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# Comparison Between Single and Combined Clinical Postural Stability Tests in Individuals With and Without Chronic Ankle Instability

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# Comparison between single and combined clinical postural stability tests and self-reported ankle instability in individuals with and without chronic ankle instability


## ABSTRACT

**Objective:** To determine if a single or/and combined clinical tests match group membership based on self-reported ankle function. **Design:** Cross-sectional. **Setting:** Biomechanics Laboratory. **Participants:** From participants, 58 meeting inclusion/exclusion criteria were divided into a Chronic Ankle Instability (CAI) group (n=25) who reported ≤ 25 on the Cumberland Ankle Instability Tool (CAIT) and a history of moderate-severe ankle sprain(s) and a control group (n=33) who reported ≥ 29 on the CAIT and no history of ankle sprain(s). **Interventions:** Participants completed the following clinical tests: Foot Lift Test (FLT), the Star Excursion Balance Test (SEBT), the Single Leg Hop Test (SLHT), and the Time in Balance Test (TIB) in a randomized order. A linear regression model was applied to determine measures that matched ankle group membership. **Main Outcome Measures:** The mean of SEBT reach distance was normalized to % leg length. The mean of number of errors in the FLT was recorded. The SLHT and TIB were reported as time in seconds, and the means were calculated. **Results:** The most parsimonious combination of tests (SLHT and SEBT) resulted in correctly matching 70.69% (41/58) of participants into groups, which was significantly better than chance. The multiple correlation coefficients (R value) for combining the SLHT and SEBT was 0.39. **Conclusions:** Using SLHT and SEBT resulted in improved recognition of participants designated into the CAI or control groups. Self-report perception of ankle function provides limited information for clinicians and researchers. Using multiple clinical function tests may be more helpful in determining deficits and intervention effectiveness. **Word Count**: 250

**Key Words:** ankle sprain; clinical tests, star excursion balance test, single leg hop test

## INTRODUCTION

Lateral ankle sprains are among the most common injuries incurred during sports participation.[1,2] An initial ankle sprain often result in repetitive ankle sprains,[3] with approximately 80% of individuals experiencing re-spraining of the ankle after their first ankle sprain.[1] Repetitive ankle sprains may have serious long-term consequences, including Chronic Ankle Instability (CAI)[3] and Osteoarthritis. CAI can be defined as the sensation of "giving way" at the ankle and as "repetitive lateral ankle instability resulting in several ankle sprains".[3,4]

The primary ligamentous cause of osteoarthritis (OA) at the ankle joint is repeated ankle sprains.[5] Preventing repeated ankle sprains, and CAI, may be an important step for decreasing risk of OA at the ankle joint.[6]

Currently CAI is identified primarily through self-report questionnaires regarding perception of function and clinical history.[7] The CAIT showed excellent test-retest reliability ($ICC_{2,1}$=0.96)[8] and is recommended to help identify individuals with CAI by the International Ankle Consortium and National Athletic Trainers' Association (NATA) position statements.[7,9] However, CAI has also been linked to deficits in postural control and physical function in hopping and changing directions during sports activity.[10,11] Relying solely on subjective self-report measures to assess a clinical condition is not recommended, and the NATA advocates applying functional tests to assess patients.[9] The International Ankle Consortium also states that as a multi-factorial problem, multiple types of assessments are necessary in research and clinical practice.[7] Finding clinical tools that are effective in identifying the presence of CAI in addition to self-report questionnaires may be useful to clinicians and researchers.[4,11]

Non-instrumented clinical postural stability tests may be one option and have shown some utility in assessing CAI.[11] Clinical tests have the advantages of being inexpensive, quick to administer, and are feasible in clinical and field settings.[12] However, non-instrumented clinical postural stability tests including up-down hop, single hop, triple-crossover hop for distance, shuttle run, and figure-8 hop have demonstrated mixed results in identifying performance differences among those with our without CAI.[13,14] Currently, there is no consensus whether a single or combination of clinical tests can accurately and objectively identify those with CAI.

Clinicians should be able to appropriately identify objective tests which may be effective at assessing initial deficits in performance and effectiveness of rehabilitation interventions, in cooperation with self-report function questionnaires. Therefore, the purpose of our study was to compare clinical postural stability tests independently and/or in combination with self-reported ankle instability scores among individuals with and without CAI to determine which tests could best match self-report perception of function. Our hypothesis was that single and combined clinical postural stability tests would effectively match with individuals' perceptive ankle condition either CAI or non-CAI based on the CAIT self-reported ankle instability questionnaire.

## METHODS

### Participants

An *a priori* sample size estimation was performed (G*Power, Version 3.1.5, Kiel, Germany) with statistical power = 0.80, $P \leq 0.05$ for an independent samples design. Nine participants were calculated to be needed in the CAI and control groups with effect size 1.41 using the mean and standard deviation data presented in a similar study using a single leg hop test with 9 participants.[15] Based on table data from a second, similar study using a multiple-hop test, sample size was 10 in each group with effect size 1.36.[16]

A total of 65 participants between 18 and 25 years of age and participated in physical activity, such as running, walking, lifting weights, or playing sports, for at least 90 min per week were recruited from physical activity classes and club sport teams at a large university. The researcher provided an orientation to participants regarding the test procedures, and participants provided informed consent.

Participants were classified into two groups. The CAI group included the following: reported ≤ 25 on the CAIT questionnaire, a history of moderate-severe ankle sprain(s) that required at least 3 days of partial or non-weight bearing, and/or a history of "giving way" with activity.[17,18] Participants who reported ≥ 29 on the CAIT questionnaire and no history of ankle sprain(s) and "giving way" were placed into the Control group.[19] Participants who had a history of fracture and/or surgery in their lower extremity and suffered any type of other lower extremity injury in the last 3 months were excluded from the study prior to data collection.[7] Data from 58 participants were included for analysis based on inclusion and exclusion criteria (Figure 1) which include the critical information and a comprehensive description for the research participants recommended by the International Ankle Consortium[7]. Our sample size is well within the established limits for meaningful outcomes comparisons of interest. Demographics are reported in Table 1.

**Data collection procedures**

Following informed consent, participants who met the inclusion completed the Cumberland Ankle Instability Tool (CAIT).[8] The participants' age, gender, and leg lengths were measured.

Participants completed clinical tests, including the Time in Balance Test[20] (TIB), Foot Lift Test[21] (FLT), Star Excursion Balance Test[22] (SEBT) and Single-Leg Hop Test[23,24] (SLHT), in a randomized order. These tests were selected based on previous research that demonstrated deficits in performance in CAI groups because they would be easy to perform in clinical settings.[20-22,24] Also, these clinical tests can be classified into different subsets including static, semi-dynamic, and dynamic tasks. Performance of the TIB, FLT, and SLHT were videotaped with consumer DCR-TRV280 Digital Video Camera Recorder (290K Pixels; Sony®, San Diego, CA).

**Non-Instrumented Postural Stability Clinical Tests (Clinical Tests)**

*Time in Balance Test*

Participants performed the TIB on a stable surface in a single-leg stance according to published directions.[20] Participants were instructed to keep their eyes closed and their hands on their hips (at the iliac crests), and remain motionless for as long as possible up to 1 minute. A single rater blinded to injury history and group membership viewed the video at a later date and used a stopwatch to time how long a participant was able to remain in the testing position. The rater stopped timing when the participant lost balance or made an error such as moving the testing foot or touching the floor with the un-tested foot. Three trials were collected on each foot. The maximum length of the test was one minute in each trial. The mean of three trials was used as the TIB score.[20]

*Foot Lift Test*

For the FLT, participants stood in a single-leg stance on a stable surface same as the TIB. Participants maintained their balance without opening their eyes and using their other extremities for 30 seconds. Entire testing performance were videotaped. After testing, the single rater watched the video and scored the number of foot lifts, or part of foot lifts.[21] A “part of foot lift” can be described as lifting any part of the foot such as toes or heel, from the surface.[21] Also, if the un-tested foot touched the floor, this was considered an error.

*Star Excursion Balance Test*

Prior to performing the SEBT, leg length was assessed in a supine position from the medial malleolus to the anterior superior iliac spine of each limb to normalize maximum reach distance to limb length.[25] Only the posteromedial (PM) (Figure 2) component of the SEBT was performed in a single-leg stance because PM component reach distance was the most highly representative of all 8 components of SEBT in individuals with and without CAI.[22] In order to save time in the larger study and avoid fatigue, only this direction was selected for testing. Participants stood barefoot at the center of a grid where two lines were extended at 45° angle from the center to PM direction and marked by athletic tape. Participants were instructed to reach with one foot in the PM direction, while maintaining a single-leg stance with the testing leg.[22] Participants had 3 practice trials before test trials. For data collection, participants performed 3 trials on each foot in a randomized order. The mean distance from the 3 trials was used as the score of a participant.

*Single Leg Hop Test*

The participants also performed the SLHT. Participants were instructed to complete a task of lateral hopping (30 cm distance between start point and end point) and then come back to the point where they started for 10 repetitions as fast as they could while meeting the required distance.[24] After testing, a single rater watched the video and recorded the finish time to the nearest 0.01 second. Participants completed 2 trials without a practice trial. A 1-minute rest break between tests was provided to avoid fatigue.[20,21,24]

Rater reliability for the single rater scoring the SLHT, FLT, TIB, and SEBT was established prior to data reduction to ensure consistent scoring across participants. The rater developed a set of criteria for each test, determined by published instructions. A single rater, blinded to injury history and group membership scored all the tests. The rater viewed 20 preliminary participants' videos, scored them, and then viewed the video again 1 week later. The rater scored the video again, blinded to the initial score. Intra-class correlation coefficients ($ICC_{2,1}$) for tester reliability and standard error of measurement (SEM) were calculated for TIB, FLT,SLHT, and SEBT in Table 2.[26] The value of $ICC_{2,1}$ with a consistency of 1.0 is in perfect agreement.[27] All videos were played through Windows Live Movie Maker® (Version 12, Microsoft, Redmond, WA).

**Data Reduction and Analysis**

Means and standard deviations were calculated for participants' demographics and performance on each clinical test. An alpha level of $p \leq 0.05$ was set a priori to indicate statistical significance. Effect sizes (Cohen's *d*) and Power (1-ß) were also calculated. Pearson product-moment correlation coefficients (Pearson's r values) were calculated to demonstrate the relationship between clinical postural stability measures.

Logistic regression analysis and linear discriminant analysis are equivalent when only two groups are used (CAI and Control group).[28] Linear discriminant analysis was selected because it is appropriate for normally distributed explanatory variables, as these data were. Linear discriminant analysis was used to determine which of the clinical tests best matched group membership (CAI or Control group).[29] R (multiple correlation coefficients) values indicated the strength of the association between the dependent (ankle condition) variable. The group membership coded score was 0 = CAI and 1 = Control. Matched scores were rounded to 0 when the matched values was less than .5 while a matched score of .5 or higher was rounded to 1. Number and percentage of correctly matched group memberships were calculated, and a Z score was calculated to determine if the identification was better than chance. Chance was defined as 50%. The statistical hypothesis was that percent of correct identification of membership was 50% and the alternated hypothesis was "better than chance," or greater than 50%. An alpha level of $p \leq 0.05$ was set *a priori* to indicate statistical significance. The Statistical Package for the Social Sciences™ 20.0 (SPSS, Inc., Chicago, IL) was used to perform all statistical analyses.

**Ethical Considerations**

This research project was approved by the University of Georgia Institutional Review Board (Study ID#2010103164).

**RESULTS**

There were no significant differences in means and standard deviations for the demographic characteristics (Table 1). The ICCs for rater reliability in the TIB, FLT, and SLHT and scores in the SEBT are reported in Table 2. Pearson's *r* values (Table 3) indicated that clinical postural stability tests were not correlated except for the relationship between the SLHT and SEBT ($P<0.05$)

Clinical tests associated with the self-reported ankle condition that were statistically better than chance included a combination of 4 clinical tests (TIB, FLT, SLHT, and SEBT), 3 clinical tests (TIB, SLHT, and SEBT), or 2 clinical tests (SLHT and SEBT), indicated by a significant value of the Z-test on a proportion ($Z \geq 1.65$). Approximately 70.69% (41/58) of participants in the CAI and control group based on the self-reported ankle score were correctly assigned to groups by combinations of 4, 3, 2 clinical tests, while chance assignment would be

50%. The most parsimonious model would then be 2 clinical tests (SLHT and SEBT). The multiple correlation coefficients (R value) for the regression equation, and number and percentage of correctly matched group memberships are reported in Table 4.

## DISCUSSION

Our most important finding was that combining scores on 4 clinical tests (TIB, FLT, SLHT, and SEBT), 3 clinical tests (TIB, SLHT, and SEBT), and 2 clinical tests (SLHT and SEBT) revealed the same and the highest percentage of correct matched value for CAI versus control group membership. It appears a test item cluster of 2 to 4 clinical tests best captures functional performance as it relates to CAI self-report. The SEBT showed the highest matched value as a single clinical test. The percentages of correct match were significantly better than chance (Table 4).Therefore, using two clinical tests (SLHT and SEBT) for assessing CAI may be considered the most clinically efficient while maintaining a relatively high level of accuracy. While the results are lower than a preferred clinical accuracy of at least 80%, they are on par with the clinical utility of other functional tests in this population (65 %).[11,30,31] Currently, no gold standard clinical test or tests can be recommended for identifying group membership in those with and without CAI, and a combination of tests may be most appropriate as an objective measurement.

To our knowledge, no previous studies have utilized a single clinical test and/or combined clinical tests to match with group membership based on a self-report questionnaire. Researchers[11,24] have suggested future studies should determine whether clinical tests may be useful to identify group membership, and to determine the best combination of clinical tests (postural-stability tests) to identify group membership and establish a guide for CAI, which we have undertaken.  Previous studies[12,24] have only conducted correlations between self-report questionnaire scores and clinical tests and/or to identify postural stability deficits using clinical tests.[11] While correlational relationships are relevant, and important step is determining clinical utility of specific tools in order to make recommendations to clinicians. Our findings are a first step in this process, demonstrating that 2 clinical tests have moderate usefulness in matching to accepted group criteria.

Clinicians need to use objective measures which demand actual performance ability from athletes throughout rehabilitation protocols to determine progress.REF14 Although clinical tests are recommended for use in making decisions for return-to-play (RTP), the clinical tests should not be applied as sole, independent measures. Each clinical test may provide alternate information and combining tests shows a higher percentage of correct group membership identification than any single test. Our findings support test item clustering and offer evidence that clinical tests may be used to offer information about presence of CAI and possibly responsiveness to intervention.

Based on the results, we recommend clinicians use multiple clinical test to identify CAI group membership. Applying combined clinical tests may provide more accurate and objective information for identifying group membership into CAI versus control groups based on the self-report questionnaire. Specifically, our findings suggest that clinicians may use the SLHT and SEBT together, which was the most parsimonious model from our study, as screening tools to match up with group membership based on the self-report questionnaire.

## Limitations

Limitations include the use of self-report injury history for the ankle and the low power and moderate effect size on some tests. The correct identification percentage was below 80% and the multiple correlation coefficient values were classified as “weak associations”. This may be due to the nature and different demands of each clinical test, including rotary or multiplanar demands.[32] The narrow age range utilized also limits generalizability to other populations. Therefore, the application of these tests to match up with individuals with CAI based on the self-report questionnaire should be done with caution.

## CONCLUSION

We suggest clinicians seeking to determine if a patient has functional deficits secondary to CAI apply combined clinical tests (SLHT and SEBT) as their first step of evaluation and assessment. The clinical tests can be used to quickly and objectively evaluate a patient and appear to have some clinical usefulness. Clinicians may use the combination of clinical tests to quantify functional deficit more objectively than relying solely on self-report measures. While self-report is valuable, information regarding objective function provide a more complete picture for clinicians.

Future prospective and treatment efficacy studies could use test item clusters to help determine clinical course after injury and comparative effectiveness of treatment. Developing cutoff score for single and combined clinical tests may help to use specific cutoff score to identify individuals with CAI for clinicians.

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