



Perception of stability correlates with objective performance of dynamic stability for people with chronic ankle instability

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Abstract

Purpose Lateral ankle sprains are one of the most prevalent musculoskeletal injuries, with one of the highest recurrence rates. One in five people develops chronic ankle instability (CAI) after a lateral ankle sprain. CAI is mainly described as a subjective phenomenon, but is associated with recurrent symptoms, reduced dynamic stability, and reduced physical activity and quality of life. Understanding the relationship between perception of stability and effect on performance for people with CAI could inform rehabilitative strategies in clinical practice. This study aimed to investigate the relationship between the perception of stability and objective performance of dynamic stability this population.

Methods This study is a sub-analysis of data from four separate studies in Australia and the United Kingdom. Participants were screened and categorised as a CAI, copers, or healthy participant. Each participant completed the Star Excursion Balance Test (SEBT) and Cumberland ankle instability tool (CAIT). Distances reached in the anterior, posterior-medial, and posterior-lateral directions, and average, of the SEBT were analysed.

Results Data from 95 participants with CAI, 45 copers, and 101 healthy participants was analysed. There was a significant moderate correlation between CAIT score and SEBT reach distance in all directions for the CAI group ($p < 0.001$). For copers, there was small significant correlation in the posterior-lateral direction ($p < 0.05$).

Conclusion This study highlights the discrepancies between the perception of stability and objective dynamic stability, and reinforces the importance of using both types of measures for continual assessment in practice to optimise selecting rehabilitative strategies.

Keywords Star excursion balance test · Cumberland ankle instability tool · Chronic ankle instability · Ankle sprains · Ankle instability · Perception

Introduction

In sport and military populations, lateral ankle sprains (LAS) are the most prevalent musculoskeletal injury, but LAS are also extremely common among the general population [1, 2]. The perception that LAS are benign injuries has led to only around 55% of people seeking medical treatment following injury [3, 4], and for those who do, there is a lack

of consensus for the rehabilitation process and adherence to the process. LAS has one of the highest recurrence rates of all musculoskeletal injuries [2, 5]. As a result, research has shown that one in five people develop chronic ankle instability (CAI) [6]. People with CAI experience recurrent and residual debilitating symptoms and have been shown to be more likely to develop ankle posttraumatic osteoarthritis [1]. As a chronic condition, CAI has been associated with reduced physical activity and quality of life, which can have further health implications to both physical and mental health [1, 7].

CAI is mainly described as a subjective phenomenon, whereby there is only a perception of instability and often no evidence of a mechanical deficit [8]. CAI has also been associated with a reduced postural control as performance in functional tests is reduced compared to people with no CAI [9]. However, for people with CAI, a subjective physical

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deficit alone decreased physical activity levels, even when there were no objective physical deficits [7, 9]. This highlights the importance of understanding both psychological—defined as feelings and perceptions—and physical performance in this population to ensure that rehabilitative strategies and patient discharges are appropriate. This relationship has been assessed before in Spanish recreational athletes with and without CAI [10]. The Star Excursion Balance Test (SEBT) was used to assess dynamic stability as a predictor for CAI and relate this to the Cumberland Ankle Instability Tool (CAIT). A small–moderate significant correlation was shown between the SEBT and the CAIT in the Spanish athletes with and without CAI, however, it remains unknown if this relationship holds true in a general population, or for people who have experienced an ankle sprain but not developed CAI (copers). This is important given the prevalence of ankle injuries in the general population worldwide [1, 2].

Evidence of the impact on quality of life and performance of activities or sports from a mismatch in physical and psychological abilities has been particularly evident for return to play decisions in sport [11]. The decision is often based on the physical performance outcomes, and not considering the psychological readiness, despite the correlation between psychological factors and injury occurrence [12]. As an example, Ardern and colleagues [13] reported a higher number of athletes not returning to sport following ACL surgery because of psychological factors opposed to functional performance of the knee. This implies that a perception of low ankle stability may prevent someone from being physically active and performing daily activities, reducing quality of life, whereas a high perception of stability may lead to someone attempting tasks they are not capable of yet thus increasing risk of injury or re-injury. If the relationship between perception of stability and objective performance of dynamic stability is known, it will inform rehabilitative strategies in clinical practice and decisions regarding clinical discharge and return to activities. This relationship has yet to be investigated in the general population.

This study aimed to investigate the relationship between the perception of stability measured by CAIT and performance outcome of a test for dynamic stability measured by the SEBT. It was hypothesized that there should be a positive linear relationship between the measures of perceived stability and dynamic stability performance.

Methods

Design

This study is a sub-analysis of data from four separate studies [14–17]. Data from the four research studies across

Australia and the United Kingdom were pooled and analysed. The process of data collection is provided in detail in the published studies. The process is briefly explained here.

Participants

Participants in all studies were categorised into one of three groups: people with CAI, copers, and healthy participants.

Participants with CAI were screened using the International Ankle Consortium guidelines [18, 19]. Participants with CAI were required to have experienced all of the following: (1) history of at least one significant ankle sprain, (2) most recent injury to have occurred more than 3 months prior to study participation, (3) history of previous episodes of ‘giving way’, recurrent sprain, or ‘feelings of instability’, and (4) perceived ankle instability determined by a score of $\leq 25/30$ on the CAIT [19, 20]. The CAIT was used to screen participants for CAI and quantify perception of stability.

Participants were considered as copers if they had sustained at least one ankle injury, reported no residual symptoms associated with the previous ankle sprain, and their CAIT score was ≥ 27 .

Participants were included in the healthy group if they had not sustained any previous ankle injuries and scored ≥ 27 on the CAIT.

All participants were aged between 18 and 65 years. Participants with any other lower limb injuries, fractures, vestibular impairments, or any other health-related diagnosis that would impact their participation were excluded from the studies.

Instrumentation and protocol

The CAIT was used as a screening tool for all the studies, and it was, therefore, completed prior to the laboratory visits. The Cumberland Ankle Instability Tool (CAIT) is a recognised valid and reliable tool for assessing CAI where a lower score indicates a lower perception of stability (intra-class correlation coefficient $[ICC]_{2,1} = 0.96$) [20].

At the testing session, demographic information such as age, body mass, leg dominance, physical activity levels, and sport participation, and ankle injury history were collected and the SEBT was completed. Participants wore comfortable clothing that was suitable for rehabilitative practice and performed the test barefoot.

The SEBT is an accepted and reliable method adopted in clinical practice to measure dynamic postural control of those with CAI [21–25]. It was completed while reaching to maximum distance in pre-determined directions, while maintaining unilateral stance and without shifting the weight from the supporting limb [22]. To guide movement, the reach directions were identified by tape on the floor. Hands

remained on the hips throughout the performance/test. Loss of balance or failure to comply with the verbal instructions meant the trial was discarded and repeated. The SEBT was performed on both the affected and unaffected sides for up to four practice trials, to diminish learning effects, and up to three test trials of which either the best performance was analysed [15–17, 26, 27], or the average of the furthest two reaches was analysed [14].

For participants with bilateral CAI the ankle which had sustained a greater number of injuries and was perceived as more unstable as per the CAIT, was the ankle analysed. For the participants with no previous ankle injuries, the side which scored a lower reach distance on average was analysed.

Statistical analysis

The mean (SD) CAIT score and anterior, posterior-medial, and posterior-lateral reach distances for the SEBT were calculated.

All statistical analysis was performed using SPSS Statistics (SPSS Statistics v. 26, USA). Data Normality was tested using Kolmogorov–Smirnov test for normality. Data were not normally distributed for CAIT and so Spearman's correlation was used due to the non-parametric data. The strength of the correlation between the CAIT and SEBT scores for each direction was calculated using (r). Partial correlations controlled for weight, age, and sex. The correlations

were interpreted as weak: 0.3–0.49; moderate: 0.5–0.79 or strong: ≥ 0.8 [28].

Results

Data from 95 participants with CAI, 45 copers, and 101 participants with no previous ankle injuries were analysed (Table 1).

For the CAI group, the median CAIT score was 21. For the copers and No-CAI groups, the median CAIT score was 29. Table 2 shows the mean results for the SEBT and CAIT for each group.

The relationship for CAI, Copers and No-CAI groups was unaffected when age, sex and weight were individually controlled for. The correlation between the CAIT score and each reach direction is shown in Table 3 and Figs. 1, 2, 3, and 4.

Discussion

For people with CAI, there was a significant moderate, positive correlation between the CAIT score and distances reached for all SEBT directions. This supports the hypothesis that there was a positive relationship between perception of stability and dynamic stability using the CAIT and SEBT.

The results for the CAI population agree with the results from Sierra-Guzman et al. [10] smaller sample of younger athletes with CAI. Results reported significant moderate correlations between SEBT performance and CAIT score in all directions, which was also greatest in the posterior-medial direction ($r=0.45$, $p=0.001$). When different patient-reported outcome measures were used for the CAI population (FAAM-ADL and FAAM-S and VAS for pain, stability, and function) a small correlation was reported, but this did not reach statistical significance [7]. This demonstrates the limited evidence that perception of stability and foot and ankle function incurs greater dynamic stability. Thus, the moderate correlation in this study highlights the importance of subjectively monitoring patients alongside objective assessments. This will maximise the potential for the

Table 1 Descriptive statistics for CAI, Copers, No-CAI participants

	CAI	Coper	Healthy
Number of participants	95	45	101
Age (years)	27 (7.92)	32.1 (8.6)	28 (8.9)
Weight (kg)	72.71 (17.13)	67.55 (12.87)	66.54 (14.06)
Sex (F/M)	47/48	19/26	56/45
Ankle analysed (R/L)	55/40	33/12	56/45

Results are presented as mean (SD) for continuous data and number for dichotomous data

F female, M male, R right, L left

Table 2 Mean (SD) CAIT score and SEBT reach distances for all directions for CAI, Copers and No-CAI participants

	CAI	Coper	Healthy
CAIT Score	18.31 (5.22) ⁺	28.93 (1.10) ⁺	29.27 (1.10) ⁺
SEBT A (% leg length)	72.37 (11.04)	74.62 (11.04)	70.69 (9.98) ⁺
SEBT PL (% leg length)	69.04 (16.63) ⁺	74.22 (11.30)	67.92 (12.91) ⁺
SEBT PM (% leg length)	79.75 (18.09)	85.55 (13.48)	77.06 (16.88)
SEBT Average (% leg length)	73.75 (14.00) ⁺	78.13 (10.76)	72.00 (11.39) ⁺

CAIT chronic ankle instability, SEBT Star Excursion Balance Test, A anterior, PL posterior-lateral, PM posterior-medial

⁺Non-parametric data

Table 3 Pearson correlations for CAIT and A, PM, PL, and Average SEBT reach directions when uncontrolled and controlled for age, weight, and sex

	SEBT A		SEBT PL		SEBT PM		SEBT average	
	Uncontrolled	Controlled	Uncontrolled	Controlled	Uncontrolled	Controlled	Uncontrolled	Controlled
CAI	0.43*	0.40*	0.44*	0.40*	0.49*	0.42*	0.51*	0.43*
Coper	0.10	0.13	0.34**	0.35**	0.20	0.23	0.23	0.26
Healthy	0.12	0.10	0.05	0.04	0.15	0.14	0.13	0.12

CAI chronic ankle instability, SEBT Star Excursion Balance Test, A anterior, PL posterior-lateral, PM posterior-medial

*Sig $p < 0.001$

**Sig $p < 0.05$

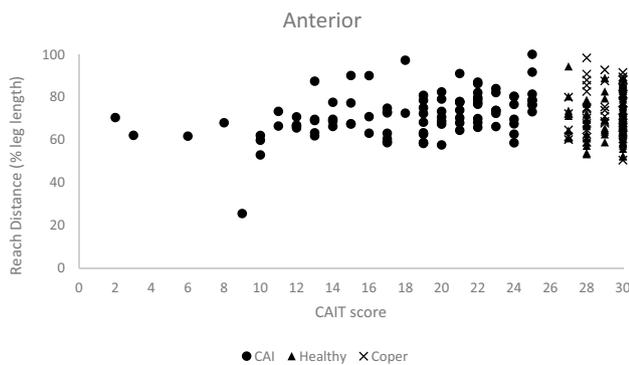


Fig. 1 CAIT score and anterior reach performance for participants

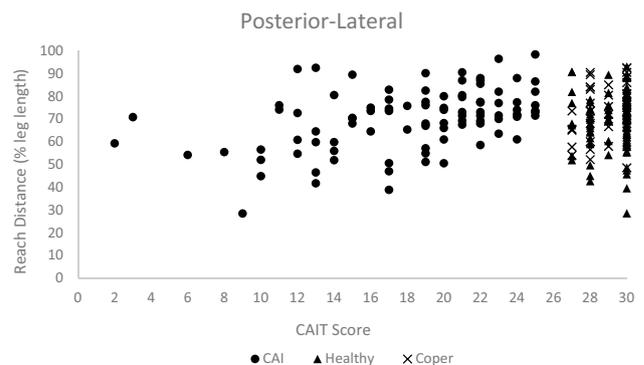


Fig. 3 CAIT score and posterior-lateral reach performance for participants

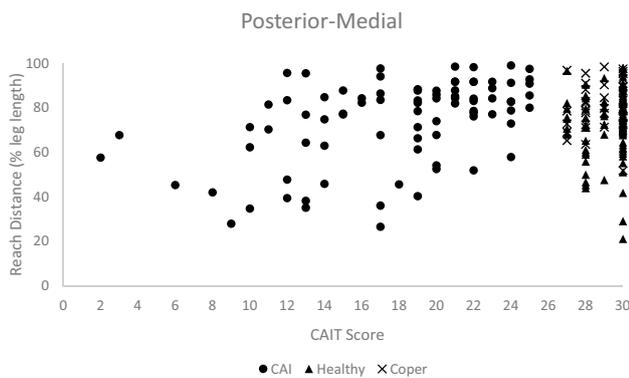


Fig. 2 CAIT score and posterior-medial reach performance for participants

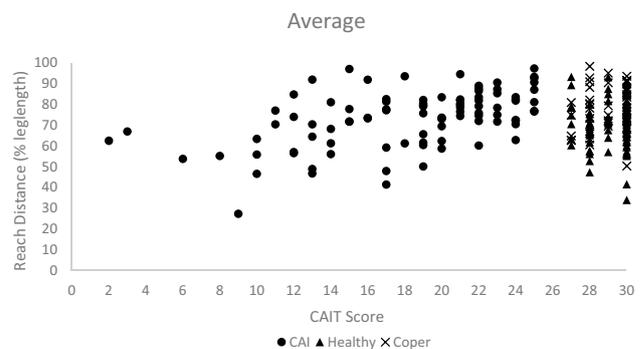


Fig. 4 CAIT score and average reach performance for participants

clinician to understand a patient’s feelings and perceptions, and determine the most appropriate rehabilitative approach.

Posterior reach directions showed slightly stronger correlations, highlighting increased perception of stability was recorded alongside increased reach distances posteriorly. This is despite the higher degree of reach difficulty in these directions from reduced visual feedback and increased reliance on somatosensory feedback [29]. This supports Sierra-Guzman and colleagues [10] results

which found that the posteromedial reach direction was the variable with largest contribution to the CAIT ($\beta = 0.26$, $p = 0.02$). Other factors may have a greater effect on the anterior reach direction which have not been controlled for in this study. Examples of which could be flexibility and strength, both of which have been shown to predict the variance and outcome [29–32]. Specifically, for the anterior reach direction, ankle dorsiflexion was significantly moderately correlated, but this was not apparent in the posterior reach directions [7].

The relationship between stability and the perception of stability becomes more prominent when preparing for return to play following an injury. Psychological readiness and physical performance have not been researched in people with CAI previously, however, it has been reported following ACL reconstruction (ACLR) surgery [33, 34]. Following ACLR, it has been reported that there were no functional differences for any of the tests conducted between the participants who did and did not return to sport. There was, however, a difference in the patient-reported outcome (International Knee Documentation Committee Subjective Knee Evaluation Form score: 95.52 vs 82.76, $p = 0.03$) [34]. Fones et al. [33] also found that patient-reported outcomes were significantly lower in the people who did not return to sport in adolescents after 2 years post-surgery. The results suggest that PROs may be able to detect ongoing symptoms affecting patients' wellbeing that cannot be fully detected using traditional functional test batteries [34]. The work presented here supports previous literature that the psychological readiness had the strongest association with returning to sport participation, thus implying that the physical capacity to perform sport-related tasks is not as important [13]. This has not yet been researched in a CAI population. However, the current study provides evidence to warrant future research into the relationship between psychological readiness and physical performance for people with CAI.

For the copers and healthy groups, there was a small positive correlation between the CAIT and SEBT, however, this did not reach statistical significance. This is expected to be a result of the ceiling effect of the CAIT for these two groups, where a near-maximum score was required for study participation. This is important to consider when interpreting these results [35]. This is the first study to analyse copers. Interestingly, for healthy participants, a ceiling effect has not been acknowledged previously when analysing this relationship [10]. This may have influenced the results from the Sierra-Guzman [10] study. Future research may consider using more than one patient-reported outcome to assess perception of stability to reduce the potential impact of the ceiling effect for the copers group, and better understand this relationship, as well as for healthy participants if a comparison between groups is necessary.

Strengths and limitations

Due to the collaborative nature of the study, the sample size for the CAI and healthy groups was larger than that of previous research [5]. The copers group was a smaller size from one dataset.

This study is strengthened and limited by the diverse population from the four datasets used. The sample offered a diverse group from the general population from both the UK

and Australia. This is in comparison to the majority of CAI studies have been in youth or college athletic populations.

Only one patient-reported outcome was used in this study—the CAIT. Therefore, it is unknown whether this result would be replicated using other patient-reported outcomes.

Conclusion

To summarise, there is a significant moderate correlation between SEBT performance and CAIT score in the CAI population. It highlights the discrepancies between objective and subjective stability (both the physiological and psychological performance variables), and reinforces the importance of using both types of measures for continual assessment in practice.

Author contributions Concept/idea/research design: LF, CRC, CEH, Writing: LF, FP, data collection: LF, FP, SAA, data analysis: LF, project management: LF, CRC, consultation (including review of manuscript before submitting): LF, CRC, FP, SAA, CEH.

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Code availability Not applicable.

Declarations

Conflict of interest No conflict of interest with any person, company, or institution.

Ethics approval All studies included in the analysis were approved by the respective University ethics committees (Department of Biomedical Engineering, University of Strathclyde and NHS R&D (DEC 2018.243), The University of Sydney Human Research Ethics Committee (HREC) (12808, 15075, 2015/84)).

Informed consent All participants provided informed consent prior to participating in the study. No patient identity is revealed.

Consent for publication Not applicable.

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