Original Research

Association between Cumberland Ankle Instability Tool score and postural stability in collegiate soccer players with and without functional ankle instability

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Abstract

Objective

The purpose of this study was to investigate the association between Cumberland Ankle Instability Tool (CAIT) scores and postural stability during a diagonal landing, and to investigate whether postural stability is altered in collegiate soccer players with and without functional ankle instability (FAI). *Design*: Cross-sectional study.

Setting

Laboratory.

Participants

Ninety-one soccer players were classified into a FAI group (history of at least two ankle sprains and a CAIT-Japanese version score ≤25, n = 28), a copers group (history of one ankle sprain and a CAIT-Japanese version score ≥26, n = 32), or a control group (no history of ankle sprain, n = 31).

Main outcome measures

Time to anteroposterior stabilisation (TTSAP) and mediolateral stabilisation (TTSML) were measured during the diagonal single-leg landing.

Results

The CAIT scores were correlated with TTSAP ($P < 0.05$, $r_s = -0.214$) and TTSML ($P < 0.01$, $r_s = -0.566$). TTSAP was longer in the FAI group than in the control group, and TTSML was longer in the FAI group than in the other groups.

Conclusions

Our findings indicate the presence of an association between the CAIT-J score and TTSML, as well as postural stability deficits in collegiate soccer players with FAI during diagonal landings.

Keywords: Functional ankle instability; Cumberland Ankle Instability Tool; Postural stability; Time to stabilisation

1 Introduction

Compared to other collegiate athletes, soccer players tend to suffer from relatively higher rates of ankle sprain, preceded only by basketball players (Hootman, Dick, & Agel, 2007). In soccer, the ankle joint is particularly susceptible to injury due to repetitive kicking motion, constant change of direction, and frequent landing after jump heading. In collegiate soccer specifically, ankle sprain is one of the most common injuries, and accounts for approximately 23% of the total injuries incurred during games and practices (Agel, Evans, Dick, Putukian, & Marshall, 2007). Moreover, 17.5% of players with ankle injuries miss more than 6 weeks of soccer training after acute ankle sprains (Cloke, Ansell, Avery, & Deehan, 2011), and ankle sprains are known to have the highest risk of recurrence in soccer (Nielsen & Yde, 1989). Functional ankle instability (FAI), which often develops as a result of ankle sprain, is characterised by a sensation of ‘giving way’, and recurrent ankle sprains most often occur during physical activity (Hertel, 2002). Patients with FAI have postural stability deficits (Arnold, De La Motte, Linens, & Ross, 2009), which potentially lead to recurrent ankle sprain, particularly in players with FAI. Athletes with single-leg stability deficits have an increased risk of ankle sprains (Trojian & Mckeag, 2006), and kinaesthetic deficits at the ankle joint frequently persist in patients with repetitive ankle sprains (Gran & Newton, 1988). For this reason, postural stability should be evaluated in collegiate soccer players who have risk factors for ankle sprain, such as history of ankle sprain (Kofotolis, Kellis, & Vlachopoulos, 2007), increased body mass index (Gribble, Terada, Beard, & et al, 2016), or decreased dorsiflexion range of motion (Willems, Witvrouw, Delbaere, & et al, 2005).

Time to stabilisation (TTS) is used to evaluate postural stability and indicates the time required for an individual to return to single-leg stability after landing from a jump. The landing test is considered to be an effective evaluation method for soccer players with FAI, as the most common mechanism of soccer-related, non-contact ankle sprain is landing (Woods, Hawkins, Hulse, & Hodson, 2003). Ross & Guskiewicz previously reported that individuals with FAI required longer times to reach anteroposterior stabilisation (TTSAP) and mediolateral stabilisation (TTSML) compared to individuals with stable ankles (Ross & Guskiewicz, 2004); however, other studies only reported differences in either TTSAP (Brown, Ross, Mynark, & Guskiewicz, 2004) or TTSML (de Noronha, Refshauge, Crosbie, & Kilbreath, 2008; Wright, Arnold, & Ross, 2016), but not in both (Steib, Hentschke, Welsch, Pfeifer, & Zech, 2013). In addition, it has been reported that copers, who have a history of one ankle sprain with no instability at the ankle joint, have longer TTSAPs compared to individuals with FAI and healthy individuals (Wright et al., 2016), although this was not observed in other studies (Steib, Hentschke, Welsch, & et al, 2013; Liu, Dierkes, & Blair, 2016). The inconsistency among findings from previous studies is likely due to different methodologies, such as different landing directions, use of high boxes, or recruitment of study participants. Regarding landing height, Brown, Ross, Mynark, and et al (2004) required participants to hop forward from a 16-cm high box and showed that those with FAI required more time to regain mediolateral stability (Brown et al., 2004). Additionally, there was no association between TTS and the Cumberland Ankle Instability Tool (CAIT) score, which is a questionnaire consisting of nine items for measuring self-reported ankle instability (Hiller, Refshauge, Bundy, & Kilbreath, 2006). These findings may suggest that the task did not adequately challenge those with FAI; therefore, in athlete-focused research, more challenging tasks may be required to evaluate potential differences. As some situations in soccer require landing from a height of over 30 cm and in diagonal directions, we speculate that a sport-specific movement would enable a more task-specific evaluation of postural stability in soccer players with FAI.

The aims of this study were to determine whether collegiate soccer players with FAI and copers took longer to regain postural stability after diagonal landing than those with stable ankles. In addition, this study examined whether an association existed between the CAIT score and TTS. As poorer balance is a risk factor for ankle sprain in soccer players (Henry, Evans, Snodgrass, Miller, & Callister, 2016), screening for postural instability may be effective for the prevention of injuries. However, TTS tests to evaluate postural instability may not be possible in the clinic because the tests require using expensive equipment. Therefore, if an association exists between the CAIT score and TTS, CAIT may be a clinically simple and useful alternative tool to screen individuals with FAI for postural stability deficits during a single-leg landing in a diagonal direction. We hypothesised that there was an association between the CAIT score and TTS, and that soccer players with FAI would require longer TTS than those with stable ankles when performing a diagonal landing task.

2 Methods

This cross-sectional study was approved by the institutional review board of the university (no. 26–75). At the end of the competitive season, male collegiate soccer players who had trained six or more times per week were recruited from our university soccer club, which belongs to the Division 1 Japan University Football Association. All participants received an explanation regarding the experimental procedure and the purpose of this study, and provided written consent before participation.

Of the 91 players who participated in the study, 28 were classified as having FAI (FAI group), 32 had a history of one significant ankle sprain but no functional instability (copers group), while 31 reported no history of ankle sprain (control group). The inclusion criteria for the FAI group included the following: (a) a history of at least two significant ankle sprains, occurring at least 12 months prior to study enrolment, and leading to at least one interrupted day of desired physical activity; and (b) a history of the previously injured ankle joint ‘giving way’ and/or experiencing a recurrent sprain and/or having ‘feelings of instability’. ‘Feelings of instability’ were defined as CAIT-Japanese version (CAIT-J) scores of ≤25 (Kunugi, Masunari, Noh, Mori, Yoshida, & Miyakawa, 2017). The inclusion criteria for the copers group were a history of one ankle sprain (at least 12 months prior to study enrolment), and no current experiences of ‘giving way’ or ‘feelings of instability’ (CAIT-J score ≥ 26). The exclusion criteria were as follows: (a) a history of previous surgery on musculoskeletal structures and/or fracture requiring realignment of either limb of the lower extremities; (b) acute injury to the musculoskeletal structures of other lower extremity joints in the previous three months that impacted joint integrity and function, and resulted in at least one interrupted day of desired physical activity; and (c) performance of balance training on a daily basis. These criteria were outlined by the International Ankle Consortium (Gribble, Delahunt, Bleakley, & et al, 2013).

For those individuals in the FAI group who reported bilateral ankle sprains, the injured ankle with the lowest CAIT-J score (most affected) was designated as the involved limb for testing. For those individuals in the copers and control groups who reported bilateral ankle sprains, the ankle with the highest CAIT-J score (least affected) was designated as the involved limb for testing. In instances where both ankles had the same score, participants were asked to select the ankle that they used more frequently for single-leg landing in soccer training. The participant demographics are described in Table 1.

Table 1 Participant demographics.

alt-text: Table 1

	Age (years)	Height (cm)	Weight (kg)	Body fat (%)	CAIT-J score	Number of sprains
FAI group (n = 28)	19.9 ± 0.8	172.2 ± 5.6	65.9 ± 6.3	11.7 ± 1.8	22.5 ± 2.8[a]	4.6 ± 3.6[a]
Copers group (n = 32)	19.7 ± 0.7	173.2 ± 4.9	67.0 ± 5.5	11.6 ± 1.6	28.1 ± 1.6[b]	1.0 ± 0.0[b]
Control group (n = 31)	20.0 ± 0.8	173.9 ± 5.0	66.7 ± 4.5	11.4 ± 1.5	28.9 ± 1.5	0.0 ± 0.0

Note. Values are mean ± standard deviations. CAIT-J, Cumberland Ankle Instability Tool-Japanese Version; FAI, functional ankle instability.

[a] FAI group was significantly different than copers and control groups ($P < 0.01$).

[b] Copers group was significantly different than control group ($P < 0.05$).

TTS during the diagonal single-leg landing test was calculated to evaluate postural stability. Participants were instructed to stand barefoot on one leg on top of a 30-cm high box that was positioned 5 cm posterior to the force plate. The participants then hopped down diagonally (45° anterolateral) and landed on the same leg at the centre of the force plate (Type 9286; Kistler Instrument Corp., Winterthur, Switzerland). Then, participants stabilised as quickly as possible after the landing, and balanced for 20 s with their hands on their hips to constrain stabilisation of posture using the upper limbs. The participants performed a few practice landings (up to three times maximum to eliminate a learning effect) in order to feel comfortable with the task. During testing, three successful landings were recorded. A trial was considered unsuccessful if a participant displaced his standing leg, touched the floor with the contralateral leg, or disengaged his hands from his hips. The learning effect was minimal because all trials were conducted five times at most (two unsuccessful and three successful).

Ground reaction forces (GRFs) were recorded using the force plate and were converted from analogue to digital at a sampling rate of 200 Hz. Data were filtered using a second-order recursive low-pass Butterworth digital filter with an estimated optimum cut-off frequency of 12.53 Hz. The anteroposterior and mediolateral components of GRFs were analysed separately during peak GRFs for 20 s using a data analysis program (TRIAS System; Biometrics Ltd., Cwmfelinfach, Gwent, UK). Overall reference value, which is the mean value plus three standard deviations, were calculated from the last 10 s of the data from the control group divided by the body weight of each participant (Fransz, Huurnink, de Boode, & Dieen, 2015; Ross, Guskiewicz, & Yu, 2005). The overall reference values in the anteroposterior and mediolateral directions were 0.0049 and 0.0137, respectively. To calculate the reference values for each participant, the overall reference values were multiplied by the body weight of each participant. We fit an unbounded third-order polynomial to each of the rectified components of the GRFs in the anteroposterior and mediolateral directions. TTSAP and TTSML for each component of the GRFs were defined as the time required for the unbounded third-order polynomial to reach a value below the reference variable. The average value of TTS for each participant was calculated using the three successful trials.

Data analysis was performed using SPSS version 21 (IBM Corporation, Armonk, NY, USA). For CAIT-J scores and numbers of sprains, a Kruskal–Wallis test was used to calculate the differences among the groups, as the two values were not normally distributed. A Mann–Whitney *U* test was used as a post hoc test. Spearman's rank correlation coefficients (r_s) were used to determine potential correlations between the CAIT-J scores and TTSAP and TTSML, respectively. The correlation coefficients were defined as follows: very weak, $0 \le |r_s| \le 0.25$; weak, $0.26 \le |r_s| \le 0.49$; moderate, $0.50 \le |r_s| \le 0.69$; strong, $0.70 \le |r_s| \le 0.89$; and very strong, $0.90 \le |r_s| \le 1.00$. Significant differences between the correlation coefficients were calculated using Fisher's *z* transformation ($r_s \rightarrow z$). The TTS differences among the groups were evaluated using one-way analysis of variances, and Tukey tests were used as a post hoc test. Effect sizes and mean differences with 95% confidence intervals (95% CIs) were calculated. Effect size was based on the report of Hedges *g* as small (0.2), medium (0.5), or large (0.8). The significance level was set a priori at $P < 0.05$.

3 Results

We confirmed that the FAI group had a significantly lower CAIT-J score and greater number of sprains than the other groups ($P < 0.01$ for both) (Table 1). There was a very weak negative correlation between the CAIT-J scores and TTSAP (Fig. 1), and a moderate negative correlation between the CAIT-J scores and TTSML (Fig. 2). A significant difference was observed between the correlation coefficients ($z = 2.81$, $P < 0.01$).

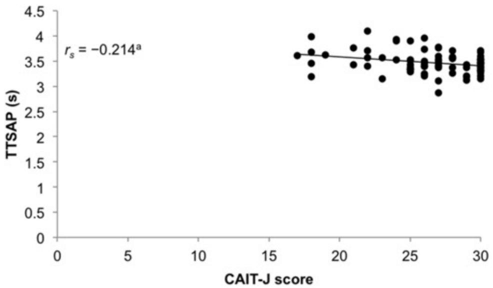

Fig. 1 Correlation between Cumberland Ankle Instability Tool-Japanese Version (CAIT-J) and time to anteroposterior stabilisation (TTSAP). [a]: There was very weak negative correlation between the CAIT-J score and TTSAP ($P < 0.05$).

alt-text: Fig. 1

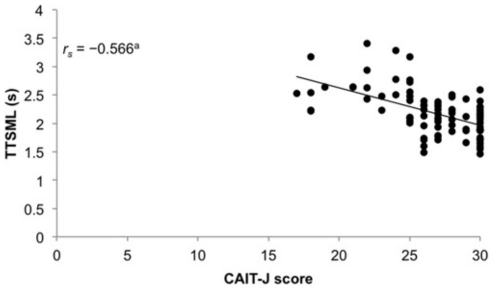

Fig. 2 Correlation between Cumberland Ankle Instability Tool-Japanese Version (CAIT-J) and time to mediolateral stabilisation (TTSML). [a]: There was a moderate negative correlation between the CAIT-J score and TTSML ($P < 0.01$).

alt-text: Fig. 2

There were significant differences in TTSAP and TTSML between the groups (Table 2). Post hoc tests indicated that TTSAP was longer in the FAI group than in the control group ($t = 2.69$, $df = 57$, $P = 0.018$, $g = 0.67$, mean difference = 0.147 s [95% CI, 0.020–0.274]), and the TTSML was longer in the FAI group than in the copers ($t = 5.52$, $df = 58$, $P < 0.001$, $g = 1.41$, mean difference = 0.474 s [95% CI, 0.285–0.663]) and the control group ($t = 7.35$, $df = 57$, $P < 0.001$, $g = 1.89$, mean difference = 0.607 s [95% CI, 0.417–0.797]).

Table 2 One-way analysis of variance for time to stabilisation.

alt-text: Table 2

	FAI group (n = 28)	Copers group (n = 32)	Control group (n = 31)	*F* values	*P* values
TTSAP (s)[a]	3.55 ± 0.25[b]	3.47 ± 0.18	3.40 ± 0.18	3.86	0.03
TTSML (s)[a]	2.56 ± 0.38[c]	2.09 ± 0.29	1.95 ± 0.25	31.628	<0.01

Note. Values are mean ± standard deviations. FAI, functional ankle instability; TTSAP, time to anteroposterior stabilisation; TTSML, time to mediolateral stabilisation.

[a] Significant differences among the groups ($P < 0.05$).

[b] FAI group was significantly different than control group ($P < 0.05$).

[c] FAI group was significantly different than copers and control groups ($P < 0.01$).

4 Discussion

To the best of our knowledge, this is the first study to find a moderate correlation between the CAIT-J score and TTSML in male collegiate soccer players. This finding supports our hypothesis that the CAIT-J score was associated with TTS. Meanwhile, TTSAP may not be correlated with the CAIT-J scores, as the value of the correlation coefficient was small, indicating a very weak correlation. Fisher's *z* transformation analysis indicated that the correlation between CAIT-J scores and TTSML was significantly different than that of CAIT-J scores and TTSAP during diagonal landings. Given these findings, we speculate that CAIT-J score is more associated with the evaluation of mediolateral stability than anteroposterior stability. Thus, CAIT may be useful proxy for identifying deficits, especially for mediolateral postural stability, during diagonal landing in individuals with a score ≤25.

Hiller, Refshauge, Bundy, and et al (2006) reported a relationship between the CAIT score and perception of ankle instability that was measured using a 10-cm visual analogue scale. The CAIT consists of questions that are related to sport activities, such as running, sharp turning, standing on one leg, and jumping (Hiller, Refshauge, Bundy, & Kilbreath, 2006). With regards to ankle instability, an individual's overall perception is considered to occur at the time in which the foot is in contact with the ground, and a rotational stress is generated on the lateral aspect of the ankle. Thus, evaluation of ankle instability may be effective during these sport-related activities, especially landing in diagonal or lateral directions. A previous study reported that there were no significant correlations between CAIT scores and TTSAP and TTSML, as measured using a forward single-leg landing test (de Noronha, Refshauge, Crosbie, & et al, 2008). However, there may be a correlation between self-reported feelings of ankle instability and postural stability, as measured during a diagonal landing rather than a forward landing. Performance of a figure-8 hop test was shown to be correlated with self-reported feelings of ankle instability, while performance of a forward single-hop test was not correlated with feelings of ankle instability (Docherty, Arnold, Gansneder, Hurwitz, & Gieck, 2005). The results of the above study suggest that the diagonal performance test, which seems to generate a rotational stress on the ankle, might be useful in assessing functional performance deficits in individuals with FAI. An inverted ankle position and lower peroneus longus activity are features of individuals with FAI (Delahunt, Monaghan, & Caulfield, 2006). Since a typical mechanism of the ankle is lateral movement, which causes inversion of the ankle (Hertel, 2002), these characteristic features might have been caused by an injury to the lateral structures of the ankle. It is believed that individuals with FAI have certain deficits in the lateral aspect of their ankles. The diagonal landing test, which may place more stress on the lateral ligament complex than the forward landing test, is an effective method for assessing impaired balance in individuals with FAI. This may explain why a moderate correlation between the CAIT-J score and TTSML was observed in the present study.

The current study found longer TTSAP in those with FAI compared to controls, which confirms the finding of another study that reported anteroposterior stability deficits in individuals with FAI (Brown et al., 2004). Anterior displacement of the talus from the talocrural joint is restrained by the anterior talofibular ligament, which is the most frequently injured lateral ankle ligament (Hertel, 2002). TTSAP increases because of mechanical dysfunction, proprioceptive deficit, and/or neural inhibitions due to repetitive ligamentous injury. In addition, individuals with FAI have different landing strategies, which lead to greater ankle dorsiflexion and knee flexion (Caulfield & Garrett, 2002). The sagittal joint movements, which require longer time to regain a stabilised single-leg stance, are likely due to longer TTSAP during diagonal landing.

Additionally, the current study found longer TTSML in those with FAI compared to controls during diagonal landing, confirming the finding of another study that reported mediolateral stability deficits in individuals with FAI during forward landing (de Noronha et al., 2008; Wright et al., 2016). Excessive inversion and internal rotation of the calcaneus in relation to the talus are restrained by the anterior talofibular and calcaneofibular ligament, which is the second most injured lateral ligament (Hertel, 2002). TTSML also increases because of mechanical dysfunction, proprioceptive deficit, and/or neural inhibitions due to repetitive ligamentous injury. Decreased muscle activity of the peroneus longus, a mediolateral stabiliser of the ankle, and increased inversion of the ankle joint during pre-initial contact in landing have been observed in individuals with FAI (Delahunt et al., 2006). The inverted ankle position is likely due to proprioceptive impairment of specific receptors at the ligament and muscle-tendon that do not appropriately send feedback, and results in inappropriate feed-forward to control the mediolateral ankle position (i.e., weaker evertor muscles against invertor muscles). Therefore, the altered muscle activity and coronal plane movement might lead to longer TTSMLs in those with FAI.

Further, the copers group had shorter TTSMLs than the FAI group, although no significant differences were found for TTSAP. Our results are in disagreement with those of a previous study, which reported that there were no significant differences between copers and individuals with FAI for TTSML and TTSAP during diagonal landing (Steib et al., 2013). The previous study recruited participants from different sports teams and calculated TTS value using a different method than the current study. The methodology might have affected the TTS values, because stability during one-legged stance is different among athletes from different sports (Matsuda, Demura, & Uchiyama, 2008), and personal reference values vary according to each participant's stabilizing ability. These factors might have caused the difference between the previous study's and present study's findings. We found longer TTSMLs in participants with FAI. This may have been due to anterior talofibular and calcaneofibular ligamentous deficits, as the function of this ligament is to restrain excessive inversion and internal rotation at the ankle. In copers, this ligamentous function may have been repaired or may not have been impaired. Therefore, in the copers group, ankle stability in the coronal plane is maintained and ankle sprains do not recur. Although not measured in this study, individuals with FAI have a different landing strategy, which leads to greater hip flexion compared to copers (Doherty, Bleakley, Hertel, Caulfield, Ryan, & Delahunt, 2016). The altered kinematics might contribute to prolonged TTS in diagonal landing.

Several limitations of the present study must be noted. First, mechanical ankle instability, which is related to postural instability (Hubbard, Kramer, Denegar, & Hertel, 2007), was not evaluated. Second, the definition of the copers group in this study differed from the original meaning in which a coper should be a person with the same index injury (e.g., the number of ankle sprains) who does not exhibit the signs/symptoms of the affected group. Third, participants in the FAI group had scores ranging from 17 to 25 on the CAIT-J; thus, our study did not include any participants with a CAIT-J score <16. Therefore, further research including mechanical ankle instability evaluations, classifying the number of ankle sprains, and subjects with CAIT-J scores <16 is warranted. Lastly, further investigation is necessary to confirm whether an improvement in postural instability, as evidenced by shortening TTS, is accompanied by an improvement in CAIT score.

5 Conclusion

(1) Our findings indicate the presence of an association between the CAIT-J score and TTSML during the diagonal landing test. Additionally, male collegiate soccer players with FAI took longer to regain postural stability after landing compared to those with stable ankles.

Ethical statements

All procedures associated with this study were approved by the university's Institutional Review Board.

Funding

None.

Conflicts of interest

None declared.

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Highlights

- Implications for Rehabilitation.
- CAIT might be useful for assessing FAI related to postural stability.
- CATI scores likely associate more with TTSML than TTSAP during diagonal landings.
- A soccer player with feelings of ankle instability might have impaired postural stability.

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