Postural Control Deficits in Participants with Functional Ankle Instability as Measured by the Balance Error Scoring System

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Abstract:

Objective: To determine if postural control deficits are present in participants with functional ankle instability (FAI) as measured by the Balance Error Scoring System (BESS).
Design and Setting: We used a between-groups design to assess postural control. All testing was conducted in a university athletic training facility.
Participants: Sixty collegiate Division I athletes were included in this study. Thirty participants had functional ankle instability and thirty participants had no history of ankle injuries.
Main Outcome Measurements: Postural control was measured using the BESS. The BESS test battery requires participants to stand unsupported on two different surfaces (firm and foam) in three different stances (double, single, and in tandem). Each condition lasted 20 seconds. The number of errors were calculated for each individual condition and then summed to produce a total BESS score.
Results: We found a significant group by condition interaction ($F_{5,290}$=5.12, P<0.001) and significant main effects for group ($F_{1,58}$=16.01, P<0.001) and condition ($F_{5,290}$=228.88, P<0.001). Post hoc analyses revealed that subjects with functional ankle instability scored more errors (poorer balance) on the single stancefirm condition (2.9±2.1 versus 1.6±1.3 errors), tandem stancefoam condition (4.3±2.4 versus 2.7±1.6 errors), single stancefoam condition (7.0±1.6 versus 5.6±1.8 errors), and total BESS score (15.7±6.0 versus 10.7±3.2).
Conclusions: Postural control deficits were identified in participants with functional ankle instability using the BESS. These deficits could be a contributing factor to the repeated episodes of instability and giving way that often occurs following an inversion ankle sprain. These results suggest the BESS, traditionally used for monitoring recovery from mild head injury, may also be useful in screening athletes for postural deficits following lower extremity injury.

Keywords: postural sway | balance | proprioception

Article:

Functional ankle instability (FAI) following a lateral ankle sprain is a common disability that can affect both athletic performance and activities of daily life.[1] It has been reported that residual symptoms, such as a feeling of instability or giving way, occurs in approximately 40% of ankle sprains.[2,3] The mechanism of injury for a lateral ankle sprain is plantarflexion and inversion of the ankle.[4] This stress can damage not only the ligaments, but the muscles, nerves, and mechanoreceptors that are located on the lateral aspect of the lower leg, ankle, and foot.[5]

Postural sway deficits have been identified followed an acute lateral ankle sprain [6,7] and is thought be a corollary symptom to functional ankle instability.[7] The majority of studies to date have identified postural sway deficits in participants with recurrent ankle instability using stabilometric devices such as force platforms,[6,7,9–11] the NeuroCom Equitest System,[12] the New Balance Master,[13] and the Chattanooga Balance System.[14,15] However few studies have bridged the gap between these laboratory based devices and objective clinical measures of postural sway. Some studies have used the modified Rhomberg test,[16,17] which is a more clinical measure, but the results can lack sensitivity when evaluating small changes in postural sway.[18] To date, only one study using a readily available clinical measure, the Star Excursion Balance Test (SEBT), has attempted to evaluate participants with functional ankle instability.[19] The SEBT is an objective measure of lower extremity maximal reach that is performed while maintaining single leg balance with the contra-lateral limb. In this study participants performed six maximal reach trials in eight directions (anterior, antero-medial, medial, postero-medial, posterior, postero-lateral, lateral, and antero-medial).[19] Their results agreed with the majority of investigations, finding that subjects with a history of lateral ankle sprains and functional ankle instability have deficits in postural stability.[11,16,17,19–21] However, the test is somewhat time-intensive and requires that a grid be firmly affixed to the floor surface as a guide for each reach direction.

Other studies have identified postural deficits as a predisposing factor to functional ankle instability, implying that those with increased sway may be at a higher risk of sustaining an ankle injury, either an acute ankle sprain or recurrent episodes of instability.[13,22] Therefore, it would be helpful to the clinician to have an inexpensive and easy-to-interpret method of measuring postural sway. The Balance Error Scoring System (BESS) is a valid and reliable measure of postural sway,[23] but has primarily been used in the assessment of mild head injuries.[24,25] To date, the BESS has not been utilized in the assessment of postural sway in participants with FAI or any lower extremity pathology. The BESS attempts to challenge the sensory systems by combining a variety of stances on a firm surface as well as a more unstable surface, foam. The addition of the unstable surface makes the task more challenging than the traditional Rhomberg test, but does so with equipment that is available in most clinics and athletic training rooms. Therefore, the purpose of this study is to determine if postural control deficits are present in participants with FAI as measured by the BESS.

METHODS

Participants

Sixty collegiate athletes from a Division I school volunteered for this study. Participants were separated into 2 groups: 30 participants had unilateral Functional Ankle Instability (9 Men, 21 women, 20.0±1.5 years, 172.7±9.5 cm, 68.5±8.8 kg) and 30 participants had no history of ankle injuries (9 Men, 21 women, 18.7±0.8 years, 173.4±9.8 cm, 68.2±15.8 kg). FAI was defined as a history of at least one inversion ankle sprain and repeated feeling of giving way or instability in the ankle. This information was gathered using a medical questionnaire. Of the 30 FAI participants, the history of ankle sprain occurred in the last six months in 10 participants (32%), between 6-12 months ago in 6 participants (20%), between 1–2 years ago in 9 participants (29%), and greater than 2 years ago in 5 participants (16%). Additionally, 18 (60%) reported instability monthly, 11 (37%) reported instability weekly, and 1 (3%) reported instability daily. Subjects were excluded if they had a history of fractures or surgeries to the foot, ankle, or lower leg, cerebral concussion, vestibular, visual, or equilibrium dysfunction. Subjects were also excluded if any symptoms of an acute ankle sprain (swelling, pain, etc.) were present. All subjects read and signed an informed consent form approved by the University's Institutional Review Board for the protection of Human Subjects, which also approved the study.

Procedures

Postural control of all participants was measured using the Balance Error Scoring System. The BESS test battery requires participants to stand unsupported with their eyes closed under six conditions, using a combination of two surfaces (firm and foam) and three stances (double-limb, single-limb, and tandem) (Fig. 1). The firm surface was done on the floor of the athletic training room. The foam surface was done on a 50.8×41.7×6.4 cm block of medium-density foam (Perform Better, Airex Balance Pad, Craston, RI). Subjects in the uninjured group were matched to subjects in the FAI group by limb, so an equal number of right and left limbs were tested in each group. The single-leg stances were done on the FAI limb in the injured group and the matched limb in the uninjured group. That same leg was used as the back leg in the tandem stances. For each condition, participants were instructed to close their eyes, place their hands on their hips and remain as motionless as possible for 20 seconds. If they lost their balance they were instructed to try to get back into the test position as quickly as possible. During each trial we recorded one error for each time we observed any of the following: 1) lifting hands off iliac crests; 2) opening eyes; 3) stepping, stumbling, or falling; 4) moving the hip into more than 30 degrees of flexion or abduction; 5) lifting the forefoot or heel; 6) remaining out of the testing position for more than five seconds. The total number of errors were calculated for each individual condition and then summed to produce a total BESS score. Two examiners performed all the testing (the primary investigator collected 75% and a research assistant collected 25% of the data). Previous investigation reported inter-tester reliability to be good with ICC values ranging from 0.78 to 0.96 for the six test conditions.[23] A practice trial was done in each test condition to familiarize participants with the task. Following the practice trial, one test trial was conducted for each of the six conditions.

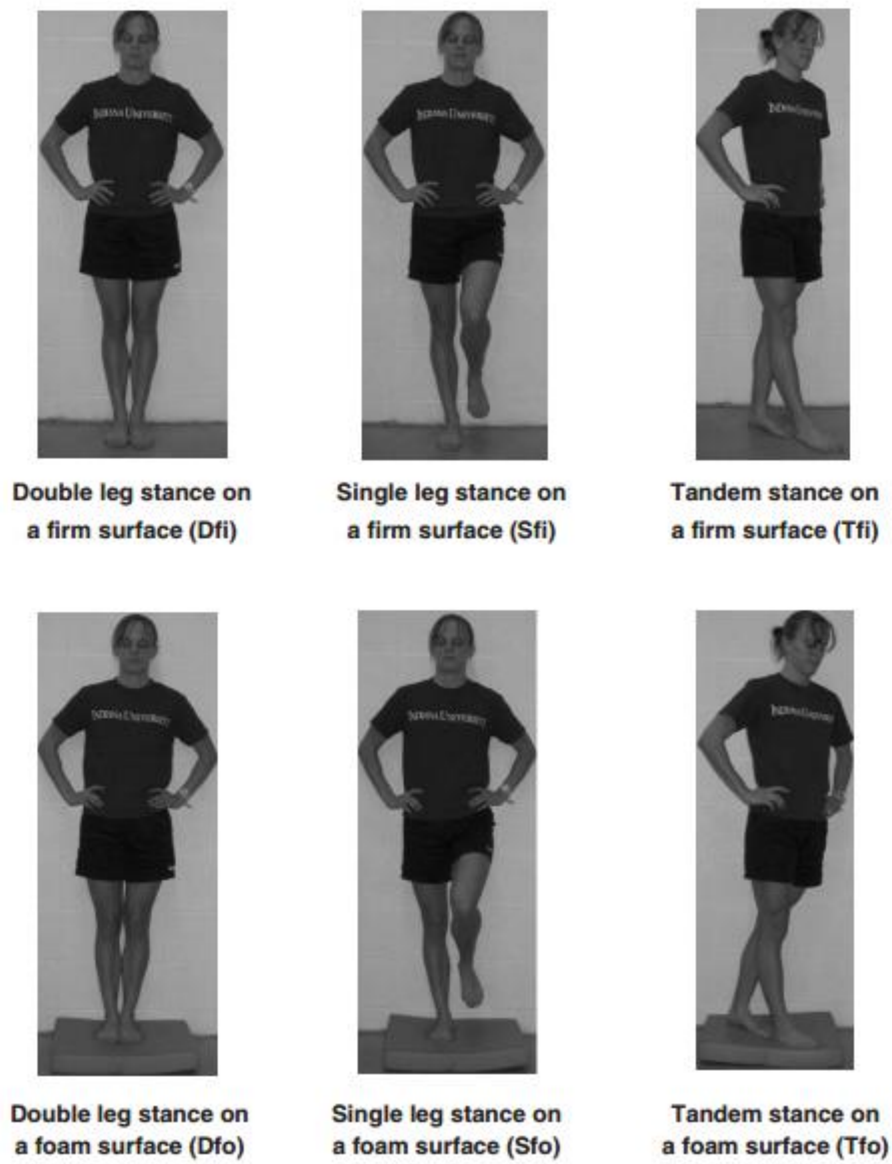

FIGURE 1. BESS Stances.

Statistical Analysis

Using SPSS Version 12.0 (SPSS Inc, Chicago, IL), we ran a repeated measures ANOVA with one between-subjects factor [group at two levels: FAI and uninjured] and one within-subjects factor [condition at six levels: Double-leg stance, Firm surface (Dfi); Single-leg stance, Firm surface (Sfi); Tandem stance, Firm surface (Tfi); Double-leg stance, Foam surface (Dfo); Single-leg stance, Foam surface (Sfo) Tandem stance, Foam surface (Tfo)] to investigate group differences in BESS performance. Tukey HSD post hoc tests were used to further analyze significant findings. Significance was set a priori at $P<=0.05$.

RESULTS

We found a significant group by condition interaction ($F_{5,290}$=5.12, P<0.001) and significant main effects for group ($F_{1,58}$=16.01, P<0.001) and condition ($F_{5,290}$=228.88, P<0.001). Post hoc analyses revealed that subjects with FAI scored more errors (poorer balance) on the Sfi (2.9±2.1 versus 1.6±1.3 errors), Tfo (4.3±2.4 versus 2.7±1.6 errors), and Sfo (7.0±1.6 versus 5.6±1.8 errors) conditions (Fig. 2). No group differences were found on the Dfi, Dfo, or Tfi conditions. The main effect for group demonstrated that subjects with FAI scored significantly more total BESS errors (15.7±6.0 versus 10.7±3.2 errors) than the uninjured group. For all subjects, the main effect of condition revealed that subjects scored significantly more errors on the Sfo condition compared with all other conditions, significantly more errors on the Tfo condition compared to the Dfi, Dfo, Tfi, and Sfi conditions and significantly more errors on the Sfi condition compared to Dfi, Dfo, and Tfi (Fig. 3). There were no differences between scores on the Dfi, Dfo and Tfi conditions.

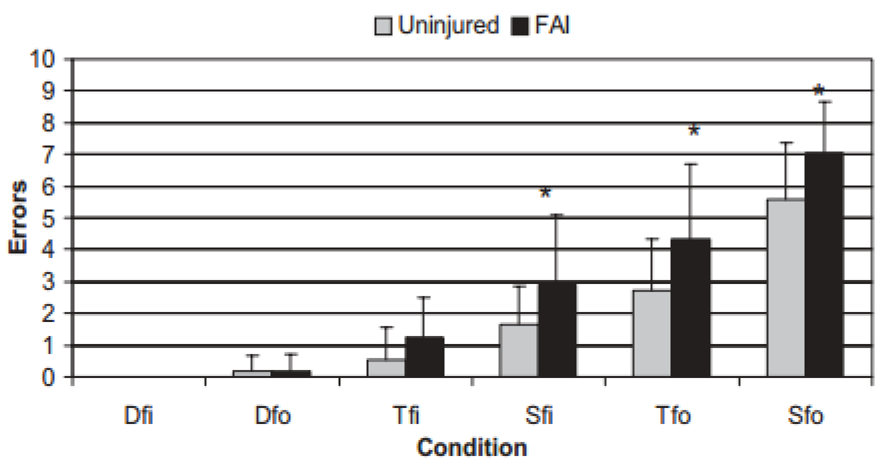

FIGURE 2. Group by condition interaction. *Subjects with FAI scored significantly more errors than the uninjured group.

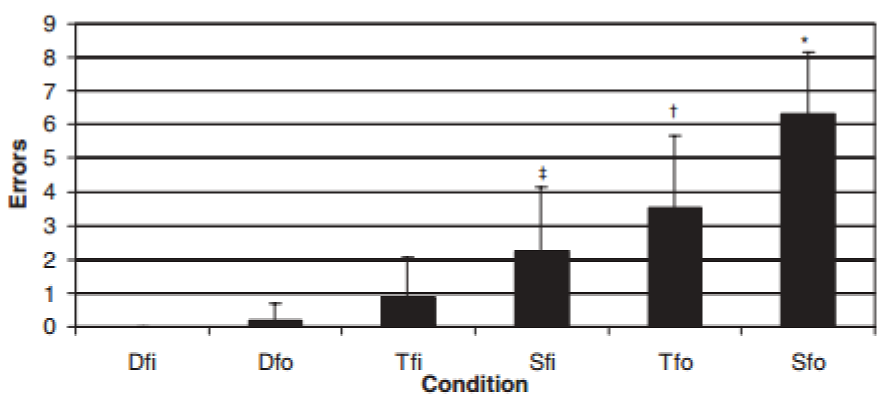

FIGURE 3. Main effect for condition. *Significantly more errors than all other conditions; †Significantly more errors than Dfi, Dfo, Tfi, Sfi; ‡Significantly more errors than Dfi, Dfo, Tfi.

DISCUSSION

The primary finding of this study was that participants with FAI had deficits in postural control as compared to uninjured participants. The deficits were reflected in the Total BESS score as well as three of the six individual conditions. As expected, the more challenging conditions, single firm, single foam, and tandem foam, were the conditions that participants with FAI had more errors. The significant difference between the FAI and uninjured subjects during the single-leg stance on the firm surface recreates those early studies done with the modified Rhomberg test.[16,17,26] However, the BESS single leg stance on a firm surface is different in that the Rhomberg primarily uses a subjective feeling of less balance by either the participant or examiner,[16,17] while the BESS uses an objective scoring system to report postural deficits.[21] This decreases the risk of subjectivity and poor test-retest reliability when using different examiners. Additionally, the complexity of the single-leg stance and the foam surface has constantly been reported as the most challenging tasks in healthy 27 and fatigued subjects.[28] Because of the lack of group differences between injured and healthy subjects on the double-leg conditions, further investigation should be done to determine if the these stances are necessary in assessing postural stability in injured participants.

The Total BESS scores reported for the FAI group (15.7±6.0 errors) are also similar to those reported in athletes on day 1 following concussion.[24] This finding gives us confidence that the range of scores is consistent to other injured populations. Although the BESS has been primarily been used as a pre-season screening tool to acquire baseline postural data for assessment of mild head injuries, our results shows promise for using the BESS as a tool to identify those participants that might be predisposed to ankle injuries, however further validation is warranted. The presence of a chronic pathology such as FAI should not affect the use of the BESS in assessing mild head injuries since the balance deficits would be present during the baseline testing. However, it should be noted that an acute injury that occurs between the baseline test and a concussion may affect the usefulness of this measure. Clinicians should be aware of this potential confounding variable and continued research should be conducted to gain a better understanding of how acute injuries affect BESS performance.

Our findings are also consistent with postural control deficits identified in participants with FAI utilizing other balance measures. Olmsted et al [19] identified reach deficits in participants with chronic ankle instability using the Star Excursion Balance Test (SEBT). Participants with ankle instability had significantly less reach while still maintaining balance than the uninjured participants. Other studies utilizing a force plate found that participants with ankle instability had increased postural sway.[29,30] Finally, when balance was assessed through a jump to stabilization maneuver, participants with FAI took significantly longer to stabilize than uninjured participants.[31,32] While a few studies have contradicted these findings,[10,14] the general consensus is that postural deficits occur as a result of ankle injuries.[6,7,13,19,31,32]

The postural control deficiency that seems to exist in participants with ankle instability may be due to a variety of factors. Generally, postural equilibrium is established by the integration of three components: afferent information from the vestibular, visual, and somato-sensory systems, interpretation of the afferent information into a motor command, and finally efferent information that produces the actual movement.[33] If any of these components are disrupted postural control will be affected. Freeman initially hypothesized that de-afferentation, disruption of afferent information from the mechanorecptors, occurs following an ankle injury and this may produce postural control deficits.[26] While little evidence has been produced to support this theory it continues to be reported. One potential explanation is that, following an inversion stress to the ankle joint, the mechanoreceptors located within the ligaments and joint capsule may be stretched. Additionally the afferent nerve fibers, which distribute the sensory information, may also be damaged. One or both of these functions would reduce the afferent information and potentially affect postural control.[33]

Other symptoms such as decreased range of motion, decreased strength, increased joint laxity, increased swelling, and increased pain that are often present in functionally unstable ankles or following acute lateral ankle sprains, may have contributed to decreased postural control. Since standing posture is maintained by a combination of hip and ankle strategies,[32] such symptoms at the ankle may significantly impact postural control. However, to date, little research has been done to see how these individual ankle symptoms may affect postural control.

CONCLUSION

The BESS is an effective measure to detect postural control deficits in functionally unstable ankles. Additionally, it is an easy to use and interpret test that can be used to determine who may be predisposed to ankle injuries in the future. Future research should be done with other joint pathologies, specifically knee joint injuries, to see if this test is sensitive in detecting more proximal joint pathologies. The length of time that deficits exist following injury (ie, recovery curves) and measurable improvements following rehabilitation or training are also important directions for future research.

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