Introduction

Inversion sprain of the ankle joint occurs frequently in basketball players and lateral ligament injuries of the ankle joint account for 45% of all traumas in basketball [1, 2]. Of these injuries, the incidence of anterior talofibular ligament injury is the highest [3], and this is the primary cause of lateral instability of the ankle joint, for which concomitant occurrence of osteochondral injury in the talocrural joint region is of concern [4–6]. McKay reported the rate of ankle injury and risk factors of ankle injuries in basketball players. The chronic ankle symptoms were as high as 74% [7]. Turner et al. reported physical activity levels in college students who have chronic ankle instability were decreased in comparison to the healthy group [8]. It is important to prevent these pathological conditions from developing, so children should be trained correctly from a young age [8, 9].

The repair process of osteochondral injury and impacts between bones in the talocrural joint due to frequent sprains promote osteophyte formation and may cause pain and restriction of the range of motion [10–12]. Persistence of this condition may induce osteoarthrosis of the ankle and markedly reduce ADL.

It has also recently been reported that ankle joint sprain may be a risk factor for anterior cruciate ligament injury of the knee [13]. Therefore, prevention of this pathological condition is important because it may trigger a disorder-trauma chain in athletes. However, understanding of the actual state of ankle joint disorder and its prevention is insufficient in student players. Moreover, medical care for student players is limited compared to that for professional and national sports teams. Thorough medical checkups of the joint should be performed for student players who are immature physically, and this may promote the development of promising players with reduced disorders.

With this background, we used a team approach including an orthopedist expert in ultrasonography diagnosis for musculoskeletal sports injuries, athletic trainers and physical therapists for...
student basketball players as an educational activity for injury prevention. A questionnaire survey, ultrasonography screening, and physical condition checks were performed.

Ultrasonographic diagnostic equipment was set up in trainer booths in basketball competition venues in Kyoto Prefecture, and past sprains were surveyed by questionnaire. A simple flexibility evaluation (anteflexion, open-leg anteflexion, bending of the upper body backward, twisting the body at the waist (left and right), kicking the buttocks (left and right), lying down from sitting straight, open leg, and 5-grade evaluation of the ankle) was performed by physical therapists and trainers, and ankle joints were checked using ultrasound. Self-care guidance was provided to student players based on the results of the flexibility evaluation and ultrasonography. This simple flexibility evaluation method designed by Bright Body is used for regular student training.

We have previously found that frequent past sprains significantly increase osteochondral findings and that appropriate concomitant use of orthosis inhibits the increase in osteochondral findings in subjects with frequent sprains, based on ultrasonographic data in medical checkup of ankle joints in 71 senior high school student basketball players [14]. Ultrasonography is one of the convenient and helpful tools to screen for sports injuries. According to our results, wearing an ankle supporter might be useful for preventing the development of an osteophyte for young student basketball players [14].

In this current study, data collected from male senior high school and college student players were analyzed to investigate the influence of frequent sprains on the ankle joint.

Subjects and Methods

Subjects

The subjects were 17 senior high school students who participated in a senior high school student basketball competition in Kyoto prefecture (mean age: 16.4 years old) and 19 college students who played in the Kansai League Division 1 (mean age: 20.4 years old).

Methods

Ultrasonography of the ankle joint

Ultrasonographic diagnostic equipment (Noblus, Hitachi-Aloka Medical, Ltd., Tokyo) was set up in a trainer booth at a student basketball competition venue, and tests were performed by orthopedic surgeons with 8 or more years of experience in the ultrasonographic examination of motor organs. Senior high school and college student players who voluntarily participated in the checkup between games were examined. Subjects with no acute trauma were scanned using a 5–18 MHz radiofrequency linear probe (L64) while sitting on a chair with their legs straight and ankle flexed and resting on another chair with pressure on the heel to create a slight anterior stress. The presence of an old anterior talofibular ligament (ATFL) injury was evaluated based on the long-axis view visualized by scanning the lateral ankle joint. Subjects were evaluated as grades 0 or 1 (healthy ankle) and 2 or 3 (injured ankle), with reference to the ultrasonographic classification of old ATFL injury described by Cheng et al. [15]. We set up the healthy ankle group and the injured ankle group and both feet of every player were evaluated in 5 min (Fig. 1a, b). The injured ankle group was further classified based on the injured region: fibular side, the central region of the ligament, and talus side [16]. In the long-axis view of the dorsal ankle joint scan, the talocrural joint was observed based on the area of the lateral margin, central region, and medial margin. The evaluation included several items, with counts of individual irregular bone contours and osteophytes.

Questionnaire

Physical findings (age, gender, height, and body weight), past sprains, the current status of ankle joint pain, and use of aids were evaluated via a questionnaire survey. An additional questionnaire survey was used to evaluate each joint. Subjects selected the number of sprains that they were aware of: 0, 1–4, 5–9, or ≥ 10. Regarding current ankle joint pain, the presence of pain at rest and in motion was also surveyed. Finally, students were questioned about their use of orthosis during practice.

Statistical analysis

Data from the questionnaire were handled as qualitative variables, excluding physical findings, and used as ordinal and nominal scales. Between-group comparison of background factors was performed by a Mann-Whitney U-test. Subjects were divided into groups with <10 and ≥10 previous sprains, groups with and without ATFL injury, and groups with and without osteochondral findings, and all measurement items were compared between the bilateral sides in the high school and college students using a χ² test. All analyses were performed using SPSS ver. 21 for Windows (SPSS Inc., USA), with the significance level set at <5%.

Results

Questionnaire findings

17 senior high school students who were members of Kyoto prefectural final 16-level clubs (mean age: 16.4 years old) and 19 college students who played in Kansai League Division 1 (mean age: 20.4 years old) voluntarily participated in the checkup. The mean height and body weight were 180.9 ± 8.5 cm and 72.5 ± 9.3 kg in the senior high school students, and 180.1 ± 7.2 cm and 74.1 ± 8.3 kg in the college students, with no significant difference between the groups. The mean years of experience in the respective groups were 8.1 ± 1.7 and 11.9 ± 2.5 years, with significantly longer experience in the college students (P<0.01) (Table 1). 16 of the 19 college students had experience ≥10 years (Fig. 2).

Based on the questionnaire survey, 70.6% and 76.5% of the high school students and 73.7% and 79.0% of the college students had one or more past sprains on the right and left sides, respectively. More than 20% in both groups reported that they had ≥10 past sprains, suggesting the presence of frequent sprain-induced ankle joint instability (high school students: right, 29.4%; left, 23.5%; college students: right, 26.3%; left, 21.1%), with a higher frequency on the right side. Pain at rest on the right and left sides was present in 11.8% and 11.8% of the high school students, and in 15.8% and 10.5% of the college students; and pain in motion on the right and left sides was present in 29.4% and 35.3% of the senior high school students and 21.1% on both sides in the college students.
There was no significant laterality or difference between the high school and college students (▶ Table 2).

**Ultrasonographic checkup of the lateral side (old ATFL injury)**

Old ATFL injury was observed at high frequencies in senior high school and college students, with rates on the right and left sides of 64.8% and 82.4%, respectively, in the high school students, and 84.2% and 100%, respectively, in the college students. The frequency was higher on the left side in both groups (▶ Table 3). By region, the highest frequency (35.2%) was found in the central region of the ligament on the right side in the high school students.

The frequency on the left side was 17.6%, whereas it was 36.8% on both sides in the college students. Rupture on the fibular side was found on the right and left sides in 17.6% and 35.3% of the high school students, and at higher rates of 26.3% and 42.1% in the college students. The rates of rupture of the talar side on the right and left sides were 0.0% and 17.6% in the high school students, and 5.3% and 0% in the college students. The rates of old fibular sprain fracture on the right and left sides were 11.8% and 5.9% in the high school students, and 15.8% on both sides in the college students.
The frequency of old talar sprain fracture was 0% on the right side in both groups, but 5.9% and 5.3% on the left side in the high school and college students, respectively (Table 3).

### Ultrasonographic checkup of the dorsal side (talocrural joint region)

The results of the ultrasonographic checkup of the talocrural joint region are shown in Table 4. Positive findings were detected at rates of 20.6% and 23.5% on the right and left sides in the senior high school students and at higher rates of 55.6% and 50.0% in the college students. By region, there were many findings in the lateral region on the bilateral sides in the high school students (right: medial side, 5.9%; central region, 2.9%; lateral side, 11.8%; left: medial side, 5.9%; central region, 8.9%; lateral side, 8.9%). In the college students, there were many findings in the central region on the right side and lateral region on the left side (right: medial side, 11.1%; central region, 27.8%; lateral side 16.7%; left: medial side, 8.3%; central region, 19.4%; lateral side, 22.2%). There were no serious findings, such as intra-articular hematoma, synovial hyperplasia, apparent fracture, and lesions extending to subchondral bone. No osteochondral findings such as osteochondritis dissecans characteristic of the anterior talocrural joint region within the area could be shown by ultrasonography, but the college students had significantly more findings of osteophyte on the right side (P < 0.05) and also on the left side, although without a significant difference (P = 0.068) (Table 4).

### Comparison by years of experience of basketball (≥ 10 years vs. < 10 years)

The subjects were divided into groups with ≥ 10 (n = 22) and < 10 (n = 14) years of experience. The frequency of osteochondral findings in the talocrural joint region was significantly higher in the group with ≥ 10 years of experience on the bilateral sides (right: P < 0.05, left: P < 0.01) (Fig. 3). The number of findings was also significantly higher in the group with ≥ 10 years of experience (right: P < 0.05, left: P < 0.05) (Fig. 4).

### Discussion

On ultrasonography, there was no significant difference in the presence of ligament injury or the injured site between senior high school and college students, but the number of osteochondral findings in the talocrural joint region was significantly higher in college students, and the frequency of disorder and number of impaired sites were significantly higher in the group with ≥ 10 years of experience. These findings show that disorder of the talocrural joint region on ultrasonography progresses with more years of experience in student players who do not take specific preventive measures. Medical care for student players is not as good as that for corporate and national sports teams. Active medical checkups of motor organs and educational activities for prevention in student

<table>
<thead>
<tr>
<th>Table 2</th>
<th>Comparison of history of sprain and current pain in the 2 groups.</th>
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<tbody>
<tr>
<td></td>
<td>Senior high school students (n = 17) (%)</td>
</tr>
<tr>
<td></td>
<td>Right foot (%)</td>
</tr>
<tr>
<td>Sprain in the past (one or more) (%)</td>
<td>70.6</td>
</tr>
<tr>
<td>Frequent sprain in the past (10 or more) (%)</td>
<td>29.4</td>
</tr>
<tr>
<td>Pain at rest (%)</td>
<td>11.8</td>
</tr>
<tr>
<td>Pain during motion (%)</td>
<td>29.4</td>
</tr>
</tbody>
</table>

χ² test was performed. There was no significant laterality or difference between the senior high school and college students.

<table>
<thead>
<tr>
<th>Table 3</th>
<th>Results for old ATFL injury on ultrasonography in the 2 groups.</th>
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</table>

<table>
<thead>
<tr>
<th>Items</th>
<th>Right foot (n) (%)</th>
<th>Left foot (n) (%)</th>
<th>P</th>
<th>Senior high school students</th>
<th>College students</th>
<th>P</th>
</tr>
</thead>
<tbody>
<tr>
<td>Old ATFL injury</td>
<td>64.8</td>
<td>84.2</td>
<td>0.168</td>
<td>82.4</td>
<td>100</td>
<td>0.095</td>
</tr>
<tr>
<td>Injured site</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>n.p</td>
<td>35.2</td>
<td>15.8</td>
<td></td>
<td>17.6</td>
<td>0</td>
<td></td>
</tr>
<tr>
<td>Center of the ligament</td>
<td>35.2</td>
<td>36.8</td>
<td>0.673</td>
<td>17.6</td>
<td>36.8</td>
<td></td>
</tr>
<tr>
<td>Fibular side</td>
<td>17.6</td>
<td>26.3</td>
<td></td>
<td>35.3</td>
<td>42.1</td>
<td>0.185</td>
</tr>
<tr>
<td>Talar side</td>
<td>0</td>
<td>5.3</td>
<td></td>
<td>17.6</td>
<td>0</td>
<td></td>
</tr>
<tr>
<td>Sprain fracture: fibular side</td>
<td>11.8</td>
<td>15.8</td>
<td></td>
<td>5.9</td>
<td>15.8</td>
<td></td>
</tr>
<tr>
<td>Sprain fracture: talar side</td>
<td>0</td>
<td>0</td>
<td></td>
<td>5.9</td>
<td>5.3</td>
<td></td>
</tr>
</tbody>
</table>

χ² test was performed. There were no significant differences for old ATFL injury between the senior high school group and the college students.
The mechanism of osteophyte formation is thought to involve a hyperplastic change to repair osteochondral injury caused by collateral ligament rupture or osteochondral fracture [23]. The talocrural joint is likely to cause sprain fracture at the distal end of the fibula, with incomplete bone maturation, inversion sprain of the ankle joint, cartilage and osteochondral findings of chronic ankle injury, CT scan (computed arthrotomography) is also a very helpful, accurate and noninvasive means of determining the severity of ligament injuries including bone and cartilage injuries [24–28].

In general, to evaluate acute or chronic lateral ligament injury and osteochondral findings of chronic ankle injury, CT scan (computed arthrotomography) is very useful. MRI (magnetic resonance imaging) is also a very helpful, accurate and noninvasive means of determining the severity of ligament injuries including bone and cartilage injuries [24–28].
Previous studies indicate that soft tissues injury [30–33]. CT scan and MRI are usually performed at a hospital. However, ultrasonography is not limited with respect to the place of use and is a noninvasive and low-cost examination method. Recent ultrasonography machines are more easily carried around, so we can bring one to the sports field. Ultrasonography is a convenient and useful tool in the world of sports. It can be used for real-time examination of players in any kind of environment. With the scanning result, we can efficiently and quickly assess players for injury. However, the technique requires significant training.

In particular, ankle sprain is a very common injury that ultrasonography can examine to detect lateral injury with low cost and noninvasively. Ultrasonography performed by a highly skilled sonographer is the best method for ankle injury evaluation [34–38].

There are several limitations to this study. First, the number of subjects was small despite the study being a cross-sectional survey. However, the novelty of the use of noninvasive ultrasound by skilled operators at actual playing sites is of clinical significance. Players without a marked difference in competition level were selected as subjects. It is desirable to perform a longitudinal study in the same subjects, in addition to a large-scale nationwide survey. In this study, there were no other anatomical variants and pathological findings. However, it might be easy to encounter anatomical variants and injuries of the peroneal tendon complex on the lateral side of the ankle [39]. Finally, ultrasound elastography might be helpful and have great potential for clarifying the risk factors for injuries regarding ankle problems.

**Conclusion**

Student basketball players with a history of highly frequent ankle sprains and with 10 or more than 10 years of basketball experience should be prevented from getting worse.

An active motor organ checkup combined with an ultrasonographic examination may be important in future clinical developments with respect to injuries in basketball players.

**Acknowledgements**

We are grateful to Bright Body Ltd. and the Medical Committees of the Osaka Basketball Associations for their assistance with this study.

**Conflict of interest**

There is no conflict of interest to disclose with regard to this study.

**References**


