Prevalence and characteristics of chronic ankle instability and copers identified by the criteria for research and clinical practice in collegiate athletes

Yuta Koshino, PT, Ph.D.[1,2], Mina Samukawa, PT, Ph.D.[1], Hiromu Murata, PT, M.S.[1], Satoshi Osuka, PT, M.S.[1], Satoshi Kasahara, PT, Ph.D.[1], Masanori Yamanaka, PT, Ph.D.[3], Harukazu Tohyama, M.D., Ph.D.[1]

1. Faculty of Health Sciences, Hokkaido University, Sapporo, Japan
2. Rehabilitation Center, NTT Medical Center Sapporo, Sapporo, Japan
3. Faculty of Health Science, Hokkaido Chitose College of Rehabilitation, Chitose, Japan

Address for correspondence:

Mina Samukawa, PhD, PT

Faculty of Health Sciences, Hokkaido University, West 5, North 12, Kita-ku, Sapporo 060-0812, Japan.

Phone & Fax: +81-11-706-3329

E-mail: mina@hs.hokudai.ac.jp

Acknowledgement: There was no financial assistance with this study.

Conflicts of interest: none.

Funding statement: No funding.

Highlights

1. The prevalence of CAI research (10%) was approximately half of that of clinical CAI (19.8%).
2. The prevalence of copers was about 5%.
3. The prevalence of CAI and copers was dependent on the type of sport.
4. The age at the initial ankle sprain may be associated with developing CAI.
5. The standard criteria for research may not capture the entire clinical population of CAI.

Abstract

Objectives: To investigate the prevalence and characteristics of chronic ankle instability (CAI) and copers among collegiate athletes as identified by criteria for research (CAI-R and copers-R) and for clinical practice (CAI-C and copers-C).

Design: Cross-sectional study.

Setting: University.

Participants: Collegiate athletes (n=507).

Main outcome measures: Participants were assessed by questionnaires based on the International Ankle Consortium guidelines. The percentages of participants with CAI-R, CAI-C, copers-R and copers-C were calculated, respectively. Demographic and injury data were statistically compared between CAI-R and copers-R groups.

Results: The data of 470 participants was retained after exclusions. Of these, the prevalence of CAI-R (10.0%) was only half of that of CAI-C (19.8%), and that of copers-R and copers-C was about 5%. Seventy percent of unclassifiable participants had recurrent ankle sprains. CAI was most common in basketball, while copers were less prevalent in basketball, judo, rugby and gymnastics. The age at the initial injury was significantly younger in the CAI-R participants than in the copers-R.

Conclusions: The type of sport and the age at the initial injury may be associated with developing CAI. The standard criteria may not capture the entire clinical CAI population, therefore, care should be taken when applying the research to clinical practice.

Keywords: ankle ligament injury; ankle sprain; recurrent sprain; sports injury

Introduction

Lateral ankle sprains (LASs), which cause lateral ankle ligament injuries, are one of the most common sports injuries [1]. Recurrence rates for LAS are high and more than half of athletes with previous ankle sprains suffer reinjury [2]. A history of at least an index LAS also leads to ankle "giving way", perceived ankle instability, persistent pain and swelling, as well as self-reported dysfunction. Such sequela is called chronic ankle instability (CAI) [3]. CAI is associated with functional deficits (i.e. postural control, muscle function, proprioception and joint kinematics) [4-6] and results in impaired health-related quality of life [7]. Therefore, CAI is seen as an important health problem in sports and clinical practice.

Although the incidence of LAS in sport activities has been investigated on many occasions, the prevalence of CAI is not well known. A systematic review published in 2014 investigated the presence of athletes with recurrent sprains, perceived ankle instability, and mechanical ankle instability, which are all aspects of CAI [2]. The review showed that while many papers have investigated the prevalence of recurrent sprains, few have investigated perceived ankle instability and mechanical ankle instability. Soccer, basketball and netball had the highest percentage of athletes with recurrent sprains (approximately 60%). The percentages of athletes with perceived ankle instability were 15-46% in basketball [2], 41% in track and field [2], and 39-64% in netball [2,8]. These studies separately investigated the prevalence of each aspect of CAI in athletes rather than investigate those athletes with CAI. Several previous studies have reported on the prevalence of CAI in athletes, but the presence or absence of CAI was identified only by self-reported questionnaires for assessing ankle instability, not by using any past medical history of an index LAS, recurrent LASs or ankle joint "giving way" [9-11]. For example, an individual with CAI must have a history of at least an index LAS and the first-time LAS must have occurred more than one year previously [3,12]. Although the findings of these studies were very helpful for understanding to what extent CAI leads to health issues in athletes playing sports, it should be noted that the definitions of CAI in previous studies did not include past medical history [9-11]. Recent studies targeting participants with CAI have often used the inclusion criteria recommended by the International Ankle Consortium (IAC) [3], which include a history of at least an index LAS followed by recurrent LASs, "giving way", and/or a feeling of ankle instability. Self-reported ankle

instability should also be identified using validated self-reported questionnaires [3]. To the best of our knowledge, no study has yet investigated the prevalence of CAI using both past ankle medical history and self-reported questionnaires for ankle instability, which are described in the criteria of IAC [3]. The prevalence needs to be investigated using the recommended criteria. In addition, copers, with a history of an index LAS that has not developed into CAI [13], would be more suitable as a comparison group to CAI groups than healthy controls in order to clarify how CAI develops after the index LAS. However, the percentage of copers existing within athletes is still unclear. Identifying the prevalence of CAI, copers, and the differences between the characteristics of CAI and copers would help to clarify the factors that lead to the development of CAI after the index LAS.

Since the IAC guidelines provide the standards for participant selection criteria in controlled research settings targeted at CAI participants, certain factors were listed as exclusion criteria in order to clarify the effects of isolated CAI, including any history of surgery to or fractures of the lower limbs [3]. In the newest CAI model for a clinical setting, the three categories of impairment by LAS, personal factors and environmental factors are all interwoven to produce clinical outcomes ranging from an unsatisfactory outcome (CAI) to a full recovery (coper) [12]. The history of surgery to or fractures of the lower limbs are included in the personal factors of the CAI model, and this kind of medical history should be regarded as one of the important factors associated with CAI from a clinical standpoint. Therefore, IAC guidelines might not apply to all clinical or athletic populations. The three objectives of this study were 1) to determine the prevalence of CAI and copers in college athletes based on the IAC guidelines, 2) to compare the differences in the demographic characteristics and injuries between athletes with CAI and copers, and 3) to determine the prevalence of CAI as identified by the criteria for a clinical practice within a college athletic population that matches the demographics of CAI participants in a controlled research setting as determined by IAC guidelines.

Methods

Participants

We recruited 15 sports teams from Blind University and a total of 507 college athletes took part in the study. All participants were informed about the purposes and the procedures of the study and

all consented to participate. Our University Ethical Committee approved this study. We used three questionnaires to determine CAI participants, copers and excluded participants: an original questionnaire collecting demographic and characteristic data; the Cumberland Ankle Instability Tool (CAIT-J = Japanese version) [14]; and the Foot and Ankle Ability Measures (FAAM-J) sports subscale translated into Japanese [15]. These questionnaires were evaluated by a collective survey. The collective survey was conducted during team practices or meetings in order to reduce selection bias as the participants were not assembled solely to participate in the survey. At the time of the survey, we also informed participants that this survey was targeted at college students who were engaged in sporting activities, regardless of any history of injury. Participants were excluded if they had incomplete questionnaires and/or could not come in for assessment.

We determined the participants with a history of at least an index LAS, CAI participants, and copers using the data from the questionnaires (Figure 1). The index LAS was defined as follows: the injured site of the ankle sprain was the lateral side; the ankle sprain had inflammation symptoms (pain and/or swelling); the ankle sprain interrupted physical activity for at least a day, based on a position statement of the IAC [3]. To determine potential CAI participants and copers, we excluded any participant with a history of at least an index LAS who had had the first-time LAS within the last 12 months [3,12]. The inclusion criteria of CAI were (1) a history of at least an index LAS; (2) a history of recurrent LASs, at least two episodes of "giving way" of ankle within 6 months, and/or feelings of ankle instability; and (3) a CAIT-J score of 25 or less. These were based on the inclusion criteria of the IAC [3] and published cut-off scores of 25 or less of CAIT-J to discriminate between participants with and without CAI [14]. The inclusion criteria of copers were as follows: having a history of at least an index LAS, having no recurrent LASs, no "giving way" episodes, and no feelings of instability; having CAIT scores greater than 25, which were based on the previous reports [13,16]. CAI participants and copers by criteria for clinical practice (CAI-C and copers-C) were provisionally identified without excluding any participant with at least an index LAS and who had a history of surgery on or fractures of the lower limb; a history of a major lower limb injury within the last 3 months; the most recent LAS occurring within 3 months prior to enrolling in this study. Then, the CAI participants and copers by criteria for research (CAI-R and copers-R) were ultimately identified by excluding them based on the IAC

definitions [3]. We also determined the participants with recurrent LASs, who were identified as having at least two LASs on the same limb, within the participants with at least an index LAS, because the recurrent LASs is an important outcome for CAI [12].

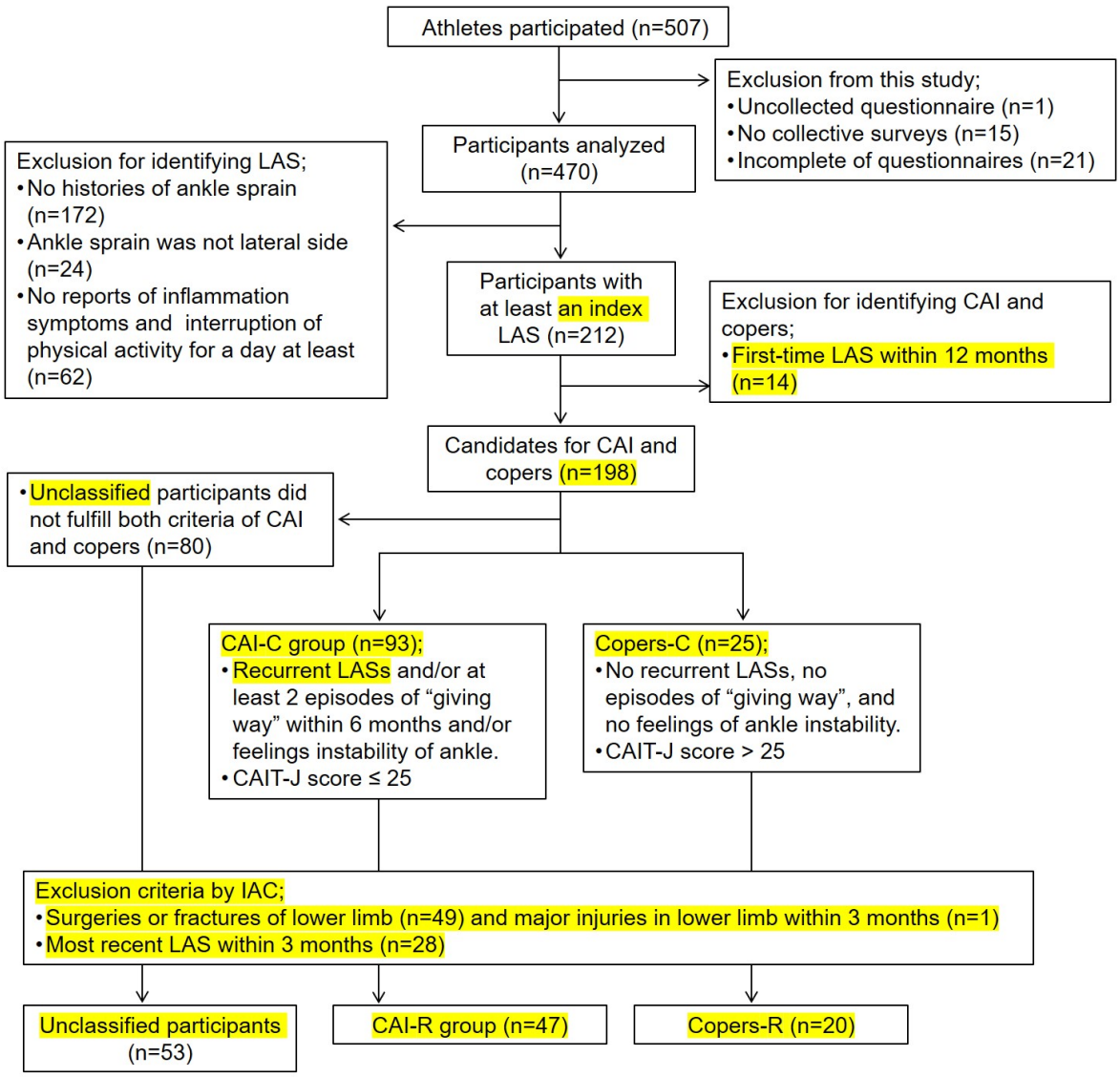

Figure 1. Flow chart for identifying the participants with CAI and copers.

Procedure

All questionnaire surveys were conducted during the athletes' practices or meetings. One of our researchers remained on site until all questionnaires had been completed. An original questionnaire with demographic data (age, sex, body height, body weight, and athletic status), a history of LAS, age

at the initial injury, symptoms and injured area of the previous LAS, a history of ankle "giving way" within the last 6 months, seeking or not seeking of medical care and receiving/not receiving rehabilitation for the LAS, and the prescription contents for LAS including crutches and protected weight-bearing, immobilization, and use of orthosis. The CAIT-J and the FAAM-J Sports subscales were used to investigate the self-reported ankle instability and the functional limitations of the foot and ankle during the sports activities, respectively. These questionnaires are both endorsed by the position statement of the IAC [3].

Data analysis

The percentages of participants with CAI-C, CAI-R, copers-C, copers-R, participants with a history of at least an index sprain and participants with recurrent LASs were calculated for the overall participants (n=470) and for each sport. The percentage of the participants with bilateral or unilateral CAI was also calculated. To investigate the differences between the characteristics of the CAI participants and the copers, unpaired t-test and Mann-Whitney U-test were used to compare the normally distributed data (height, body weight and the age at the initial LAS) and non-normally distributed data (age, hours per week in sport activity, CAIT-J scores, and FAAM-J Sport subscale), respectively. The distributions of the data were assessed by Shapiro-Wilk test. A Chi-Square test of independence was used to investigate the differences between the CAI participants and copers for gender, whether medical care and rehabilitation for LAS was sought or not, and the prescription contents for LAS. All significance levels were set as 0.05.

Results

The process for identifying the participants (either with CAI or coper) is presented in Figure 1. The questionnaire data were collected from 506 out of 507 participants (collection rate was 99.8 %). Fifteen participants were excluded because they were not investigated by the collective survey. Any participants who incompletely filled out the questionnaires were also excluded (n=21). As a result, we could use data from of 470 participants (398 males, 72 females) from 14 teams (American football, badminton, basketball, gymnastics, handball, ice hockey, judo, lacrosse, rugby football, soccer, table

tennis, tennis, track and field, and volleyball) in this study.

One hundred and seventy-two participants had no history of LAS. Although the remaining 298 participants reported a history of at least an ankle sprain, 86 participants did not meet the definition of an index LAS for the following reasons: the injured area was not on the lateral side of ankle (n=24) and the sprain did not lead to inflammation symptoms and interruptions of physical activities for at least 24 hours (n=62). As such, a total of 212 participants could be classified as having at least an index LAS history and these accounted for 45.1% of all participants (n =470). During the process of identifying participants with CAI and the copers, 14 participants were excluded from the list of a history of at least an index LAS due to having had the first-time LAS within the last 12 months. As a result, 93 participants with CAI-C and 25 copers-C were identified, while 80 participants did not fulfill either criteria for CAI-C or copers-C (Figure 1). The ratios of CAI-C and copers-C to all participants (n=470) were 19.8% and 5.3%, respectively (Table 1). Next, when identifying participants with CAI-R and the copers-R, 78 participants were excluded for the following reasons: for having a history of surgery to or fracture of the lower limb (n=49), having a history of a major injury to the lower limb within the last 3 months (n=1), and having the most recent LAS within 3 months prior to enrolment in this study (n=28). Forty-seven participants with CAI-R and 20 copers-R were identified, while 53 participants were not classified into either of the two groups. Out of the participants with CAI-R, 40.4% had CAI on both right and left sides (n=19). In addition, 67.0% of the participants with a previous index LAS had recurrent LASs (n=142).

The numbers of participants within each group and the overlap between the participants is shown in Figure 2. The CAI-R participants accounted for 50.5% of the CAI-C participants. The unclassified participants (n=80) comprised 40.4% of the participants with at least an index LAS before exclusion by IAC guidelines. Out of the unclassified participants, 70.0% had recurrent LASs. About 90% of the participant with either the CAI-C or CAI-R had also recurrent LASs.

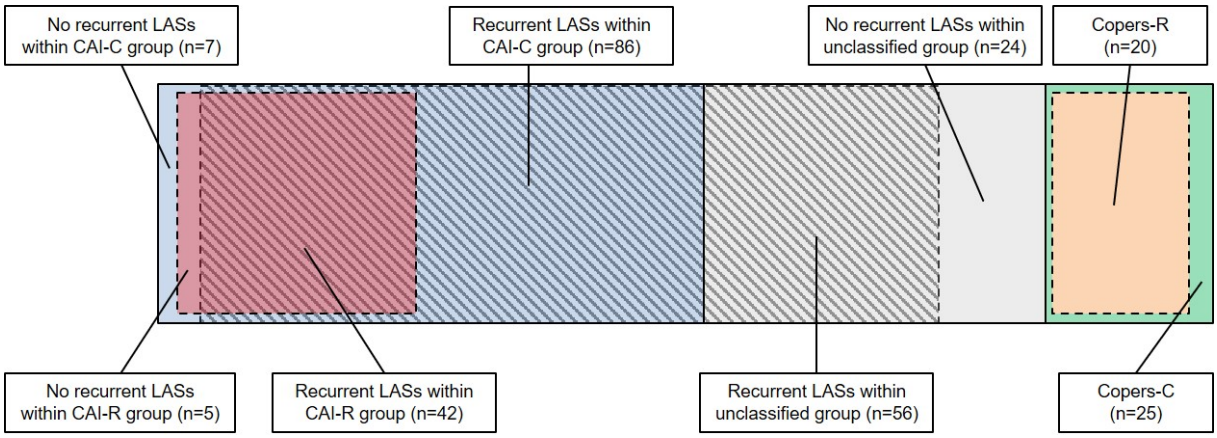

Figure 2. Diagrams showing the numbers of participants and the overlap between the participants in CAI-C (blue area), CAI-R (red area), recurrent LASs (hatched area), unclassified (light gray area), copers-C (green area), and copers-R (orange area) groups.

The numbers and ratios of the participants with a history of at least an index LAS, CAI-C, CAI-R, copers-C, and copers-R in each sport are presented in Table 1. Participants with a history of at least an index LAS were most common in basketball soccer, rugby football, gymnastics, volleyball and American football (in descending order). CAI-C and CAI-R were most common in basketball, while there were no copers in basketball and judo.

Table 1. Percentages of the participants with a history of at least an index LAS, CAI, and copers.

	Total	Participants with LAS	CAI-C	CAI-R	Copers-C	Copers-R
	n	n (%)	n (%)	n (%)	n (%)	n (%)
Basketball	22	17 (77.3)	14 (63.6)	8 (36.4)	0 (0.0)	0 (0.0)
Volleyball	26	15 (57.7)	11 (42.3)	4 (15.4)	1 (3.8)	1 (3.8)
Soccer	40	26 (65.0)	15 (37.5)	6 (15.0)	2 (5.0)	1 (2.5)
American football	45	25 (55.8)	12 (26.7)	3 (6.7)	3 (6.7)	3 (6.7)
Rugby football	35	22 (62.9)	9 (25.7)	3 (8.6)	1 (2.9)	0 (0.0)
Gymnastics	15	9 (60.0)	3 (20.0)	1 (6.7)	1 (6.7)	0 (0.0)
Handball	5	2 (40.0)	1 (20.0)	0 (0.0)	1 (20.0)	1 (20.0)
Judo	18	6 (33.3)	4 (22.2)	3 (16.7)	0 (0.0)	0 (0.0)
Lacrosse	60	23 (38.3)	9 (15.0)	6 (10.0)	2 (3.3)	1 (1.7)
Tennis	41	14 (34.1)	4 (9.8)	4 (9.8)	4 (9.8)	3 (7.3)
Ice hockey	31	11 (35.5)	3 (9.7)	3 (9.7)	3 (9.7)	3 (9.7)
Badminton	14	7 (50.0)	1 (7.1)	1 (7.1)	3 (21.4)	3 (21.4)
Track and fields	63	23 (36.5)	5 (7.9)	3 (4.8)	1 (1.6)	1 (1.6)
Table tennis	55	12 (21.8)	2 (3.6)	2 (3.6)	3 (5.5)	3 (5.5)
Total	470	212 (45.1)	93 (19.8)	47 (10.0)	25 (5.3)	20 (4.3)

LAS: lateral ankle sprain, CAI-C: chronic ankle instability as determined by the criteria for clinical practice, CAI-R: chronic ankle instability as determined by the criteria for research, Copers-C: copers as determined by the criteria for clinical practice, Copers-R: copers as determined by the criteria for research.

Demographic data (age, gender, body height and body weight) were not significantly different between the CAI-R participants and the copers-R (Table 2). The CAIT-J score and the FAAM-J Sports subscale were significantly lower in the CAI-R participants than in the copers-R (Table 2). Since 7 CAI-R participants and 1 coper-R provided unclear data concerning the age at the time of the initial injury, we could only compare 40 CAI-R participants and 19 coper-R. The age at the initial injury was significantly younger in the CAI-R participants than in the copers-R ($p = 0.0497$) (Table 2). There were no significant differences between CAI-R participants and copers who sought or did not seek medical care and rehabilitation for LAS, and the prescription contents for LAS (Table 2).

Table 2. Characteristics of the participants with CAI-R and copers-R.

	CAI-R (n = 47)	Copers-R (n = 20)	p-values
Sex, numbers	36 males, 11 females	16 males, 4 females	0.760
Age, years	20.0 ± 1.2	20.5 ± 1.4	0.193
Body height, cm	169.9 ± 6.9	167.9 ± 6.2	0.289
Body weight, kg	65.5 ± 11.5	63.8 ± 10.3	0.586
Hours per week in sport activity	11.7 ± 3.4	12.7 ± 5.1	0.451
CAIT-J scores	21.2 ± 3.7	28.2 ± 1.4	< 0.001*
FAAM-J Sports subscale, %	94.0 ± 8.7	99.7 ± 0.9	< 0.001*
Age at the initial injury, years[a]	12.6 ± 3.3	14.5 ± 3.8	0.050†
Seeking medical care, % (n)	59.6 (28)	65.0 (13)	0.677
Receiving rehabilitation, % (n)	40.4 (19)	30.0 (6)	0.419
Prescription contents for LAS, % (n)			
Crutch and protected weight-bearing	34.0 (16)	20.0 (4)	0.250
Immobilization	31.9 (15)	15.0 (3)	0.153
Orthosis	29.8 (14)	20.0 (4)	0.408
Others	4.3 (2)	5.0 (1)	0.893

* Statistically significant difference between the participants with CAI-R and copers-R ($p < 0.001$).

† Statistically significant difference between the participants with CAI-R and copers-R ($p = 0.0497$).

[a] Forty CAI participants and 19 copers were statistically compared, because 7 CAI participants and 1 coper answered unclear.

CAI-R: chronic ankle instability as determined by the criteria for research, LAS: lateral ankle sprain, CAIT-J: Japanese version of Cumberland Ankle Instability Tool, FAAM-J: Japanese version of Foot and Ankle Ability Measure.

Discussion

The present study examined both the percentages of the CAI participants and copers in college athletes based on recently recommended criteria for research (CAI-R and copers-R) as well as for clinical practice (CAI-C and copers-C), and the different characteristics of CAI participants and copers. Participants with CAI-C comprised about 20% of all college athletes surveyed, while those with CAI-R accounted for only half of the CAI-C participants. The ratios of both the copers-C and copers-R were about 5%. However, the percentages were considered to be dependent on the type of sport played. CAI was more common in basketball, soccer, and volleyball, while copers were less common in basketball, volleyball, soccer, rugby football, gymnastics, judo, lacrosse, or track and field. We also found that 70% of the unclassified participants had recurrent LASs. In addition, participants with CAI-R were younger at the time of initial injury than copers-R and this may be one of the developmental factors of CAI after an index LAS.

The percentage of CAI-C participants in the present study (19.8%) was about the same as that of previous studies targeted at young athletes, which reported 20.0% in adolescent athletes [11] and 23.4% in college and high school athletes [9]. In a community-based survey, the prevalence of chronic ankle disorders was 23.7% [17] and that of perceived ankle instability was 31.2% [18]. However, the prevalence of CAI-R was only 10.0% in the present study and lower than that of previous studies [9,11,17,18]. Previous studies defined CAI based solely upon a questionnaire assessing self-reported ankle instability. The medical history of LAS and lower limb were not included in the definitions [9,11,18]. CAI-R was determined by the results of questionnaires, the history of LAS (e.g. whether an index LAS or not, and whether the initial LAS occurred 12 months prior or not), and exclusion due to

lower limb medical histories, based on the IAC guidelines [3]. The definition of CAI-R was set for controlled research situations in order to clarify the effects of isolated CAI by reducing any confounding factors by as much as possible. As such, any participant with a history of surgery, fracture, or acute major injury to the lower limb or a most recent LAS within 3 months are supposed to be excluded. While this definition provides helpful and valid standards for research-related activities targeted at CAI participants, in clinical practice and sports, patients or athletes may have a variety of histories of major injuries to lower limbs other than LASs, and these histories should be considered to be personal factors [12]. We found the participants with CAI-R accounted for only half of those with CAI-C in the college athlete population. This finding suggests that the IAC guidelines may not capture the entire clinical population of CAI. Care should be observed when applying the results of controlled research adhering to IAC guidelines to all patients or athletes with CAI in a clinical setting.

Concerning the unclassified group, there were two reasons to be unclassifiable: 1) having an index LAS and recurrent LASs and/or at least two episodes of ankle “giving way” within 6 months but a CAIT-J score of more than 25, or 2) having an index LAS and a CAIT-J score of 25 or less but failure to have both recurrent LASs and at least two episodes of “giving way” within 6 months. Participants with recurrent LASs made up 70.0% of the unclassified group. As such, unclassified participants with recurrent LASs should be considered as a pathological condition from a clinical standpoint, but they were unable to be classified into the CAI group in the present study. In this case, careful application of the research targeted at CAI participants to such populations is necessary.

The prevalence of CAI differed between sports and was the highest in basketball in the present study. In basketball, soccer, American football and volleyball, more than half of the participants with a previous sprain had recurrent sprains in previous study [2], which is an aspect of CAI. Since these sports require multidirectional movements including jump-landings, cutting and running, and have a risk of making contact with other players (i.e. stepping on the foot of another player), the prevalence of the CAI-C was relatively high in the present study. However, the prevalence of CAI-R in these sports was considerably reduced from that of CAI-C by exclusion due to any history of surgery, fracture, or acute major injury to the lower limb or the most recent LAS having occurred within the previous 3 months. To address CAI in sports with various injury risks to the lower limbs, a clinician or trainer should give

greater consideration to personal factors such as past medical history.

The percentage of copers was low within all participants. To our knowledge, no studies have investigated copers in college athlete populations. The number of copers was less than the number of participants with CAI in this study. In the longitudinal study by Doherty et al [19], 28 (40%) out of 70 participants with a first-time acute LAS developed CAI and 42 (60%) out of them were categorized into copers at one year after the injury. This longitudinal study tracked athletes suffering first-time acute LAS for one year. The period between the time of our investigation and that of the first-time LAS was approximately six years in copers (Table 2), and the participants with CAI were also a significantly younger than copers when the first-time LAS occurred. Prolonged periods from when the first-time LAS occurred may increase the time of exposure to risk of recurrent LASs. In addition, copers were less common in basketball, volleyball, soccer, rugby football, gymnastics, judo, lacrosse, and track and field. This finding suggested that few participants in these sports have ever fully recovered from an index LAS.

A lack of appropriate medical care may contribute to the development of CAI after an index LAS occurred [20]. However, there were no significant differences between the CAI participants and the copers in either presence or absence of seeking medical care and receiving rehabilitation for LAS, and the prescription contents for LAS. Several previous studies reported that approximately half of athletes with LAS did not seek medical care [9,10,21]. Although the copers had only one previous LAS, unlike the CAI participants, 65% of them sought medical care and the percentage is relatively higher than in the previous studies [9,10,21]. On the other hand, only 59.6% the participants with CAI sought medical care, despite having more previous LASs than copers. The number of medical care situations for CAI participants might increase due to their tendencies towards more LASs and more significant LAS. Consequently, significant differences between the groups might have escaped undetected. We believe that more CAI participants should have sought medical care earlier, but the present study could not clarify whether receiving medical care was effective in preventing the development of CAI. A prospective study is needed to clarify this question.

This study has several limitations. First, the participants were recruited from solely within our university and this may limit the generalizability of the study. A broader study that includes athletes

from other universities should be conducted. Second, the number of the participants in each sport was not the same and there were only 5 participants in handball, in particular. Ankle sprains were one of the most common injuries in handball [22]. If the number of the participants was increased, the prevalence of CAI in handball might change. Finally, there was a possibility of recall bias. Although this could affect the validity and reliability of our data, the assessment using self-reported information is standard to identify the CAI and copers. A prospective follow-up study should be conducted after a first-time LAS to overcome this limitation.

Conclusion

The prevalence (10.0%) of CAI as identified by research definitions were only half of that (19.8%) of CAI identified by clinical practice definitions in college athletes. Copers identified by research definitions and clinical practice existed in about 5% of all participants. Clinicians or athletic trainers should be careful when applying the findings of controlled research focused on CAI to all patients or athletes with CAI in a clinical setting. CAI was more common in basketball, soccer, and volleyball, while copers were less common in basketball, volleyball, soccer, rugby football, gymnastics, judo, lacrosse, or track and field, therefore, the prevalence depended on the type of sport. In addition, participants with CAI were significantly younger than copers when the first-time LAS occurred, suggesting that the age at the time of the initial injury may be one of the developmental factors of CAI.

References

1. Hootman JM, Dick R, Agel J. Epidemiology of collegiate injuries for 15 sports: summary and recommendations for injury prevention initiatives. *J Athl Train.* 2007;42:311-319.
2. Attenborough AS, Hiller CE, Smith RM, et al. Chronic ankle instability in sporting populations. *Sports Med.* 2014;44:1545-1556.
3. Gribble PA, Delahunt E, Bleakley C, et al. Selection criteria for patients with chronic ankle instability in controlled research: a position statement of the International Ankle Consortium. *J Orthop Sports Phys Ther.* 2013;43:585-591.

4. Koshino Y, Ishida T, Yamanaka M, et al. Kinematics and muscle activities of the lower limb during a side-cutting task in subjects with chronic ankle instability. *Knee Surg Sports Traumatol Arthrosc.* 2016;24:1071-1080.
5. Koshino Y, Yamanaka M, Ezawa Y, et al. Lower limb joint motion during a cross cutting movement differs in individuals with and without chronic ankle instability. *Phys Ther Sport.* 2014;15:242-248.
6. Thompson C, Schabrun S, Romero R, et al. Factors contributing to chronic ankle instability: a systematic review and meta-analysis of systematic reviews. *Sports Med.* 2018;48:189-205.
7. Houston MN, Hoch JM, Hoch MC. Patient-reported outcome measures in individuals with chronic ankle instability: a systematic review. *J Athl Train.* 2015;50:1019-1033.
8. Attenborough AS, Sinclair PJ, Sharp T, et al. A snapshot of chronic ankle instability in a cohort of netball players. *J Sci Med Sport.* 2016;19:379-383.
9. Tanen L, Docherty CL, Van Der Pol B, et al. Prevalence of chronic ankle instability in high school and division I athletes. *Foot Ankle Spec.* 2014;7:37-44.
10. Simon J, Hall E, Docherty C. Prevalence of chronic ankle instability and associated symptoms in university dance majors: an exploratory study. *J Dance Med Sci.* 2014;18:178-184.
11. Donovan L, Hetzel S, Laufenberg CR, McGuine TA, et al. Prevalence and impact of chronic ankle instability in adolescent athletes. *Orthop J Sports Med.* 2020;8(2): 2325967119900962.
12. Hertel J, Corbett RO. An updated model of chronic ankle instability. *J Athl Train.* 2019;54:572-588.
13. Wikstrom EA, Brown CN. Minimum reporting standards for copers in chronic ankle instability research. *Sports Med.* 2014;44:251-268.
14. Kunugi S, Masunari A, Noh B, et al. Cross-cultural adaptation, reliability, and validity of the Japanese version of the Cumberland ankle instability tool. *Disabil Rehabil* 2016;39:50-58.
15. Uematsu D, Suzuki H, Sasaki S, et al. Evidence of validity for the Japanese version of the foot and ankle ability measure. *J Athl Train.* 2015;50:65-70.
16. Wright CJ, Arnold BL, Ross SE, et al. Recalibration and validation of the Cumberland Ankle Instability Tool cutoff score for individuals with chronic ankle instability. *Arch Phys Med Rehabil*

2014;95:1853-1859.

17. Hiller CE, Nightingale EJ, Raymond J, et al. Prevalence and impact of chronic musculoskeletal ankle disorders in the community. *Arch Phys Med Rehabil.* 2012;93:1801-1807.
18. Baldwin JN, McKay MJ, Hiller CE, et al. Correlates of perceived ankle instability in healthy individuals aged 8 to 101 years. *Arch Phys Med Rehabil.* 2017;98:72-79.
19. Doherty C, Bleakley C, Hertel J, et al. Recovery from a first-time lateral ankle sprain and the predictors of chronic ankle instability: a prospective cohort analysis. *Am J Sports Med.* 2016;44:995-1003.
20. Gribble PA, Bleakley CM, Caulfield BM, et al. Evidence review for the 2016 International Ankle Consortium consensus statement on the prevalence, impact and long-term consequences of lateral ankle sprains. *Br J Sports Med.* 2016;50:1496-1505.
21. McKay GD. Ankle injuries in basketball: injury rate and risk factors. *Br J Sports Med.* 2001;35:103-108.
22. Seil R, Rupp S, Tempelhof S, et al. Sports injuries in team handball. A one-year prospective study of sixteen men's senior teams of a superior nonprofessional level. *Am J Sports Med.* 1998;26:681-687.