players.

Table II. Comparison of dominant and non-dominant side invertor - evertor muscle strength, Ever / Inver strength ratio and proprioception in elite female handball players.

<table>
<thead>
<tr>
<th>Side</th>
<th>Dominant side</th>
<th>Non- dominant side</th>
<th>p</th>
</tr>
</thead>
<tbody>
<tr>
<td>30 °/sn Ankle _inverto PT/BW (Nm/Kg)</td>
<td>49 ± 12</td>
<td>53 ± 14</td>
<td>0.228</td>
</tr>
<tr>
<td>30 °/sn Ankle Evertor PT/BW (Nm/Kg)</td>
<td>28 ± 9</td>
<td>31 ± 9</td>
<td>0.140</td>
</tr>
<tr>
<td>30 °/sn Ankle Ever / Inver Ratio (%)</td>
<td>0.58 ± 0.18</td>
<td>0.61 ± 0.23</td>
<td>0.598</td>
</tr>
<tr>
<td>120 °/sn Ankle _inverto PT/BW (Nm/Kg)</td>
<td>37 ± 8</td>
<td>40 ± 10</td>
<td>0.181</td>
</tr>
<tr>
<td>120 °/sn Ankle Evertor PT/BW (Nm/Kg)</td>
<td>22 ± 6</td>
<td>22 ± 6</td>
<td>0.739</td>
</tr>
<tr>
<td>120 °/sn Ankle Ever / Inver Ratio (%)</td>
<td>0.56 ± 0.12</td>
<td>0.57 ± 0.15</td>
<td>0.751</td>
</tr>
<tr>
<td>Active Joint Position Sense (°)</td>
<td>3.38 ± 2.39</td>
<td>3.75 ± 2.64</td>
<td>0.125</td>
</tr>
</tbody>
</table>

PT/BW: Pik Torque/ Body Weight.
strength of the invertor and evertor muscles in handball players with the isokinetic system. These studies include comparisons of people with ankle injuries rather than describing the strength profile in healthy athletes. In a study comparing the isokinetic muscle strength of handball players with and without repetitive lateral ligament sprain, it was determined that the Ever / Inver strength ratio was lower in the sprain group (Pontaga. 2004). In our study, when the Ever / Inver ratio was examined, it was seen that there was no asymmetry between the two sides. Ersoz et al. (2009), evaluating healthy men and women at 30°/s and 120°/s speeds and Bonetti et al. (2018), evaluating female volleyball players at 60°/s and 180°/s also found no difference between the dominant and non-dominant side in terms of Ever / Inver strength ratio. A high Ever / Inver strength ratio (>1) indicates tendency for inversion ankle sprain (Baumhauer et al., 1995). Although the normative range of the Ever / Inver strength ratio remains unclear, the optimal Ever / Inver peak torque ratio (muscle balance) in normal individuals has been reported in various studies between 0.7 and 0.9 at 30°/s and between 0.65 and 0.85 at 120°/s (Pontaga, 2004; Cho et al., 2019). The mean values of Ever / Inver ratio in our study ranged from 0.58 to 0.61 at 30°/s and from 0.56 to 0.57 at 120°/s. These values showed that the Ever / Inver ratios of the handball players in our study were significantly lower than the values reported in the literature. Therefore, we can say that it is important to normalize Ever / Inver ratios by making pre-season evaluations of handball players in terms of these parameters to provide ankle stabilization and to prevent common pathologies such as ankle sprain and CAI, by adding evertor muscle strengthening exercises to training programs if necessary.

Joint position sense is a component of proprioception and is usually measured to evaluate proprioception (Willems et al., 2002). It was stated that ankle inversion proprioception is significantly associated with sports performance (Zou et al., 2019). Impaired proprioception was reported to be an indicator of lateral ankle sprain and also a contributing factor to FAI following lateral ankle sprain (Madkhali & Nuhmani, 2021). As a result of our study, it was seen that there was no difference between the dominant and non-dominant sides in terms of proprioception sense. Sousa et al. (2017) reported that the absolute error was 3.93° when proprioception was measured at the 15° inversion position in healthy individuals. In our study, the values were parallel to the values in the study of Sousa et al. (2017). In our study, the absolute error value of the dominant side was 3.38 ± 2.39, while it was 3.75 ± 2.64 for the non-dominant side.

The inclusion of only elite female handball players in our study and not including male handball players is a limitation. The fact that the eccentric strength and eccentric Ever / Inver ratio of the invertor and evertor muscles were not evaluated as parameters maybe another limitation. We also evaluated proprioception as only active repositioning sensation. A limitation may be that we did not include the kinesthesia and force sensation components of proprioception in our assessment.

The results of this study showed that elite, professional, female handball players showed symmetrical values in terms of ankle invertor and evertor muscle strength, Ever / Inver strength ratio, and active joint position sense, but the mean values of Ever / Inver ratio were below normal for both limbs. It is important to normalize unilateral ratios and achieve bilateral balance between the limbs, both to minimize the risk of injuries such as ankle sprain and CAI, and to improve athletic performance. The results and methods highlighted in this study provide an opportunity for handball players to construct a comprehensive isokinetic strength profile. This information can be used to help improve understanding of injury occurrence while generating more detailed information for a handball player’s return to sports. Further studies with larger samples, including male handball players at different angular velocities and with different contraction types, are needed to fully determine the risk of injury and to contribute to the scientific knowledge of the performance of the invertor and evertor ankle muscles.


RESUMEN: La evaluación de la fuerza muscular inversora y eversora y la propriocepción son importantes para determinar el riesgo de lesión en los jugadores de balonmano. El objetivo de este estudio fue determinar la fuerza isocinética y el perfil de propriocepción de los músculos inversores y eversores del tobillo de jugadoras de balonmano de élite. Se incluyeron 15 jugadoras de élite de balonmano. La fuerza muscular inversora y eversora del tobillo y la propriocepción se evaluaron mediante el sistema isocinético. El test de fuerza isocinética se realizó en modo concéntrico a 30°/s (5 repeticiones) y 120°/s (10 repeticiones). El sentido de propiocepción se evaluó como sentido activo de posición articular. No hubo diferencias estadísticamente significativas entre los lados dominante y no dominante en términos de fuerza muscular inversora y eversora, relación eversor/inversor (Ever/Inver) y sentido activo de la posición de la articulación en ambas velocidades angulares (p>0.05). La relación Ever/Inver en ambos lados fue inferior a los valores normales. Se concluyó que las jugadoras de balonmano presentaron simetría bilateral en los músculos inversores y eversores. Sin embargo, el hecho de que la relación de fuerza Ever/Inver fuera inferior a los valores normales en ambos lados sugirió que se debe tener precaución en términos de riesgos como el esguince de tobillo o la inestabilidad crónica de tobillo. Se deben realizar evaluaciones de pretemporada y sería
beneficioso agregar ejercicios de fortalecimiento a los grupos musculares relacionados en los programas de entrenamiento para normalizar las proporciones unilaterales en estas atletas.

PALABRAS CLAVE: Músculos del tobillo; Relación de fuerza; Sentido de posición conjunta; Propiocepción.

REFERENCES


Cho, B. K.; Park, J. K.; Choi, S. M.; Kang, S. W. & Soohoo, N. F. The peroneal strength deficits in patients with chronic ankle instability compared to ankle sprain copers and normal individuals. Foot Ankle Surg., 25(2):231-6, 2019.


Corresponding author:
Nebahat Eler
School of Physical Education and Sports
67100 Incivez
Zonguldak
TURKEY

E-mail: nebahateler@gmail.com

ORCID
Nebahat Eler : 0000-0002-3857-3459
Serdar Eler : 0000-0001-9396-501X
Gamze Cobanoglu: 0000-0003-0136-3607
Gokhan Mehmet Karatay: 0000-0002-4319-1009
Nevin Atalay Guzel : 0000-0003-0467-7310