Isokinetic Ankle Inversion and Eversion Muscle Strength in Korean Men's Professional Basketball Players

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INTRODUCTION

Basketball, with its fast pace and 24-second shot clock, is regarded as a high-risk sport for injury because it involves frequent and repetitive movements involving rapid changes in direction, acceleration, deceleration, jumping, and landing, as well as the potential for physical contact [1,2]. Ankle injuries were identified as a major cause of time loss in a comprehensive study spanning 17 years of NBA injuries, accounting for approximately 14.7% of all reported injuries [1]. Lateral ankle sprains (LAS) were highlighted as the predominant orthopedic injury in basketball, with a higher incidence rate than any other injury at 3.2 per 1,000 athlete exposures [1]. This basketball-specific injury pattern has been consistently observed across genders and levels of competition [3-6].

Meanwhile, LAS has been reported to cause invertor and evertor muscle weakness and imbalances in the ankle eversion to inversion strength ratio (E/I R). Recent ankle sprains or chronic lateral ankle instability resulted in invertor muscle weakness in physically active adolescents [7]. Recurrent ankle lateral ligament sprains reduced the torque ratio of the evertor to invertor muscles in the inversion positions of the range of motion in male handball players [8]. Strengthening the invertor and evertor muscles is known to be a critical component in the rehabilitation of athletes with LAS and chronic ankle instability (CAI) [9]. These previous study observations are basically based on the assessment of inversion and eversion muscle strength.

PURPOSE: In this study, the isokinetic strength of ankle inversion and eversion in Korean professional basketball players (KBL) was assessed, distinguishing between their dominant and non-dominant legs, as well as across different positions.

METHODS: A meticulously designed study was conducted involving 25 KBL players (12 guards, 11 forwards, and 2 centers) with an average age of 27.8±5.3 years. The CSMI Norm isokinetic dynamometer, a highly accurate instrument, was used to measure bilateral isokinetic concentric strength at 60°·s⁻¹ and 150°·s⁻¹. The study measured peak torque (Nm), body mass normalized peak torque (Nm·kg⁻¹), bilateral strength asymmetry, and the eversion-to-inversion strength ratio in both dominant and non-dominant legs.

RESULTS: Peak torques, normalized peak torques, and eversion-to-inversion strength ratios were not significantly different between the dominant and non-dominant legs at the two angular speeds. There was also less than a 10% asymmetry in strength between the two legs. However, a position-specific analysis revealed that guards had a significantly higher normalized peak torque (0.35 vs. 0.30 Nm·kg⁻¹, p = .048) for ankle inversion of the dominant leg at 150°·s⁻¹ compared to forwards.

CONCLUSIONS: The results suggest that healthy KBL players exhibit symmetrical ankle inversion and eversion muscle strength between their dominant and non-dominant sides, with possible positional differences in strength. These findings serve as a reference for the assessment of inversion and eversion strength in basketball players.

Key words: Ankle, Inversion, Eversion, Peak torque, Basketball player
vertor and evertor strength in professional basketball players. The purpose of this study was to assess the isokinetic strength of ankle inversion and eversion in professional basketball players, distinguishing between their dominant (D) and non-dominant (ND) legs and between positions. The findings of this study can serve as helpful reference values for assessing ankle joint strength in basketball players.

METHODS

1. Study design

The ankle is one of the most commonly injured body parts among basketball players. Providing reference values for isokinetic ankle inversion and eversion strength specific to basketball players has significant utility for coaches and athletic trainers in determining RTP decisions for injured players. In this study, we aimed to evaluate the isokinetic strength values of ankle inversion and eversion in professional basketball players, distinguishing between their D and ND legs. This retrospective study used data from Korean Basketball League (KBL) basketball players who underwent preseason strength screenings at the Samsung Training Center (STC) (https://en.wikipedia.org/wiki/Samsung_Training_Center), the largest private sports rehabilitation institution in South Korea, from the 2019-2020 season to the 2021-2022 season.

2. Subjects

The study initially included 30 KBL professional basketball players who underwent ankle isokinetic strength testing at our institution (STC). We excluded those with a history of injury or surgery (n = 5), including two cases of modified Brostrom surgery, one case of fifth metatarsal stress fracture, and one case of disc herniation resulting in neurological problems in the lower extremities, as diagnosed by an orthopedic surgeon [10]. The remaining 25 players (12 guards, 11 forwards, and 2 centers) were included in the final analysis (Fig. 1). All participants in the analysis had no lower extremity injuries in the six months preceding the study.

During the preseason, study participants attended regular team training sessions, which were typically held five times a week. Isokinetic strength testing was conducted in September, before the regular season began, followed by a rigorous preseason training regimen. Participants were also evaluated for characteristics such as dominant leg, injury history, and musculoskeletal surgery. The participants had an average age of 27.8 ± 5.3 years, a height of 192.1 ± 6.6 cm, a weight of 90.0 ± 11.5 kg, and 7.1 ± 4.4 years of professional experience (Table 1).

Before participating in the study, all participants received detailed information about the research and provided informed consent. The Institutional Review Board reviewed and approved the study protocol (SKKU Eligible professional basketball players who performed ankle inversion and eversion isokinetic testing from the 2019-2020 to 2021-2022 seasons (n = 30)

Excluded players (n = 5)
- 1 Chronic ankle instability
- 3 Previous surgical history: 2 MBO and 1 MTB stress fracture
- 1 Nerve problems due to HIVD

Included players (n = 25)

Fig. 1. Flow chart of the eligible and included participants. MBO, modified Brostrom operation; MTB, metatarsal bone; HIVD, herniation of intervertebral disc.

Table 1. Physical characteristics of study participants (mean ± SD)

<table>
<thead>
<tr>
<th></th>
<th>Age (yr)</th>
<th>Height (cm)</th>
<th>Weight (kg)</th>
<th>BMI (kg/m²)</th>
<th>Career (yr)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total (n = 25)</td>
<td>27.8 ± 5.3</td>
<td>192.1 ± 6.6</td>
<td>90.0 ± 11.5</td>
<td>24.4 ± 2.5</td>
<td>7.1 ± 4.4</td>
</tr>
<tr>
<td>Guards (n = 12)</td>
<td>27.2 ± 4.2</td>
<td>187.8 ± 5.5</td>
<td>81.8 ± 8.8</td>
<td>23.2 ± 2.4</td>
<td>6.3 ± 3.8</td>
</tr>
<tr>
<td>Forwards (n = 11)</td>
<td>28.6 ± 6.9</td>
<td>195.6 ± 5.2</td>
<td>95.5 ± 6.6</td>
<td>25.0 ± 2.0</td>
<td>8.0 ± 5.4</td>
</tr>
<tr>
<td>Centers (n = 2)</td>
<td>26.5 ± 0.7</td>
<td>199.0 ± 1.4</td>
<td>109.5 ± 3.5</td>
<td>27.7 ± 1.3</td>
<td>7.5 ± 0.7</td>
</tr>
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BMI, body mass index.
3. Isokinetic assessment

Isokinetic concentric inversion and eversion strength were assessed in both D and ND legs at angular velocities of 60°·s⁻¹ and 150°·s⁻¹ using the CSMi Norm dynamometer (CSMi, Stoughton, MA, USA). These velocities have been used in previous studies assessing ankle instability [11], and the intratester and intertester reliability of isokinetic ankle inversion and eversion strength assessments is well established [12].

The warm-up consisted of a series of lower leg flexibility exercises and 10 minutes of cycling [10]. During the measurements, players wore low-heeled running shoes to minimize potential errors associated with shoe height. The dynamometer was tilted 55 degrees upward, as directed by the manufacturer’s guidelines, and the ankle adapter was installed. Participants were seated in the dynamometer chair, hips flexed at 70 degrees, knees flexed at 80 degrees, and ankles plantarflexed at 15 degrees. The subjects’ trunks and thighs were securely strapped to reduce compensatory movements, and the sole was secured to the ankle adapter plate for precise measurement. After aligning the midpoint of the patella with the second toe to establish the zero point, the total range of motion was limited to 30 degrees for inversion and 20 degrees for eversion. Each repetition began in the everted position, transitioned to the inverted position, and returned to the everted position. Before testing, participants completed three submaximal repetitions at each speed to familiarize themselves with the isokinetic equipment and angular velocities. The tests were then repeated four times at each speed. There was a one-minute break between the various angular velocities and a three-minute break when changing the machine settings from the D to the ND side [13]. The tests were conducted sequentially from the D to the ND leg, with verbal encouragement provided to the subjects throughout to elicit their peak torque. The peak torque values for ankle inversion and eversion exerted during four consecutive muscle contractions at each angular velocity were used in the analysis.

The peak torque (Nm), body mass normalized peak torque (hereinafter referred to as normalized peak torque) (Nm·kg⁻¹), bilateral strength asymmetry (BSA), and the E/I ratio were measured. Peak torque represents the absolute maximum strength of the joint produced by isokinetic muscle contraction, whereas normalized peak torque represents the relative maximum strength of the joint. BSA denotes the percentage difference in peak torque values between the D and ND legs. The D leg was designated as the preferred leg for a single-leg jump [14,15]. Bilateral strength imbalance was defined as a BSA greater than 15%, as previously described [14,16]. The intraclass correlation coefficients for inversion and eversion ranged from 0.90 to 0.92 and 0.85 to 0.88, respectively.

4. Statistics

Continuous variables were presented as mean ± standard deviation. Normality tests for the main variables were conducted using the Shapiro-Wilk test (Table 2). Normalized peak torque was calculated using the formula: peak torque (Nm) divided body weight (kg), and the E/I ratio was calculated as (eversion strength (Nm) divided inversion strength [Nm]) × 100. A paired t-test was used to compare measurements between the D and ND legs, while an independent t-test was used to compare normalized peak torque values of the D legs between playing positions. The level of statistical significance was set at p < .05. All statistical analyses were performed using IBM SPSS version 25.0 (IBM Corp., Armonk, NY, USA).

RESULTS

Table 3 displays the results of isokinetic inversion and eversion tests conducted at 60°·s⁻¹ angular velocity for both the D and ND legs. The inversion peak torque for the D and ND legs was 39.3 Nm and 39.7 Nm, respectively, and the inversion normalized peak torque for the D and ND legs was 0.44 Nm·kg⁻¹ for both legs. There were no statistically significant differences in peak torque and normalized peak torque between the two legs. The eversion peak torque for the D and ND legs was 32.5 Nm and 31.5 Nm, respectively, and the eversion normalized peak torque for the D and ND legs was 0.36 Nm·kg⁻¹ and 0.35 Nm·kg⁻¹, respectively. There were no statistically significant differences in peak torque and normalized peak torque between the two legs. The E/I ratio showed no statistical difference between the D and ND legs. BSA for inversion was
6.1%± 6.3%, and for eversion, it was 10.1%±7.9%.

Table 4 displays the results of isokinetic inversion and eversion tests conducted at 150°·s⁻¹ angular velocity for both the D and ND legs. The inversion peak torque for the D and ND legs was 29.8 Nm and 30.5 Nm, respectively, and the inversion normalized peak torque for the D and ND legs was 0.33 Nm · kg⁻¹ and 0.34 Nm · kg⁻¹, respectively. There were no statistically significant differences in peak torque and normalized peak torque between the two legs. The eversion peak torque for the D and ND legs was 23.3 Nm and 23.8 Nm, respectively, and the eversion normalized peak torque for the D and ND legs was 0.27 Nm · kg⁻¹ and 0.25 Nm · kg⁻¹, respectively. There were no statistically significant differences in peak torque and normalized peak torque between the two legs.

The E/I ratio was not significantly different between the D and ND legs. BSA for inversion was 9.2%± 5.9%, and for eversion, it was 8.2%± 6.4%.

Table 5 displays the normalized peak torque values for guard and for ward inversion and eversion, respectively. At 60°·s⁻¹, guards and forwards had similar normalized peak torque values for inversion (0.45 Nm · kg⁻¹ vs. 0.41 Nm · kg⁻¹) and eversion (0.36 Nm · kg⁻¹ vs. 0.36 Nm · kg⁻¹). At 150°·s⁻¹, guards exhibited a significantly higher normalized peak torque for inversion compared to forwards (0.35 Nm · kg⁻¹ vs. 0.30 Nm · kg⁻¹, p = .048). The normalized peak torque values for eversion were not statistically different between the playing positions (0.27 Nm · kg⁻¹ for guards vs. 0.25 Nm · kg⁻¹ for forwards).

**DISCUSSION**

This study examined the isokinetic strength of the ankle invertor and evertor muscles in a sample of 25 KBL professional basketball players. Across the measured angular velocities, there were no significant differences in isokinetic ankle strength for inversion and eversion between the D and ND legs. However, guards exhibited higher normalized peak
torque for ankle inversion compared to forwards. This discrepancy suggests potential strength differences based on player roles.

We are unaware of any normative values for isokinetic ankle inversion and evasion strength in professional basketball players. Although a direct comparison is not possible, the inversion and evasion peak torques at 60°·s⁻¹ in this study exceeded those reported by Payne et al. [17] for male collegiate basketball players at 30°·s⁻¹. Given the well-established trend of peak torque decreasing with increasing angular velocity [12,18], the peak torque values of our study participants are likely higher than those observed by Payne et al. [17]. However, caution is advised because normalized peak torque values, rather than peak torque values, are more suitable for comparing strength levels among players with different physical characteristics.

Between the D and ND legs, our study found no statistically significant differences in either the absolute and relative strength of ankle inversion and eversion at any of the measured angular velocity levels. These findings are consistent with those of Lin et al. [19], who analyzed the lower legs as left and right, and Payne et al. [17], who divided the legs into D and ND sides. Lin et al. [19] reported a minimal mean difference in strength between the D and ND legs of 0.02 to 0.25 Nm·kg⁻¹ in young adults. Payne et al. [17] found a marginal difference in the left-right strength of ankle inverters and evertors in college basketball players, ranging from an average of 0.2 to 0.4 Nm. Together, the findings from the current and previous studies suggest that isokinetic ankle inversion and eversion strength are similar in both legs in healthy adults as well as basketball players.

Consistent with Risberg et al. [20], the current study rigorously controlled for injury history and found no significant strength imbalance for ankle inversion and eversion between the D and ND legs, with differences falling within a 10% range. These findings contradict the Im et al. [21] study, which used the same population and found an average deficit rate of 13-15% for ankle inversion and eversion. However, it should be noted that the Im et al. [21] study used more lenient criteria for subject selection than the current study and the Risberg et al. [20] study. In another study of 15 professional basketball players, Schiltz et al. [14] found no strength imbalance between the D and ND legs in 10 players who had no previous knee injuries, whereas the five players with a history of knee injury showed a bilateral strength imbalance of more than 10%. To summarize, when injury history is taken into consideration, basketball players are unlikely to have a significant bilateral lower limb strength imbalance. These findings can be interpreted as reflecting the asymmetrical movement patterns of basketball players who use both lower limbs equally during practice and competition [22].

The agonist-antagonist strength ratio is regarded as a valuable tool for predicting injury [10,23], making it one of the critical variables in interpreting isokinetic strength data. In this study, the E/I ratio at 60°·s⁻¹ angular velocity was 0.84 for the D leg and 0.81 for the ND leg, whereas at 150°·s⁻¹ angular velocity, it was 0.79 for the D leg and 0.79 for the ND leg. These findings are consistent with previous studies, which found higher E/I ratios at lower angular velocities [7,19]. Dabadghav et al. [10] linked an E/I ratio greater than 1.0 to a higher risk of ankle injury. Based on previous research [10], the E/I ratio values below 1.0 observed in the participants of this study indicate a lower risk of ankle injury, an expected finding given that athletes with a history of CAI and ligament reconstruction surgery were excluded. However, due to the relatively small sample size of this study, it is premature to regard the derived E/I ratio values as normative for the ankle joints of basketball players.

Comparing strength between playing positions, the current study found that guards had significantly higher normalized peak torque in inversion than forwards at 150°·s⁻¹ angular velocity. These findings are consistent with previous studies by Bradic et al. [24] and Im et al. [21], which found significant differences in ankle strength based on playing position. Although the question of strength variations between playing positions remains open, Bradic et al. [24] suggest that these differences might plausibly be attributed to the specialized training and gameplay inherent to each position. During games, centers perform frequent vertical jumps, guards perform high-intensity movements like defensive shuffles and directional changes, and forwards fall somewhere in the middle, emphasizing mobility [25-27]. In conclusion, basketball players’ relative ankle inversion strength may differ by position. Although additional research is needed, coaches and trainers should be aware of these position-specific strength differences and take them into consideration when assessing athletes’ muscle function.

This study has some limitations. First, the participant pool was limited to a few KBL players, so the derived isokinetic ankle inversion and evasion strength values cannot be considered normative. Second, we only evaluated isokinetic inversion and evasion strength at 60°·s⁻¹ and 150°·s⁻¹ angular velocities. To gain a more comprehensive understanding of isokinetic ankle strength in basketball players and to allow for comparisons with other studies, strength must be measured at various angular velocities. Third, the positional analysis was limited to guards and forwards due to the small number of cases involving center players. Fi-
nally, this study could not examine the relationship between position-specific injuries and ankle strength because it was designed to provide baseline data on isokinetic ankle inversion and eversion strength in professional basketball players. Further research addressing these limitations is necessary to establish normative isokinetic ankle inversion and eversion strength values in basketball players.

CONCLUSION

This study examined isokinetic ankle inversion and eversion strength in professional basketball players. The results of the study showed no differences in both ankle inversion and eversion strength between D and ND legs in healthy professional basketball players. However, guards exhibited greater relative ankle inversion strength compared to forwards. The difference in isokinetic ankle strength between positions observed in this study indicates the importance of assessing strength based on position. These findings may be helpful for strength and conditioning professionals working with basketball players, particularly in the assessment and interpretation of isokinetic ankle inversion and eversion strengths.

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CONFLICT OF INTEREST

All authors have no conflict of interest to disclose.

AUTHOR CONTRIBUTIONS

Conceptualization: MK Song; Data curation: MK Song; Formal analysis: MK Song; Methodology: MK Song; Project administration: MK Song; Visualization: MK Song; Writing - original draft: MK Song; Writing - review & editing: MK Song.

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