The influence of ankle dorsiflexion and self-reported patient outcomes on dynamic postural control in participants with chronic ankle instability

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ABSTRACT

We investigated the influence of ankle dorsiflexion range of motion (DF-ROM) and self-reported patient outcomes on dynamic postural control assessed with the Star Excursion Balance Test (SEBT) in individuals with chronic ankle instability (CAI). Twenty-nine participants with self-reported CAI volunteered. The primary outcome measurements were categorized into clinician-and patient-generated. Clinician-generated outcome measurements included anterior (SEBT-A), posteriormedial (SEBT-PM) and posteriorlateral (SEBT-PL) reach distances (cm) normalized by leg length (cm) of the SEBT, maximum weight-bearing dorsiflexion (WB-DF) (cm), and open-chain DF-ROM ($°$). Self-reported patient-generated outcome measures included the foot and ankle ability measure and the level of perceived pain, stiffness, stability, and function of their involved ankle on a 10-cm visual analog scale (VAS). Pearson product moment correlations were used to examine the relationship of the SEBT performances with DF-ROM and self-reported patient outcome measures. A multiple linear regression was performed to determine the influence of patient- and clinician-generated measures on the SEBT. SEBT-A performance was significantly and fairly correlated with WB-DF ($r = 0.410$, $p = 0.014$), perceived ankle stiffness ($r = 0.477$, $p = 0.014$), and open-chain DF-ROM ($r = 0.404$, $p = 0.015$). The strongest predictor of the variance in SEBT-A was the combination of the variance in WB-DF and VAS-stiffness ($R^2 = 0.348$, $p = 0.004$). There were no significant correlations with the SEBT-PM and SEBT-PL. WB-DF and VAS-stiffness may represent targets for intervention that need to be addressed to produce the best outcome in participants with CAI when altered dynamic postural control is detected on the SEBT-A.

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1. Introduction

Chronic ankle instability (CAI) is common following an acute ankle sprain in physically active populations. It has been reported that 32–74% of individuals sustaining an acute ankle sprain develop CAI [1,2] that is characterized by self-reported disability, pain, repeated episodes of "giving-way," and/or recurrent ankle sprains [3]. The presence of CAI leads to a decrease in activity level [2] and a lower quality of life [1,4], and is a leading contributor to the development of posttraumatic osteoarthritis in the ankle [5].

The development of CAI following an initial ankle sprain is highly complex [6], resulting from multiple sensorimotor and mechanical insufficiencies. Impaired sensorimotor control has been demonstrated in individuals with CAI [6–11], which may manifest as decreased functional performance and diminished postural control [12]. The Star Excursion Balance Test (SEBT) has been described as a reliable clinician-generated measure of dynamic postural control [13]. It has been used previously to show increased risk of acute lateral ankle sprain [14,15]. Additionally, decreased reach distances of the SEBT and altered proximal joint neuromuscular control has been observed in individuals with CAI [12,16], which suggests that CAI may constrain the sensorimotor control system. While the SEBT has been used to estimate sensorimotor function in individuals with CAI [13], mechanical insufficiencies, such as mechanical deficits in weight bearing dorsiflexion (WB-DF), are associated with CAI,

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negatively influencing dynamic control measured with the SEBT-A in CAI populations [17,18]. Therefore, the SEBT may be a global measure that assesses the ability of individuals with ankle pathology to organize both sensorimotor and mechanical functions.

Assessing ankle dorsiflexion range of motion (DF-ROM) in the weight bearing position has been suggested as a viable alternative to open-chain goniometric measurements of ankle DF-ROM (open-chain DF) [19]. While a relationship between the WB-DF and the anterior reach of the SEBT (SEBT-A) has been shown to be present in individuals with CAI [17,18], there is little evidence to substantiate any correlation between the SEBT-A, and other directions such as the posteriormedial (SEBT-PM) and poster-iorlateral (SEBT-PL), and open-chain DF, as well as between WB-DF and open-chain DF assessments in the CAI population. Decreased ankle DF-ROM has been observed in both the weight bearing and open-chain positions during gait [20,21]. The availability of DF-ROM in the weight-bearing and open-chain positions could influence ankle motions during functional tasks. Examining interactions among these three measures may provide additional insight into the influence of the availability of DF-ROM on dynamic postural control, and provide a foundation for continued work to identify the most effective interventions after SEBT performance deficiency is detected.

Patient-generated outcome measures have been emphasized in health care [22] and provide valuable information on how the patient experiences physical limitations and disability due to CAI. Various self-reported questionnaire have been developed in previous literature to quantify physical limitations and disability associated with CAI [4,23]. Enchaute et al. [23] suggested that the foot and ankle ability measure (FAAM) is the most appropriate self-reported questionnaires to assess disability in individuals with CAI. A visual analog scale (VAS) is also commonly used to assess the levels of the typical symptoms (perceived pain, instability, and limited function) across the continuum of disability associated with ankle injuries [24]. The interaction of patient-generated and clinician-generated outcome measures is crucially important to assess how impairments measured with clinician-generated variables contribute to patient-reported functional disability and understanding of the phenomenon of CAI [25]. However, it is unknown how functional impairment measured with the SEBT is related to self-reported functional disability in CAI participants. Examining the correlation between the SEBT and self-reported outcomes may help to improve the identification of deficits related to CAI.

Therefore, the purposes of this study were to determine (1) if the SEBT-A, SEBT-PM, and SEBT-PL are correlated with WB-DF, open-chain DF, and patient-oriented outcomes (FAAM and VAS) in individuals with CAI; and (2) if WB-DF is correlated with open-chain DF in this population. Additionally, we examined which of these variables provided the greatest contribution to global dysfunction measured with the SEBT in participants with CAI.

2. Method

2.1. Participants

Twenty-nine participants with self-reported CAI were recruited from the University community (Table 1). We included partici-pants who had: (1) a previous history of at least one acute ankle sprain that caused swelling, pain, and temporary loss of function; (2) at least two episodes of "giving way" in the previous 6 months; (3) self-reported functional disability as a result of their ankle sprain history by scoring ≤90% on the foot and ankle ability measure (FAAM) activities of daily living subscale (FAAM-ADL) and ≤80% on the FAAM sports subscale (FAAM-S) [26]. No participant with CAI had acutely sprained his or her ankle in the 3 months before testing [26]. In the event participants reported a bilateral

Table 1
Demographic information and foot and ankle ability measure activities of daily living, and FAAM sports scale, for participants with chronic ankle instability.

Dependent variable	Means ± standard deviation
n	29
Age (year)	21.19 ± 2.82
Sex	Male = 14, female = 15
Height (m)	1.71 ± 0.09
Body mass (kg)	73.77 ± 18.40
FAAM[a]-ADL[b] (%)	80.28 ± 9.93
FAAM sport (%)	61.38 ± 17.19

[a] FAAM = foot and ankle ability measure.
[b] ADL = activities of daily living.

history of ankle sprains, the limb with the greatest reported functional disability on the FAAM was included in the study. We excluded participants if they had engaged in rehabilitation during the past 6 months and had a history of self-reported joint hypermobility dysfunction, any musculoskeletal and neurovascu-lar injuries/disorders in the lower extremity other than an ankle sprain, concussion or head injury in the past 6 months, lower back pain in the past 6 months, or any diagnosed balance or vestibular disorders. All participants read and signed the informed consent approved by Institutional Review Board at the University XXXX prior to participation in the study.

2.2. Procedure

All participants reported to the research laboratory for a single session. Two investigators with previous experience using the selected outcome measures conducted the assessments, including self-reported patient outcomes, the SEBT-A, SEBT-PM, SEBT-PL, the WB-DF, and open-chain DF. Participants were asked to rate perceived pain, stiffness, stability, and function of their involved ankle on a 10-cm VAS. The self-reported patient outcomes were completed first. Zero equated with no pain, no stiffness, no instability, or normal function, while 10 was the worst pain, stiffness, stability, or function imaginable.

Participants performed the SEBT-A, SEBT-PM, the WB-DF measure, and open-chain DF measure barefoot. The order of the measurements was counterbalanced. The SEBT has been shown to have a good to excellent intra-tester, inter-tester, and test-retest reliability and validity as a functional test to identify dynamic postural control deficits [27,28]. Participants established a stable base of support on the stance limb with the toes placed at the end of the tape measure for the SEBT-A, and with the heel at the end of the tape measure for the SEBT-PM and SEBT-PL [13]. While maintaining the base of support and keeping the hands on the hips, participants performed a series of single-limb squats and made an effort to: (1) reach maximally with the non-stance, limb in the anterior direction; (2) touch lightly a point with the most distal portion of the toe along the tape measure on the ground, without shifting weight to the foot of the reaching limb or lifting the heel of the stance limb; and (3) return the reaching limb to the start position at the middle of the grid, resuming a stable bilateral stance [13]. A trial was not considered complete and discarded if the participant did not keep their hands on their hips, lost their balance, or lifted or shifted any part of the foot of the stance limb from the floor. Participants were given four practice trials in each direction prior to completing three testing trials [13]. The excursion distances, in cm, were marked with ink on the tape measure from the end of the tape measure to the marked point of maximum reach. For each reach direction, the average maximum reach distance of three trials was normalized and reported as a