

# Intrinsic Risk Factors for Ankle Sprains in Female Soccer Players: Examination of Japanese Top League Players with History of Ankle Sprain

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**The purpose of this study was to determine the intrinsic risk factors for ankle sprain in female soccer players. Twenty-four female soccer players from one team in Japan Women's Football League participated in this study. Medical screenings before and during the season were conducted and ankle sprains sustained during one playing season were recorded. The medical screenings included foot alignment, toe flexor strength, joint laxity and range of motion, star excursion balance test, body mass index, body fat percentage, osteo-sono assessment index, and estimated hemoglobin concentration. Players who sustained ankle sprain had significantly increased joint laxity, especially of the ankle joint, reduced performance in the Star Excursion Balance test and weak toe flexor strength. Joint laxity and impaired dynamic balance ability are risk factors for ankle sprain in female soccer players.**

**Keywords:** female, soccer, ankle sprain, intrinsic risk factor

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## 1. Introduction

Soccer is a popular sport played by people worldwide. While playing the game, various injuries might occur usually to the lower limbs, due to high-intensity exercise such as sprinting, turning, jumping, kicking repeated intermittently, and frequent contact with other players, in addition to handling the ball with the foot. Ankle sprains are frequent among soccer players, and the incidence is 2.52 injuries per 1,000 player hours, which is the second-highest following rugby, among injuries sustained in various sports (Fong et al., 2007). Furthermore, the rate of recurrence of ankle sprains is extremely high. A survey among 380 athletes (271 males and 109 females) reported that 73.5% of the athletes had suffered ankle sprains twice or more, and 22% had suffered ankle sprains five times or more (Yeung et al., 1994). Therefore, prevention of ankle sprains is important for soccer players.

Intrinsic risk factors associated with ankle sprains include limited range of dorsiflexion, decreased proprioception, and impaired balance ability (de

Noronha et al., 2006). Age, obesity, and joint laxity have also been reported as risk factors (Fousekis et al., 2012). Although females experience ankle sprains nearly twice as often as males (Doherty et al., 2014), most studies investigating the risk factors for ankle sprains have been conducted among male subjects only, or in a mixed cohort of males and females. Since physical characteristics such as flexibility, laxity, and alignment greatly differ between males and females, risk factors for developing ankle sprains might differ as well. A study among soccer players belonging to the domestic leagues in Sweden reported that the factors for increased risk of acute traumatic injuries of the lower extremities included joint laxity, hyperextension of the knee joint, and decreased hamstrings-to-quadriceps ratio in concentric contractile force (Söderman et al., 2001). A prospective cohort study among 159 female students of a physical education college reported that reduced proprioception and impaired balance ability were risk factors for ankle sprain (Willems et al., 2005). However, to the best of our knowledge, there have been no studies investigating the intrinsic risk factors for ankle

sprains in female soccer players, especially at a high competitive level. To establish measures to prevent ankle sprains among female soccer players, it is necessary to understand the intrinsic risk factors for ankle sprain in female soccer players.

This study aimed to determine the relationship between the results of medical assessment conducted before and during the soccer season, and ankle sprains that occurred during the season in female soccer players belonging to the top league in Japan.

## 2. Methods

### 2.1. Subjects

This study included 24 players excluding three goalkeepers, out of the total 27 players who belonged to the Japan Women's Football League. The Japan Women's Football League is the top league for female soccer in Japan, comprising 32 teams ;10 in Division 1, 10 in Division 2, and 12 in Division 3. The subjects of this study belonged to the Division 3 competition level. Subjects were thoroughly explained about the study, verbally and in writing before enrolment, and the study was initiated after obtaining their consent. This study was conducted in accordance with the Declaration of Helsinki and was approved by the Ethics Committee at Prefectural University of Hiroshima (approval number, 19MH006).

### 2.2. Measurement items and methods

As part of the pre-season medical assessment, presence or absence of a history of ankle sprain and subjective feeling of ankle joint instability was checked, and foot alignment (arch height index and leg-heel angle), toe flexor strength, range of motion of internal rotation of the hip, joint laxity, and dynamic balancing were measured in all subjects. During the season, body mass index, percent body fat, bone strength, and estimated hemoglobin value were measured, and abnormalities in the menstrual cycle were checked.

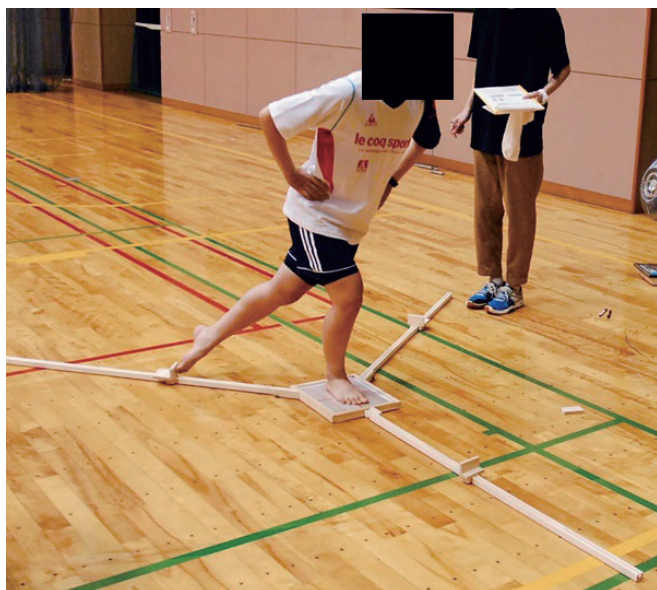
#### 2.2.1. Pre-season examination

The presence or absence of a history of ankle sprain and a feeling of ankle joint instability was confirmed in writing. For measuring the arch height index, the subject was instructed to stand on an acrylic plate with calibrations, which is our original measurement device,

and the height from the floor to the back of the foot was measured at the midpoint of the foot length. The arch height index was obtained by dividing the measured value by the truncated foot length (**Figure 1**). For the leg-heel angle, the angle between the bisector of the lateral diameter in one-third of the distal lower leg and bisector of the lateral diameter of the calcaneal bone was measured using a goniometer. For the toe flexor strength, the maximum isometric muscle strength was measured in a sitting position with the hip and knee flexed at 90 degrees, using a toe grip dynamometer (Takei Co., Ltd., Niigata, Japan) according to the previous study by Kurihara et al (2014). For the range of motion during internal rotation of the hip, the angle between the vertical axis to the floor and the longitudinal axis of the lower leg while internally rotating both hip joints in prone position with the knee bent at 90° was measured using a goniometer. For the measurement of joint laxity, the general joint laxity test proposed by Tokyo University was used. This test evaluates seven major joints in the body, as described in the report by Nakajima et al. (1984). A score of one was accorded if the laxity test was positive for each joint (0.5 points for each left and right joint); the total score was considered for general laxity, and the ankle joint scores were considered for ankle-joint laxity. The ankle joint was considered positive for laxity when the dorsiflexion angle was 45 degrees or greater. Dynamic balance was measured using the Star Excursion Balance Test (**Figure2**), which has been used in studies reporting the association between dynamic balance and ankle sprain injuries (de Noronha et al., 2013; Gribble et al., 2016; Oda et al., 2019). The high intra-rater and inter-rater reliability



**Figure 1** Measurement of arch height index



**Figure 2** Star excursion balance test

of this test was demonstrated in a study among soccer players (Plisky et al., 2009). In the Star Excursion Balance Test, the maximum distances covered in the anterior, posteromedial, and posterolateral directions were measured, and the values were normalized to the spina-malleolar distance of the supporting leg.

### 2.2.2. In-season assessment

Height from the most recent physical measurement was considered, and the weight and percent body fat were measured using a body composition monitor (KaradaScan HBF-904, Omron Healthcare, Kyoto, Japan). Body mass index was calculated from the height and weight data obtained. For bone strength, osteo sono-assessment index (OSI) was obtained using an ultrasound bone densitometry (AOS-100NW, Hitachi Aloka Medical, Tokyo, Japan). OSI was calculated from the ultrasound verbosity passing through the calcaneus and the transmission index, and was normalized by the reference values for the same sex and same age. Estimated hemoglobin values were obtained by the near-infrared spectroscopic imaging method using a health monitoring system ASTRIM FIT (Sysmex, Kobe, Hyogo, Japan). The menstrual history was obtained in writing, and those with regular menstruation every 26 to 35 days were considered to have a normal cycle.

### 2.3. Survey on ankle sprain injuries

After conducting a pre-season medical assessment, ankle sprains that occurred during one season (between

April to November) were longitudinally surveyed. Ankle sprain was defined as an injury that occurred during soccer practice or a game, and prevented the player from participating in practice or games for at least one day (Oda et al., 2019).

### 2.4. Statistical analysis

After the end of the season, players were classified based on whether they sustained ankle sprains or not, and their legs were divided into two groups: the ankle sprain injury group for injured legs that suffered ankle sprains and the no-ankle sprain injury group, which included both legs of subjects who did not suffer ankle sprains. Non-injured legs of the players who had ankle sprain only on one side were excluded from the analysis. The Shapiro-Wilk test was used to confirm the normality of the data of each measurement taken before and during the season. Differences between the two groups were compared using the independent sample t-test, for parameters with confirmed normal distribution, and the Mann-Whitney test was used for parameters without normal distribution. In addition, the effect size 'r' was calculated for parameters with a significant difference between the groups. For calculation of the effect size 'r', the following formula 1 was used for the independent sample t-test, and formula 2 was used for the Mann-Whitney test. The criteria for the effect size were set as follows: small,  $r=0.1$ ; medium,  $r=0.3$ ; large,  $r=0.5$ .

Formula 1)  $r = \sqrt{t^2 / t^2 + df}$ , r: effect size, t: t test value, df: degrees of freedom

Formula 2)  $r = Z / \sqrt{n}$ , r: effect size, Z: test statistics, n: sample size

The association between the presence or absence of a feeling of ankle instability and ankle sprain injuries was examined using the  $\chi^2$  independence test. SPSS 20.0 for Windows (IBM, NY, USA) was used for all statistical analyses, and the significance level was set at 5%.

### 3. Results

Three players could not complete all medical assessments due to injury or scheduling conflicts; thus, 21 players were included for the final analysis. All subjects had a history of ankle sprains before the pre-season medical assessment, and 14 (67%) had a subjective complaint of a feeling of ankle instability. Six legs in five players suffered ankle sprain during the 2019 season. Tables 1 and 2 show the medical assessment results

of the six legs in the ankle sprain injury group (age,  $22.3 \pm 0.8$  years; height,  $162.0 \pm 7.2$  cm; weight,  $57.4 \pm 5.0$  kg) and 32 legs in the no-ankle sprain injury group (age,  $24.1 \pm 2.8$  years, height,  $160.1 \pm 5.2$  cm; weight,  $54.6 \pm 3.8$  kg). The ankle sprain injury group showed reduced toe flexor strength ( $p=0.030$ ,  $r$  [effect size]  $=0.35$ ), increased generalized and ankle joint laxity (general joints,  $p=0.037$ ,  $r=0.34$ ; ankle joints,  $p=0.025$ ,  $r=0.53$ ), and impaired dynamic balance (anterior,  $p=0.010$ ,  $r=0.41$ ; posterolateral,  $P=0.020$ ,  $r=0.38$ ) (**Table 1**). However, BMI, percent body fat, bone strength, and estimated hemoglobin were within normal range in all subjects, and there was no significant difference between the two groups (**Table 2**). There was no significant association between the presence or absence of a feeling of ankle instability and ankle sprain injury ( $p=0.314$ ). Abnormal menstrual cycles were seen in three players (all had

oligomenorrhea), but none had ankle ligament injuries.

#### 4. Discussion

We examined intrinsic risk factors associated with ankle sprain injury in female soccer players belonging to a top league in Japan. A notable finding was that all study subjects already had a history of ankle sprains before the study. An ankle sprain is an injury with a very high rate of recurrence (Yeung et al., 1994), and a history of ankle sprain itself is a major risk factor for subsequent ankle sprain injuries (Tyler et al., 2006; de Noronha et al., 2013). Therefore, it is necessary to note that the study subjects originally had a background that is prone to ankle sprain injury, including having a history of ankle sprain and playing soccer at a high level

**Table 1** The results of pre-season measurement for the two groups

|  | Ankle sprain         |                         | P     |
|--|----------------------|-------------------------|-------|
|  | Injured<br>(n = 6)   | Non-injured<br>(n = 32) |       |
| Static foot alignment                                    |                      |                         |       |
| Arch height index  | 0.352<br>(0.021)     | 0.338<br>(0.021)        | 0.156 |
| Leg heel angle (degree)                                  |                      |                         |       |
| Loading  | 2.5<br>[-2.0/4.0]    | 2.5<br>[-1.8/4.8]       | 0.653 |
| Unloading  | -9.0<br>[-11.0/-5.0] | -6.0<br>[-8.0/-5.0]     | 0.172 |
| Toe flexor strength (%BW)                                | 14.3<br>[8.2/15.3]   | 16.5<br>[13.8/19.7]     | 0.030 |
| Range of motion of<br>the hip internal rotation (degree) | 62.5<br>[50.0/71.3]  | 57.5<br>[50.0/63.8]     | 0.297 |
| General joint laxity (point)                             | 4.8<br>[2.8/6.0]     | 3.0<br>[2.0/4.0]        | 0.037 |
| Ankle joint laxity (point)                               | 0.5<br>[0.0/0.5]     | 0.0<br>[0.0/0.0]        | 0.025 |
| Dynamic balance  |                      |                         |       |
| Star Excursion Balance Test (%SMD)                       |                      |                         |       |
| Anterior   | 82.5<br>[79.0/86.4]  | 90.7<br>[85.1/98.1]     | 0.010 |
| Posterior lateral  | 99.8<br>(6.1)        | 106.4<br>(5.6)          | 0.020 |
| Posterior medial   | 93.2<br>(6.8)        | 98.6<br>(4.5)           | 0.071 |

Values are presented as median [25th/75th interquartile] or mean (standard deviation).

SMD, spina malleolar distance.



**Table 2** The results of in-season measurement for the two groups

|   | Ankle sprain           |                        | p     |
|---|------------------------|------------------------|-------|
|   | Injured                | Non-injured            |       |
|   | (n = 6)                | (n = 32)               |       |
| Body mass index (kg/m <sup>2</sup> )      | 21.5<br>[21.3/22.1]    | 21.1<br>[20.1/22.3]    | 0.356 |
| Body fat percentage (%)                   | 21.5<br>[20.6/23.7]    | 22.1<br>[21.5/24.3]    | 0.544 |
| Osteo-sono assessment index (%)           | 139.5<br>[127.0/147.0] | 126.5<br>[115.5/139.3] | 0.106 |
| Estimated hemoglobin concentration (g/dl) | 13.5<br>[13.0/14.4]    | 14.0<br>[13.1/14.8]    | 0.422 |

Values are presented as median [25th/75th interquartile].

in which ankle sprain frequently occurs.

In this study, general and ankle joint laxity were significantly higher in the ankle sprain injury group than in the no-ankle sprain injury group. In particular, the effect size for increased ankle laxity was high ( $r=0.53$ ), which is considered to be a more significant risk factor for ankle sprain. Some previous studies reported a decrease in ankle dorsiflexion angle as a risk factor for ankle sprains (Pope et al., 1998; Willems et al., 2005). However, the subjects in these reports were males, and a recent study among college-level female soccer players identified an increase in ankle dorsiflexion angle as a risk factor for ankle sprain (Oda et al., 2019). Regardless of the level of competitiveness, increased ankle laxity seems to be a risk factor for ankle sprain common to female soccer players, which is different in males.

In our study, the dynamic balance ability was significantly decreased in the ankle sprain injury group; this concurs with the report of a previous study (de Noronha et al., 2006; Willems et al., 2005). In previous studies using the Star Excursion Balance Test to examine dynamic balance ability, a decrease in the reach distance

in the posterolateral direction (de Noronha et al., 2013) and in the anterior direction (Gribble et al., 2016; Oda et al., 2019) were identified as risk factors for ankle sprains, which is consistent with our findings. Since measurements in this study were performed in the field, we did not measure proprioception, which has often been reported as a risk factor for ankle sprain in previous studies (de Noronha et al., 2006; Willems et al., 2005). Since proprioception is closely associated with balance ability, a decline in proprioception might form the background of impaired balance ability in the ankle sprain injury group. In addition, since toe flexor strength is also important for maintaining balance, a decline in toe flexor strength in the ankle sprain injury group might have contributed to the impaired balance ability.

Based on the above findings, checking the laxity of the ankle joint and impaired balance ability in female soccer players at a high competition level can be recommended. It is also necessary to explore strategies to improve or compensate for these risk factors, to prevent ankle sprains. We did not find any relationship between ankle sprain injuries and abnormal menstruation cycle,

which is an issue unique to women, and the items that are related to the female athlete triad, including BMI and percent body fat, bone strength, and estimated hemoglobin values. However, the results of these parameters were within the normal range in most of our study subjects. In addition to this, because lack of power due to the small sample size might have affected the results, it might be premature to deny the relationship between these parameters and ankle sprains.

The limitations of this study include the small number of instances of ankle sprain injuries due to the small sample size, and the short duration of the study. Due to these factors, the detection power of the statistical analysis was reduced, and it was difficult to perform a logistic regression analysis. Moreover, only one team was included in the study, which limits generalization of the study results. In future, it is necessary to conduct a longer-term survey involving a greater number of teams at the same competitive level, to examine risk factors for ankle sprains. Another limitation of this study is that we did not consider the severity and the number of ankle sprain injuries per player, and the duration for which the player was unable to play due to the injury. Moreover, we did not examine whether preventive measures such as bracing and taping were used. At high competition levels, many players use preventive measures such as taping while playing. In a future large-scale study, this should be included as an independent variable.

## 5. Summary

The present study investigated intrinsic risk factors for ankle sprain injuries in female soccer players belonging to the top league in Japan. The results suggested that an increase in laxity of the ankle joint and decline in balance ability are risk factors for ankle sprain injuries.

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