

# 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

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**ELER, N.; ELER, S.; COBANOĞLU, G.; KARATAY, G. M. & GÜZEL, N. A.** Profile of ankle isokinetic strength and proprioception in elite female handball players. *Int. J. Morphol.*, 41(4):1118-1122, 2023.

**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 (Wilkerson *et al.*, 1997; Madkhali & Nuhmani, 2021). Proprioception includes joint position sense, kinesthesia, and force sense. It has been

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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 strengths 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  $\pm$  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.

		Female Handball Players (n=15)
Age (years)		24 ± 3
Height (cm)		173 ± 5
Weight (kg)		64.8 ± 7.2
BMI (kg/cm <sup>2</sup> )		21.53 ± 2.18
Dominance		n (%)
Right		10 (66.66)
Left		5 (33.33)

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, and it was observed that handball players showed symmetry in terms of invertor and evertor muscle strength, Ever / Inver strength ratio, and active joint position sense. Although there was no difference in the Ever / Inver strength ratio between the dominant and non-dominant sides, the Ever / Inver strength ratios of both sides were lower than normal values.

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. This result was consistent with other studies suggesting symmetry in the strength of the ankle evertor and invertor muscles. In one of the two studies on the isokinetic evaluation of healthy individuals (of both sexes who had no previous history of ankle sprain) at angular velocities of 30°/s, 60°/s, and 120°/s, Wong *et al.* (1984) found that the invertor and evertor muscles were symmetrical, except the evertor at 30°/s (Wong *et al.*, 1984; Nickson, 1987). Comparing the eversion and inversion strength and strength ratios between the dominant and nondominant sides at 30°/s and 120°/s angular velocities in young healthy adults, Lin *et al.* (2009) also stated that there was symmetry between the two sides. When we look at the studies on athletes, it was seen that there were no bilateral differences in the study conducted to investigate the asymmetry in the invertor and evertor muscle strength and strength ratios in U20 football players (Silva *et al.*, 2015). Ankle isokinetic strength in female volleyball players was evaluated at 60°/s and 180°/s and it was observed that evertor muscle strength was lower on the non-dominant side than the dominant side at 60°/s and other peak torque values and Ever / Inver strength ratios were similar, but the Ever / Inver ratio was lower than the normal values (Bonetti *et al.*, 2018). Similarly, in a study in female ballet dancers, bilateral symmetry was reported based on an isokinetic ankle invertor and evertor muscle strength test (Nagy *et al.*, 2021). However, there exists no study comparing dominant and nondominant ankle muscle strength and strength ratio in handball players. There are few studies evaluating the

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

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

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.

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**ELER, N.; ELER, S.; COBANOGLU, G.; KARATAY, G. M. & GÜZEL, N. A.** Perfil de fuerza isokinética del tobillo y propiocepción en jugadoras de élite de balonmano. *Int. J. Morphol.*, 41(4):1118-1122, 2023.

**RESUMEN:** La evaluación de la fuerza muscular inversora y eversora y la propiocepción 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 propiocepción 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 propiocepción 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.**

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