Asia-Pacific Journal of Sports Medicine, Arthroscopy, Rehabilitation and Technology 25 (2021) 30–34

Contents lists available at ScienceDirect

Asia-Pacific Journal of Sports Medicine, Arthroscopy, Rehabilitation and Technology

journal homepage: www.ap-smart.com

Original Article

Quick and simple test to evaluate severity of acute lateral ankle sprain

Yuki Noda [a, *], Shuji Horibe [b], Kunihiko Hiramatsu [c], Rikio Takao [d], Kenji Fujita [e]

[a] Department of Rehabilitation, Naragakuen University, Japan
[b] Graduate School of Comprehensive Rehabilitation, Osaka Prefecture University, Japan
[c] Department of Orthopedic Surgery, Tamai Hospital, Japan
[d] Graduate School of Life and Environmental Sciences, Osaka Prefecture Univercity, Japan
[e] Fujita Orthopedic & Sports Clinic, Japan

ARTICLE INFO

Article history:
Received 20 December 2020
Received in revised form
25 April 2021
Accepted 10 May 2021

Keywords:
Acute lateral ankle sprain
Severity evaluation
Single-leg loading test

ABSTRACT

Background/objective: For early return to sports after a lateral ankle sprain (LAS) and recurrence prevention, effective rehabilitation and gradual return to sports should be initiated while predicting the return time based on the appropriate severity evaluation immediately after injury. However, since severity evaluations performed in previous studies required large space and stairs and involved high-revel activity, their use as a test and index to evaluate severity after LAS was not appropriate considering convenience and risk of re-injury. Therefore, a quick and simple test was developed to evaluate the severity of acute LAS. This study aimed to verify the association between ankle function for severity evaluation and anterior talofibular ligament (ATFL) injury type by ultrasonography and to clarify the usefulness for acute LAS severity evaluation of the single-leg loading (SLL) test.

Methods: In total, 50 patients (34 men, 16 women) out of 58 patients who visited our sports clinic within 3 days after acute LAS and who conformed to the study criteria were included in this study. During the first visit, SLL test and objective/subjective ankle joint evaluation were performed. The SLL test consists of single-leg standing, single-leg heel raising and single-leg hopping, and patients were classified into four levels from 1 to 4 according to results. In addition, ultrasonographic evaluation was performed within 1 week after the first visit to evaluate the type of ATFL injury. Type I was defined as intact ATFL, Type II as swollen ATFL with an almost intact fibrillar pattern and Type III as ATFL appearing swollen with a disrupted fibrillar pattern. The relationship between the SLL test and each evaluation item was investigated using Spearman's correlation coefficient.

Results: As a result of the SLL test, 15 patients had Level 1 (30%), 19 Level 2 (38%), 5 Level 3 (10%) and 11 Level 4 (22%). With regard to correlation coefficients of the SLL test, Japanese Society for Surgery of the Foot ankle/hindfoot scale and sports activity were $r_s = 0.71$ ($p < 0.001$) and $r_s = 0.66$ ($p < 0.001$), respectively, showing a significant positive correlation. SLL test and the type of ATFL injury also showed a significant negative correlation ($r_s = -0.58$, $p < 0.001$).

Conclusions: The SLL test was a simple and useful test that can be used as an index to evaluate the severity of acute LAS.

Introduction

According to a survey conducted in the United States,[1] approximately half of ankle sprains occur during sports activities and can be said as one of the most frequent musculoskeletal disorders in sports.[2] However, more than half of patients who injured their ankle joint do not take a medical treatment,[3] accurate diagnosis and appropriate severity evaluation have not been made, and a previous study reported that approximately 90% of patients with lateral ankle sprain (LAS) have returned within 1 week.[4] Another report also showed that many athletes still had symptoms such as pain and joint instability 1 year after the injury,[5] and >70% of athletes were re-injured in basketball as a result of inadequate treatment and premature return to sports.[6]

* Corresponding author. Department of Rehabilitation, Naragakuen University, 3-15-1Nakatomigaoka, Nara, Japan.
E-mail addresses: noda@naragakuen-u.jp (Y. Noda), s-horibe@rehab.osakafu-u.ac.jp (S. Horibe), k-hiramatsu@umin.ac.jp (K. Hiramatsu), takao@rehab.osakafu-u.ac.jp (R. Takao), fujita@fujita-seikei-sports.jp (K. Fujita).

https://doi.org/10.1016/j.asmart.2021.05.003

To prevent re-injury and achieve the earliest possible return to sports, effective rehabilitation and gradual return to sports should be initiated, while predicting the return time based on an appropriate severity evaluation immediately after the injury. Some studies have investigated the relationship between the prognosis after LAS and physical status, such as load capacity, self-reported motor function and injured ligament evaluation, using ultrasonography at the first visit.[7,8,10] Wilson et al.[8] reported a significant correlation between the scores of six functional evaluations performed on patients after LAS and residual dysfunction duration. Docherty et al.[9] performed four hopping tests and reported a significant correlation between the score of ankle function and some hopping test. Cross et al.[10] demonstrated a significant correlation between the time to return to sports and subjective functional evaluation in collegiate athletes with LAS. However, many issues have been encountered when using the functional evaluation of previous studies as a test and index to evaluate severity after LAS. In fact, these functional evaluations needed a large space or stairs and involved high-level activity if performed immediately after injury, without considering the severity of the injured ligament. Therefore, a test for evaluating the severity of acute LAS that can be performed easily and anywhere, such as in clinical or sports settings, is required.

A single-leg loading (SLL) test was developed as a screening test and used as an index of severity for acute LAS. This study aimed to examine the relationship between SLL test and ankle functional evaluation and anterior talofibular ligament (ATFL) injury type using an ultrasonography examination.

Materials and methods

Participants

A total of 58 patients who visited our sports clinic within 3 days after acute LAS from October 2018 to March 2019 and were diagnosed with lateral ligament injury. Radiographic assessment was performed at the first visit to determine the presence of fractures.

We defined our criteria as the following: (1) cases wherein ATFL damage was the main injury and (2) cases with grade I or II lateral ligament injury were included; (3) cases with a history of LAS within 3 months of injury and (4) cases with fractures (including avulsion fractures) were excluded. Of the 58 patients, 8 patients were not analysed because they did not meet the inclusion criteria: 1 patient had grade III lateral ligament injury, 1 had avulsion fracture, 2 had other complex ligament injuries, 2 had a history of LAS within 3 months of injury and 2 were excluded due to a mistake in filling out the questionnaire. Finally, 50 patients (34 men, 16 women) were included in this study. The average age of the 50 patients was 15.6 ± 3.0 years, ranging from 9 to 28 years, and the average number of days from injury to the first visit was 1.5 ± 1.0 days. The injury was right-sided in 30 ankles and left-sided in 20 ankles.

For these cases, SLL test was performed and an objective and subjective evaluation questionnaire was administered at the first visit; ATFL ultrasonography was performed within 1 week after the first visit. All ultrasound examinations were performed by one physical therapist using SONIMAGE HS1 (KONICA MINORUTA, Japan) with linear-array probes at 18–4 MHz in B-mode. Physiotherapy was started at the first visit, and most patients were given taping or ankle brace.

This study was a case-series study approved by the institutional ethics review board of Graduate School of Comprehensive Rehabilitation, Osaka Prefecture University (approval number: 2019-110). All patients provided written informed consent after receiving an explanation of the study protocol, and the study was conducted according to the principles of the Declaration of Helsinki.

SLL test

SLL test was conducted in four steps with two fingers on the evaluator's hand to control posture (Fig. 1). First, patients were instructed to stand on a single leg. If they could not stand for 3 s, the test was terminated. Otherwise, i.e. if they could stand for 3 s, they proceeded to the next step. Then the patients were instructed to raise their heel while standing on a single leg while keeping a distance of >3 cm between the floor and heel. If they could perform this three times, they proceeded to the next step. Finally, patients were instructed to hop on a single leg such that their toes were off the floor. If they could perform this activity three times, the test was complete. The test was considered successful when the patient could complete the task with or without pain. The test was terminated if the patients were not able to continue the test owing to pain or fear. Based on the results of this test, patients were classified into four levels as follows: Level 1, difficulty in single-leg standing; Level 2, single-leg standing; Level 3, single-leg heel raising and Level 4, single-leg hopping.

Objective/subjective ankle joint evaluation

As an objective functional evaluation, Japanese Society for Surgery of the Foot (JSSF) ankle/hindfoot scale[11,12] was used, which consists of three items: '*pain*', '*function*' and '*alignment*', and has a maximum score of 100 points. As a subjective evaluation, a self-administered foot evaluation questionnaire (SAFE-Q) created by the Japanese Orthopaedic Association and Japanese Society for Surgery of the Foot[13] was used. SAFE-Q includes six subscales: pain and pain related, physical functioning and daily living, social functioning, shoe related, general health and well-being and sports activity subscales. Each subscale has a maximum score of 100 points.

Ultrasonographic evaluation of ATFL injury

Ultrasonographic evaluation of the ATFL injury was performed within 1 week after the first visit. The severity of the ATFL injury was classified using the method reported by Kemmochi et al.[14] Type I is defined as intact ATFL, Type II as swollen ATFL but almost intact fibrillar pattern and Type III as ATFL that appears to be swollen and disrupted fibrillar pattern. Type IV is defined as a completely torn ATFL, and Type V is defined as an avulsion fracture of the talar end or with distal lateral malleolus of the ankle. In this study, Types I to III injuries were included. During the examination, the patient was seated on the treatment bed with the heel of the affected ankle on the edge of the chair. The ankle joint was held in the neutral position and instructed to relax. The probe was placed at the lower end of the lateral malleolus in order to be parallel to the sole of the foot, and from that state, the ATFL was visualised by slowly rotating the probe toward the sole of the foot by 45°. ATFL was evaluated with or without anterior drawer force to the ankle joint. The anterior drawer test was performed by placing the heel to a chair as it took anterior drawer force by the weight of the lower leg (Fig. 2-a). The evaluation without anterior drawer force was performed by grasping the distal lower leg with the hand opposite to the one holding the probe and lifting the heel from the chair (Fig. 2-b).

Statistical analysis

The normality of each SLL test subscale, JSSF ankle/hindfoot scale, SAFE-Q and ATFL injury type was confirmed using the Shapiro–Wilk test. The association between SLL test and JSSF ankle/hindfoot scale, SAFE-Q subscales and ATFL injury type was examined using Spearman's correlation coefficient. All statistical

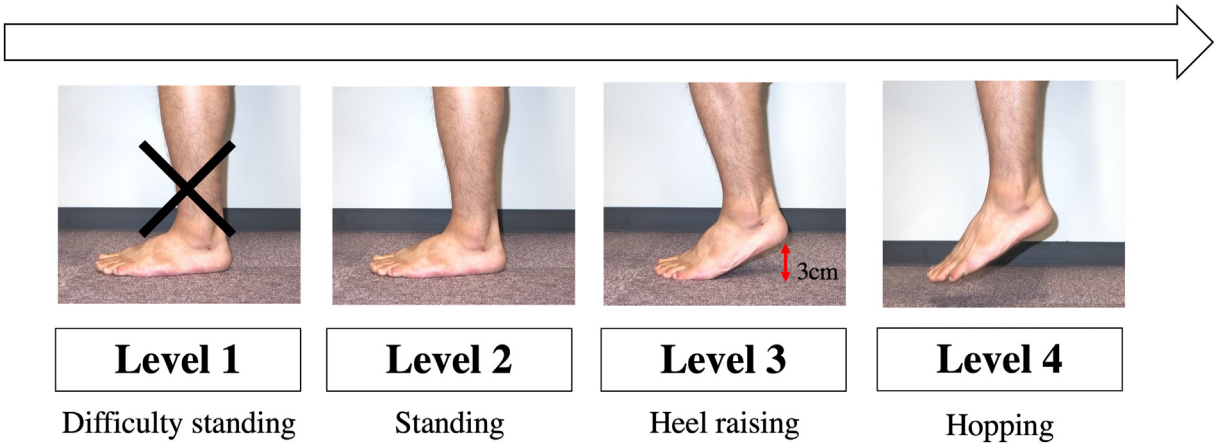

Fig. 1. Flow chart indicating the method of classification using the SLL test.

analyses were performed with EZR (Saitama Medical Center, Jichi Medical University, Saitama, Japan),[15] a graphical user interface for R (the R Foundation for Statistical Computing, Vienna, Austria). More precisely, a modified version of R commander was designed to add statistical functions frequently used in biostatistics. p-values of $\leq$0.05 were considered statistically significant. For the inter-examiner reliability of SLL test, the κ coefficient of Cohen was calculated in 31 patients who can successfully perform SLL test with two examiners. The κ coefficient of the SLL test was 0.78, and the inter-examiner reliability was substantial according to the Landis et al.'s criteria.[16]

Results

Based on the SLL test, 15 patients were classified as Level 1 (30%), 19 as Level 2 (38%), 5 as Level 3 (10%) and 11 as Level 4 (22%). In addition, based on the ultrasonographic classification of the ATFL injury, 1 patient was classified as Type I (2%), 16 as Type II (32%) and 33 as Type III (66%). The JSSF ankle/hind foot scale and SAFE-Q subscale scores are shown in Table 1. A highly significant positive correlation was observed between the SLL test and the JSSF ankle/hindfoot scale ($r_s = 0.71$, $p < 0.001$). In addition, a significant positive correlation was found between the SLL test and all SAFE-Q subscales, especially the correlation of sports activity was high ($r_s = 0.66$, $p < 0.001$) (Table 2). A statistically significant negative correlation was also observed between the SLL test and ultrasonographic classification of ATFL injury ($r_s = -0.58$, $p < 0.001$).

Discussion

This study aimed to clarify the relationship between the SLL test and objective/subjective ankle evaluation and the severity of the injured ligament and to show the usefulness of SLL test as an evaluation index for acute LAS. In this study, SLL test showed a significantly high positive correlation with the JSSF ankle/hindfoot scale. In addition, SLL test showed a significant positive correlation with all SAFE-Q subscales, especially the correlation coefficient of sports activity was higher than that of other subscales. Furthermore, a significant negative correlation was observed between the SLL test and the severity of the ATFL injury using ultrasonography.

Table 1
Scores of the JSSF ankle/hindfoot scale and SAFE-Q subscales.

Evaluation items	Median	Quartile
JSSF ankle/hindfoot scale	36.5	27.5–54.8
SAFE-Q		
Pain and Pain Related	45.8	32.3–60.0
Physical Functioning and Daily Living	52.3	39.2–67.6
Social Functioning	50.0	20.8–75.0
Shoe Related	75.0	52.1–91.7
General Health and Well Being	65.0	46.3–85.0
Sports Activity	14.3	3.0–33.8

All values are presented as the median and range. JSSF ankle/hindfoot scale, Japanese Society for Surgery of the foot ankle/hindfoot scale; SAFE-Q, self-administered foot evaluation questionnaire.

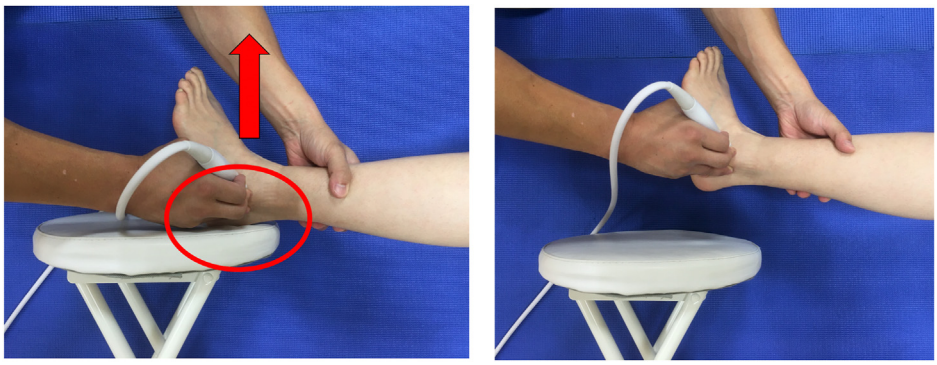

Fig. 2. Patient's ankle position during ultrasonography.

Table 2
Correlations between the SLL test and evaluation items.

Evaluation items	r	95%CI		p value
		lower	upper	
JSSF ankle/hindfoot scale	0.71	0.54	0.83	<0.001
SAFE-Q				
Pain and Pain Related	0.51	0.27	0.69	<0.001
Physical Functioning and Daily Living	0.67	0.48	0.80	<0.001
Social Functioning	0.44	0.19	0.64	0.001
Shoe Related	0.56	0.34	0.73	<0.001
General Health and Well Being	0.41	0.15	0.62	0.003
Sports Activity	0.66	0.47	0.79	<0.001
Ultrasonographic classification of ATFL injury	−0.58	−0.74	−0.36	<0.001

SLL test, single-leg loading test; 95%CI, 95% confidence interval; JSSF ankle/hindfoot scale, Japanese Society for Surgery of the foot ankle/hindfoot scale; SAFE-Q, self-administered foot evaluation questionnaire, ATFL, anterior talofibular ligament. *P*-values were determined using the Spearman's correlation coefficient.

Therefore, the SLL test was confirmed to be associated with the objective/subjective evaluation of acute LAS and also with the severity of ligament injury.

Wilson et al.[8] conducted a functional test consisting of various items, such as figure- 8 hop and cross-over hop in the acute lateral ankle ligament I and II injuries. A significant correlation between the test and the subjective motor ability assessment was reported. Functional evaluation for chronic ankle instability requires physical examinations, including varus/valgus and internal/external rotational motion examinations.[9] However, these examinations may be difficult to perform because of the risk of re-injury or aggravation in cases with acute LAS. Conversely, SLL test comprises four levels, difficulty in standing, standing, heel raising and hopping, and can be evaluated in a step-by-step manner depending on the severity of the ATFL injury. Therefore, SLL test can be safely used as a test for examining acute LAS. In addition, as SLL test takes only approximately 1 min to be performed, it can be performed easily, with minimal discomfort to the patient. Furthermore, this study demonstrated that SLL test was significantly correlated with the JSSF ankle/hindfoot scale and sports activity. Hence, SLL test was considered useful in terms of safety and convenience for evaluating the severity of acute LAS.

Several studies have reported the usefulness of ultrasonography for lateral ankle ligament injuries.[17–19] Ultrasonography for ATFL injury has been found to be equally sensitive and specific as MRI[20] and had a good correlation with intraoperative findings.[21] In addition, Kemmoch et al.[14] reported a positive outcome of ATFL injury using only ultrasonography and by deciding the treatment method based on these results. These results indicate that ultrasonographic evaluation of ATFL injury may be useful as an index of severity. In this study, a significant negative correlation was found between the SLL test and the severity classification of the ATFL injury, using ultrasonography. So, SLL test is useful for severity assessment of acute LAS because the severity level of the SLL test reflected the severity of the ATFL injury. Therefore, the SLL test can be an alternative in clinical and sports settings, where expensive procedures such as ultrasonography cannot be performed. However, since the correlation coefficient between the SLL test and ligament evaluation by ultrasonography was moderate ($r = -058$), using the SLL test in combination with ultrasonography, rather than using the SLL test alone, may provide a more accurate evaluation.

To predict the prognosis of ankle sprains, it is important to determine the exact time of return to sports. Previous studies have suggested that prognosis can be predicted more accurately by assessing not only objective evaluation but also subjective evaluation, such as walking and athletic abilities.[8,10,22,23] Choi et al. evaluated the severity of lateral ankle ligament injury using ultrasonography after LAS and then examined the relationship between the severity and foot and ankle outcome score at 12 months after the injury. They concluded that the severity immediately after injury might predict the long-term results.[24] In this study, we used the JSSF ankle/hindfoot scale for objective evaluation, SAFE-Q for subjective evaluation and ultrasonography for ligament injury classification. Questionnaires, such as the JSSF ankle/hindfoot scale and SAFE-Q are cost-effective, but are time-consuming and require approximately ≥20 min to complete (for each). Ultrasonography accurately evaluates injured ligaments, but this procedure is expensive and can be used in only few clinical or sports settings. On the contrary, the SLL test can be used easily, requires ≤1 min for completion and does not require any special techniques or equipments. Furthermore, a significant positive correlation was found between the SLL test and the JSSF ankle/hindfoot scale and SAFE-Q. Also, a significant negative correlation was found between the SLL test and the severity of ATFL injury evaluated using ultrasonography. Therefore, performing the SLL test in cases of acute LAS and observing the subsequent course might clarify the most adequate time of return to sports.

Limitations

This study has some limitations. First, this study only targeted ATFL grade I and grade II injuries and did not included grade III injuries. In fact, SLL test results may differ depending on the severity of ligament injury. However, SLL test for patients with grade III injury may pose a high risk of re-injury. Therefore, a screening method should be used to determine whether the test can be safely performed in such cases. Second, in this study only ATFL, not calcaneofibular ligament (CFL), was evaluated. As lateral ankle instability and subtalar joint instability involve CFL injury,[25] the presence or absence of CFL injury may affect load capacity and long-term performance after an injury. However, as researchers have varied opinions regarding the measurement position of the ankle during an ultrasonographic examination for CFL,[26,27] the examination method has not been established yet. Therefore, this study only focused on ATFL, which has an established test method and can be easily visualised and examined using the SLL test.

Conclusion

In this study, we devised a simple SLL test as a screening test for acute LAS. The SLL test was thought to be a useful test of the severity evaluation of acute LAS because a significant correlation was found between the objective and subjective ankle joint evaluation and the severity classification of the ATFL injury using ultrasonography.

Funding

This research did not receive any specific grant from funding agencies in the public, commercial, or not-for-profit sectors, and no material support of any kind was received.

Declaration of competing interest

None.

References

1. Waterman BR, Owens BD, Davey S, Zacchilli MA, Belmont PJ. The epidemiology of ankle sprains in the United States. *Bone Joint Surg Ser A*. 2010;92:2279–2284.
2. Doherty C, Delahunt E, Caulfield B, Hertel J, Ryan J, Bleakley C. The incidence and prevalence of ankle sprain injury: a systematic review and meta-analysis of prospective epidemiological studies. *Sports Med*. 2014;44:123–140.
3. McKay GD, Goldie PA, Payne WR, Oakes BW. Ankle injuries in basketball: injury rate and risk factors. *Br J Sports Med*. 2001;35:103–108.
4. Medina McKeon JM, Bush HM, Reed A, Whittington A, Uhl TL, McKeon PO. Return-to-play probabilities following new versus recurrent ankle sprains in high school athletes. *J Sci Med Sport*. 2014;17:23–28.
5. van Rijn RM, van Os AG, Bernsen RM, Luijsterburg PA, Koes BW, Bierma-Zeinstra SM. What is the clinical course of acute ankle sprains? A systematic literature review. *Am J Med*. 2008;121:324–331. e6.
6. Yeung MS, Chan KM, So CH, Yuan WY. An epidemiological survey on ankle sprain. *Br J Sports Med*. 1994;28:112–116.
7. Thompson JY, Byrne C, Williams MA, Keene DJ, Schlussel MM, Lamb SE. Prognostic factors for recovery following acute lateral ankle ligament sprain: a systematic review. *BMC Muscoskel Disord*. 2017;18:421.
8. Wilson RW, Gansneder BM. Measures of functional limitation as predictors of disablement in athletes with acute ankle sprains. *J Orthop Sports Phys Ther*. 2000;30:528–535.
9. Docherty CL, Arnold BL, Gansneder BM, Hurwitz S, Gieck J. Functional-performance deficits in volunteers with functional ankle instability. *J Athl Train*. 2005;40:30–34.
10. Cross KM, Worrell TW, Leslie JE, Van Veld KR. The relationship between self-reported and clinical measures and the number of days to return to sport following acute lateral ankle sprains. *J Orthop Sports Phys Ther*. 2002;32:16–23.
11. Niki H, Aoki H, Inokuchi S, et al. Development and reliability of a standard rating system for outcome measurement of foot and ankle disorders I: development of standard rating system. *J Orthop Sci*. 2005;10:457–465.
12. Niki H, Aoki H, Inokuchi S, et al. Development and reliability of a standard rating system for outcome measurement of foot and ankle disorders II: interclinician and intraclinician reliability and validity of the newly established standard rating scales and Japanese Orthopaedic Association rating scale. *J Orthop Sci*. 2005;10:466–474.
13. Niki H, Tatsunami S, Haraguchi N, et al. Validity and reliability of a self-administered foot evaluation questionnaire (SAFE-Q). *J Orthop Sci*. 2013;18:298–320.
14. Kemmochi M, Sasaki S, Fujisaki K, Oguri Y, Kotani A, Ichimura S. A new classification of anterior talofibular ligament injuries based on ultrasonography findings. *J Orthop Sci*. 2016;21:770–778.
15. Kanda Y. Investigation of the freely available easy-to-use software "EZR" for medical statistics. *Bone Marrow Transplant*. 2013;48:452–458.
16. Landis JR, Koch GG. The measurement of observer agreement for categorical data. *Biometrics*. 1977;33:159–174.
17. Park JW, Lee SJ, Choo HJ, Kim SK, Gwak HC, Lee SM. Ultrasonography of the ankle joint. *Ultrasonography*. 2017;36:321–335.
18. Lee SH, Yun SJ. The feasibility of point-of-care ankle ultrasound examination in patients with recurrent ankle sprain and chronic ankle instability: comparison with magnetic resonance imaging. *Injury*. 2017;48:2323–2328.
19. Alves T, Dong Q, Jacobson J, Yablon C, Gandikota G. Normal and injured ankle ligaments on ultrasonography with magnetic resonance imaging correlation. *J Ultrasound Med*. 2019;38:513–528.
20. Gün C, Unlüer EE, Vandenberk N, Karagöz A, Sentürk GO, Oyar O. Bedside ultrasonography by emergency physicians for anterior talofibular ligament injury. *J Emergencies, Trauma, Shock*. 2013;6:195–198.
21. Lee SH, Yun SJ. Ankle ultrasound for detecting anterior talofibular ligament tear using operative finding as reference standard: a systematic review and meta-analysis. *Eur J Trauma Emerg Surg*. 2020;46:73–81.
22. O'Connor SR, Bleakley CM, Tully MA, McDonough SM. Predicting functional recovery after acute ankle sprain. *PLoS One*. 2013;8, e72124.
23. De Bie RA, De Vet HCW, Van Den Wildenberg FAJM, Lenssen T, Knipschild PG. The prognosis of ankle sprains. *Int J Sports Med*. 1997;18:285–289.
24. Choi WS, Cho JH, Lee DH, Chung JY, Lim SM, Park YU. Prognostic factors of acute ankle sprain: need for ultrasonography to predict prognosis. *J Orthop Sci*. 2020;25:303–309.
25. Yoon DY, Moon SG, Jung HG, Kim NR. Differences between subtalar instability and lateral ankle instability focusing on subtalar ligaments based on three dimensional isotropic magnetic resonance imaging. *J Comput Assist Tomogr*. 2018;42:566–573.
26. Precerutti M, Bonardi M, Ferrozzi G, Draghi F. Sonographic anatomy of the ankle. *J Ultrasound*. 2014;17:79–87.
27. Cheng Y, Cai Y, Wang Y. Value of ultrasonography for detecting chronic injury of the lateral ligaments of the ankle joint compared with ultrasonography findings. *Br J Radiol*. 2014;87, 20130406.