INTERNATIONAL JOURNAL OF -EXERCISE SCIENCE-

Original Research

The Impact of Chronic Ankle Instability on Functional and Perceived Single-leg Balance Control

Camden Hutchinson*, Kobe Roberson*, Jordan Alexander*, Cole Cave*, You-jou Hung‡

Department of Physical Therapy, Angelo State University, San Angelo, TX, USA

*Denotes student investigator, ‡Denotes established investigator

Abstract

International Journal of Exercise Science 19(3): 1-11, 2026. *https://doi.org/10.70252/IJES2026302*

The purpose of this study was to determine whether individuals with chronic ankle instability (CAI) perform worse than those without CAI on four balance tests and the visual analog scale (VAS) ratings for perceived stability, and to examine correlations between ankle stability and balance test performance. Fifty-one participants volunteered in this study. Group assignment was determined using the Cumberland Ankle Instability Tool (CAIT). Participants performed four tests in randomized order: the Y-Balance Test (YBT), the Athletic Single-Leg Stability Test (ASLST), the Time-in-Balance Test, and the Side Hop Test. Perceived stability was recorded after each test using the VAS. Participants with CAI had significantly worse ankle stability than those without CAI ($p < .001$). For the Time-in-Balance Test and the Side Hop Test, no significant difference was found in either physical tests or perceived stability. For the ASLST and the YBT, no difference was found in the physical performance. However, participants without CAI perceived significantly superior stability in both tests compared to those with CAI ($p = .026$ and .040, respectively). Correlation analysis showed that neither the physical scores nor the VAS had a strong correlation with the CAIT scores. Participants with CAI performed as well as those without CAI in the static balance test, dynamic balance test, and functional performance. It suggests that ankle integrity may not play a significant role in overall single-leg balance control in healthy young adults.

Keywords: Neuromuscular, perception, stability, proprioception, stance

Introduction

Acute ankle sprains have been noted to be the most prominent musculoskeletal injury, with approximately two million injuries occurring annually in the United States alone.[1] The actual prevalence of ankle injuries could be much higher than reported because individuals who experience an ankle sprain often do not seek medical care.[2] These types of injuries have occurred at a much higher rate in active individuals and in sports that involve jumping, such as basketball and volleyball.[1] Moreover, after the initial ankle injury, individuals are three and a half times more likely to have a recurrent ankle sprain in the future.[2] The high recurrence rate of ankle injury is most likely due to the increased laxity of the ankle ligaments as well as decreased proprioception of the ankle. In addition, recurrent ankle sprains could further develop into chronic ankle instability (CAI). CAI is most appropriately characterized by experiencing recurrent sprains, perceived instability, and mechanical instability of the ankle. It can be diagnosed by using the Cumberland Ankle Instability Tool (CAIT), in which a score of 25 or less indicates

*Corresponding Author: You-jou Hung; Email: yhung@angelo.edu

having CAI.[3] Gribble et al. (2016) reported that 40% of individuals who experienced an ankle sprain later developed CAI one year after their injury.[4] Because of the high prevalence of ankle sprains and CAI, it is important to examine their impact on functional activities such as single-leg balance control.

The ankle joint plays a very important role in movement and balance control. As the ankle is a key component of the lower extremity kinematic chain, any disorder that hinders its load-bearing capabilities will impact the lower extremity and potentially the whole body. Therefore, it stands to reason that any deficiency of the ankle can result in serious hindrances to balance control. One of the key pieces in maintaining balance control is ankle proprioception. Studies have shown that central processing of ankle proprioceptors is crucial in maintaining proper balance.[5] Therefore, compromised proprioception may lead to balance deficits in individuals with CAI. In addition to hindering physical performance, proprioception deficits at the ankle joint can also contribute to further injury by compromising the ankle strategy that helps to regain our balance control when encountering perturbations.[6] It is well documented in the literature that training balance capabilities at every stage of ankle healing can help to increase ankle proprioception and therefore reduce future injuries.[5]

Many balance tests have been developed to examine balance control for different populations throughout the years. Some balance tests are considered static (such as the Time-in-Balance test), in which participants remain still during the test. For dynamic balance tests (such as the Y-Balance Test), participants do not remain still during the testing. However, there is limited direct comparison between the validity of various physical testing methods for assessing balance. Moreover, whether a specific balance test is appropriate also highly depends on the population (such as age, pathology, and activity level). Several studies have examined the validity of various balance tests individually or in comparison with others.[7,8] Pickenbrock et al. (2015) concluded that the static balance test was equally valid and more reliable than the Berg Balance Scale, which is considered the gold standard for balance assessment in older adults.[7] In addition, Linens et al. (2014) reported that seven balance tests (the Balance Error Scoring System, time in balance, foot lift, single-legged stance on a force plate, Star Excursion Balance Test, side hop, and figure-of-8 hop) were valid in assessing CAI but provided no conclusion on which test was superior to the others.[8] In comparison to the traditional static and dynamic balance testing, functional performance tests (FPTs), such as the Side Hop Test, provide quick, easy-to-administer assessments that offer insight into how patients perform in more practical situations.[9] Additionally, FPTs better prepare patients for the challenges and movement perturbations they encounter in their daily lives. However, it is unclear if functional balance testing can better detect individuals with CAI than static/dynamic balance testing, especially for a younger population who can perform some of the more challenging tests, such as the Side Hop Test.

The subjective Visual Analog Scale (VAS) for perceived stability is another practical tool in the assessment of CAI. Madsen et al. (2018) concluded that VAS discerned individuals with CAI more effectively than some FPTs.[10] This underscores the importance of subjective assessment tools, such as the VAS, in capturing nuances of patient experience that may not be fully captured by objective measures alone. Objective physical testing results offer valuable insights into biomechanical and functional aspects of ankle stability, but may fall short of capturing the subjective experiences of individuals with CAI. Conversely, the VAS allows patients to directly express their perceived level of instability, providing a holistic understanding of their condition. Studies indicate that the VAS correlates well with other measures of ankle stability, including objective functional tests and clinical assessments.[11] Its subjective nature enables it to capture subtle changes in symptoms and perceived instability over time, making it a valuable tool for monitoring the progression of CAI and evaluating the effectiveness of rehabilitation interventions. Furthermore, the VAS provides

clinicians with crucial information regarding patient-reported outcomes, guiding personalized treatment plans tailored to individual needs and experiences. In addition to objective physical balance tests (such as the Side Hop Test), it is unclear if the subjective VAS can also accurately reflect ankle stability status in young adults.

The first objective of this study was to examine whether individuals with CAI perform significantly worse than individuals without CAI in static/dynamic balance tests, functional performance, and perceived stability. The second objective was to examine the correlation between ankle stability and other balance test results and perceived balance control. We hypothesized that individuals with CAI would perform worse in all balance tests and perceived balance control. We also hypothesized a positive correlation between CAIT scores and other balance testing, especially for perceived balance control with the VAS.

Methods

Participants

Fifty-one participants (aged 19-30 years; 19 males and 32 females) participated in this study. The inclusion criteria included 1) being aged 18-65 years, 2) having a functional range of motion to complete all tests, and 3) being capable of single-leg balance and hopping. The exclusion criteria included 1) having any acute lower extremity injury that would prevent the participant from safely completing all tasks, 2) having to wear a prescribed ankle brace or other assistive device, 3) having undergone any lower extremity surgery in the past 6 months, 4) having any neurological condition affecting lower extremity proprioceptive input, and 5) having any vision and vestibular deficits that impact balance control. Based on the results of the CAIT, 25 participants (aged 23.40 ± 2.47; 12 males and 13 females) were classified as having CAI, and 26 participants (aged 23.42 ± 2.27; 7 males and 19 females) were classified as having no CAI. Sample size was estimated using G*POWER 3.1.9.7 (Universitat Kiel, Germany) software. For two independent groups, using an effect size of 0.8, a statistical power of 80%, and an α of 0.05, the estimated sample size was 26 participants per group.[12] All participants signed the informed consent approved by the IRB of a local university. This study was carried out fully in accordance with the ethical standards of the International Journal of Exercise Science.[13]

Protocol

This study is an observational research with a cross-sectional design. Four outcome measures were used to examine single-leg balance in this study. The Cumberland Ankle Instability Tool is a test to measure chronic ankle instability. The test is a subjective measure with scores ranging from 0-30, with 30 being the best. A score of 25 or less indicates chronic ankle instability (CAI). The sensitivity of the test is 96.6% and the specificity is 86.8%.[14] Stemmed from the Star Excursion Balance Test, the Y-Balance Test (YBT) is a single-leg balance test that measures dynamic balance in the anterior, posteromedial, and posterolateral directions. The Athletic Single-Leg Stability Test (ASLST) with the Biodex Balance System was chosen because it measures the static single-leg balance on a multi-axial platform that has various instability levels, which is unique from other balance testing. The Time-In-Balance Test was chosen because it represents a commonly implemented single-leg balance testing protocol, and the Side Hop Test was chosen because it represents a functional testing protocol.[8] The YBT has a good intra-rater reliability (.85-0.91) and inter-rater reliability (0.81-1.00).[15] The ASLST provides an overall performance in both the anterior-posterior and medial-lateral directions. A greater number of the stability index correlates with more difficulty in controlling balance.[16] Wendy et al. (2009) reported great reliability (r = .94) for the overall stability measurement.[17] Arifin et al. (2014) also reported excellent test-retest reliability (ICC = .94).[18] The Time-In-Balance Test (eyes closed) is a single-legged balance test.

The test has a participant stand on a firm surface with eyes closed and is used to determine the period that a participant can remain motionless in a single-leg stance before moving the test foot or touching the floor with the opposite limb. The maximum length of a trial is 60 seconds.[19] The ICC measures for test-retest had moderate reliability with scores of 0.609.[20] The Side Hop Test is a functional performance test that mimics dynamic movements in sports settings. The test requires a 30 cm area marked by tape on each side of the participant. The participant will be timed jumping over the designated area and back to the starting point 10 times on a single testing limb as fast as possible while being timed.[20] Greater instability of the ankle is linked to longer times during testing. The intra-rater ICC of the Side Hop Test ranges from 0.63 to 0.67, the inter-rater ICC ranges from 0.83 to 0.91, and the test-retest reliability is good in adults (ICC = 0.84).[20]

After participants signed the informed consent form, the examiners screened participants based on the inclusion and exclusion criteria to determine if they met the requirements for the study. Once the eligible participants were selected, they completed a CAIT questionnaire for both legs. The examined leg was the leg that had the worst CAIT score, but still met all our recruitment criteria. After the CAIT questionnaire was completed, the examiners assigned the participants to groups based on their CAIT score. One group included participants with CAI, and the other group included participants without CAI.

Participants performed four designated balance tests in a randomized order to prevent potential bias, and each test was measured by the same researcher to enhance intra-rater reliability. All tests will be performed on the examined leg. After each test, the participant was asked to look at a VAS chart and pick a number (from 0 to 100) to identify their perceived stability during the test. The number 0 represents the best stability (100% stable, no fall risk), and the number 100 represents the worst stability (definitely will fall). The same scale was presented to the participants after each test.

For the Y-Balance Test, participants stood on a platform with their examined leg (Figure 1). The participants pushed 3 blocks (reach indicators) with their non-examined leg in the anterior, posteromedial, and posterolateral directions as far as they could without placing their reaching foot down.[21] Participants were allowed to raise the heel of the balancing/examined limb during the testing. The participants were asked to practice three times in each direction, followed by three official trials with measurements being recorded (the distance of the "reach indicator" being moved) at the nearest half-centimeter. If the participants touched down with their reaching limb, failed to return to the starting position, or removed their hands from their hips, they would perform another trial immediately.[20] To normalize the data according to a participant's height, the leg length (from the anterior superior iliac spine to the medial malleolus) of the examined leg was measured in the supine position with a soft tape. To calculate the score, the average reach distance of the 3 official trials was divided by the participant's leg length.

For the Athletic Single-Leg Stability Test (ASLST) using the Biodex Balance System (BBS), participants stood with the examined limb and balanced on the multiaxial standing platform on level four (medium difficulty by the default setting; Figure 2A).[18] Using the visual feedback from the monitor, participants tried to keep their center of gravity at the center of the target for 20 seconds. Before each testing procedure, the participants would perform three practice trials followed by three official trials. There was a 10-second break between each trial during testing.[16] The leg not on the platform was in a slightly flexed position, avoiding contact with external surfaces. The result for each trial (Biodex Stability Index in degrees) was individually recorded, and the average of the three testing trials was taken for data analysis. For the Time-In Balance test, participants had their eyes closed with their testing limb on a firm surface (Figure 2B). Participants balanced on the examined leg for as long as possible without losing their balance, with 60 seconds

being the maximum amount of time. The timer began when the non-tested foot left the ground and was stopped as soon as the foot was returned to the ground. The participant completed three trials, with the longest trial being used for analysis.[22] For the Side Hop Test, using their examined leg, participants hopped laterally over the 30 cm identified area (marked by tape) and back to the starting position 10 consecutive times as quickly as possible without losing balance while being timed (Figure 2C). The participant performed two successful trials, with the fastest time being recorded for data analysis.[23]

A. **B.** **C.**

Figure 1. The three directions of the Y-Balance Test (YBT). 1A: anterior; 1B: posteromedial; 1C: posterolateral.

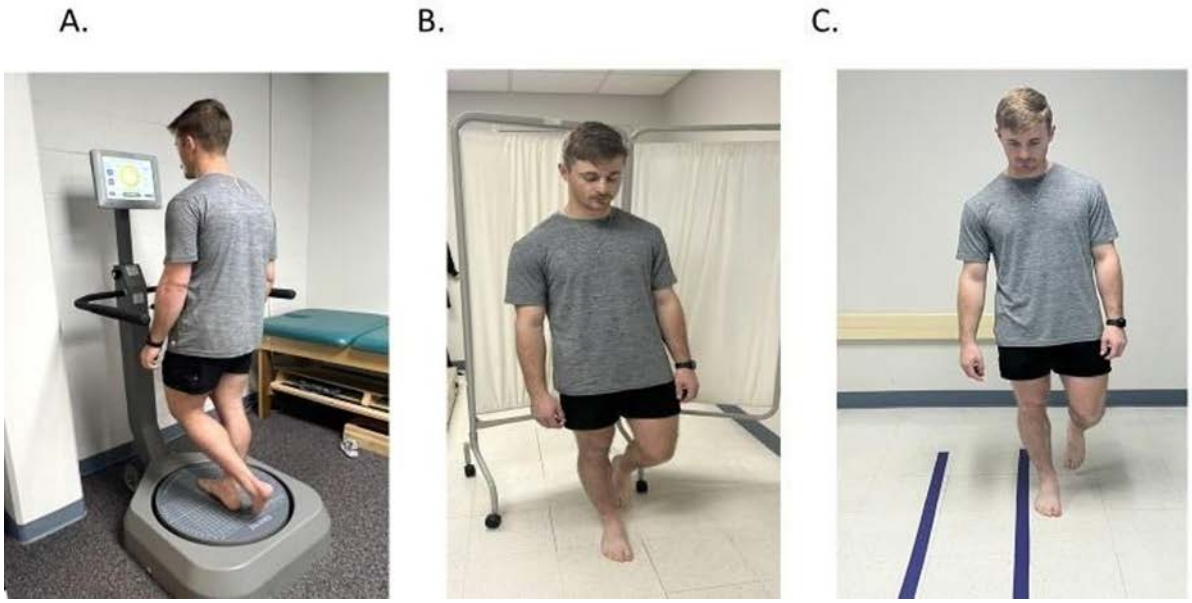


Figure 2. Balance tests. 2A: Athletic Single-leg Stability Test (ASLST); 2B: Time-in-Balance Test; 2C: Side Hop Test.

Statistical Analysis

Data were analyzed using IBM SPSS version 26 (IBM Corp, Armonk, NY). The Shapiro-Wilk test was initially conducted to examine data normality. Based on these results, the Mann-Whitney

U-test was used to examine non-normally distributed data (CAIT, Time in Balance, Side Hop Test, Side Hop Test VAS, ASLST, ASLST VAS, YBT VAS), while the Independent T-test was used for normally distributed data (Time in Balance VAS, YBT). Spearman's correlation was used to examine the relationships between CAIT scores and all other physical and perceived balance measures. The significance level (p-value) was set at 0.05 for all comparisons.

Results

Participants with CAI demonstrated significantly lower scores (worse ankle stability) on the CAIT than those without CAI (z = -5.794, $p < .001$; Figure 3) with a large effect size ($r = -.811$). According to Cohen (1988), the effect size r is classified as small (.10), medium (.30), and large (.50); and the effect size d is classified as small (.20), medium (.50), and large (.80).[23] For the Time in Balance Test, no significant difference was found between those with and without CAI in both physical tests (z = -1.358, $p = .175$, $r = -.190$; Figure 4A) and perceived stability (t = 1.496, $p = .141$, $d = .213$; Figure 4B). Similarly, no significant group differences were found in the Side Hop Test for both physical performance (z = -.235, $p = .814$; $r = -.033$, Figure 5A) and perceived stability (z = -.516, $p = .606$, $r = -.072$; Figure 5B). For the ASLST, all three physical measures showed no significant differences between groups (z = -1.726, $p = .084$, $r = -.241$ overall; z = -1.822, $p = .068$, $r = -.255$ anterior-posterior; z = -1.218, $p = .223$, $r = -.171$ medial-lateral; Figure 6A). However, participants without CAI perceived significantly superior stability for the ASLST compared to those with CAI (z = -2.219, $p = .026$; Figure 6B) with a medium effect size ($r = -.311$). For the YBT, there were no significant differences in group performance across all directions tested (t = 1.117, $p = .269$, $d = .159$ anterior; t = -.611, $p = .544$, $d = -.087$ posteromedial; t = -.011, $p = .991$, $d = -.002$ posterolateral; t = -.281, $p = .781$, $d = -.041$ composite; Figure 7A). However, participants without CAI perceived significantly superior stability compared to those with CAI (z = -2.052, $p = .040$; Figure 7B) with a small effect size ($r = -.287$). Correlation analysis indicated that none of the physical and perceived balance test scores had a strong correlation with the CAIT score (r_s ranging from .002 to .415). However, the correlations between the VAS of the Y-Balance test and the CAIT ($r_s = -.376$) and the correlation between the VAS of the ASLST and the CAIT ($r_s = -.399$) were both significant ($p < .05$).

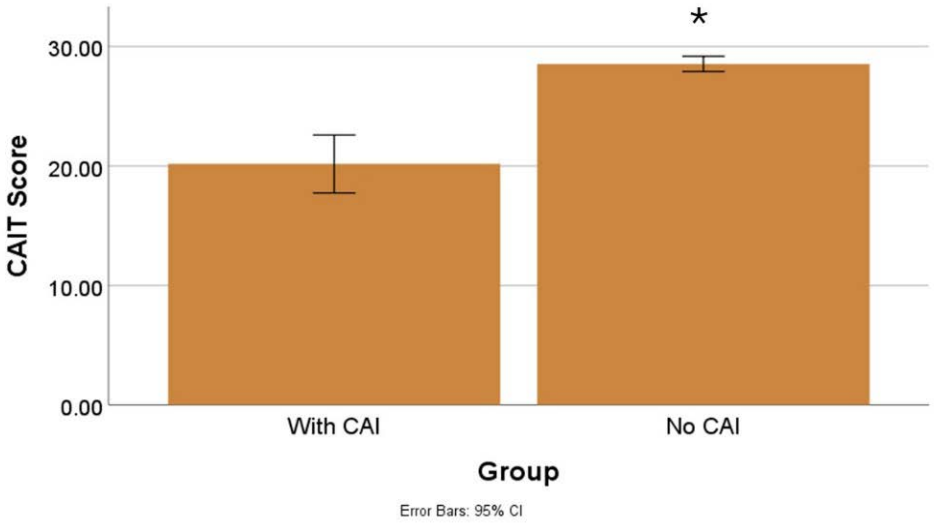
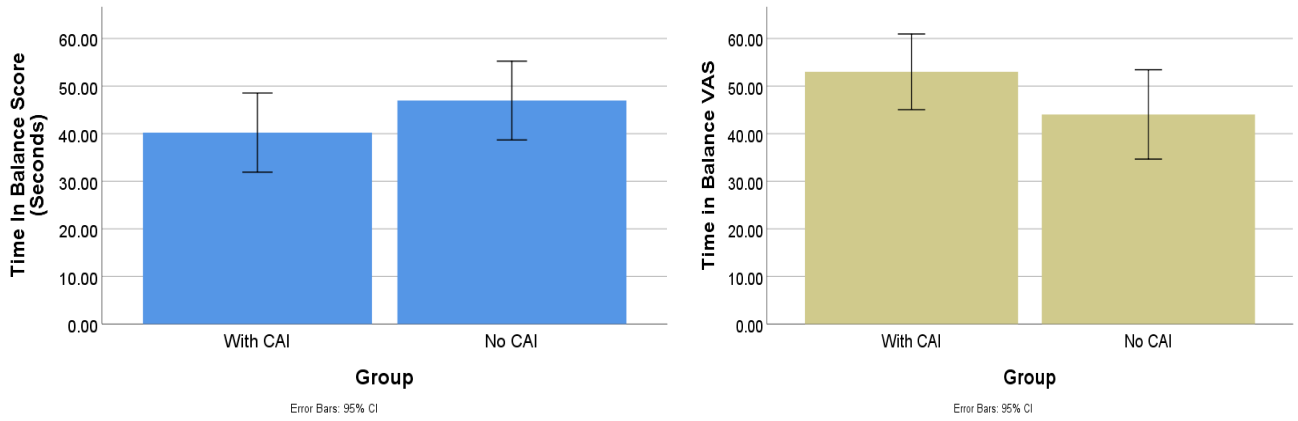
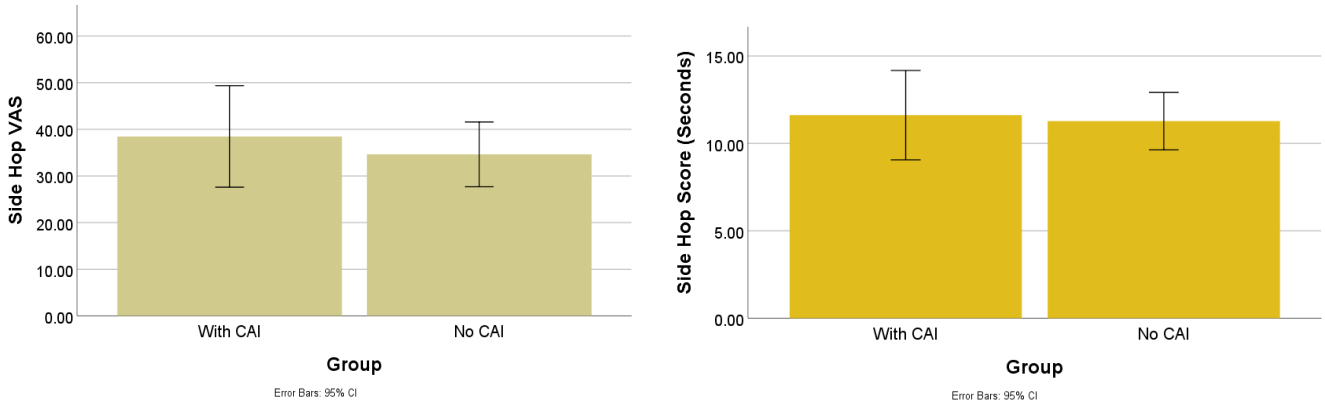


Figure 3. Cumberland Ankle Instability Tool (CAIT) scores for participants with and without Chronic Ankle Instability (CAI). The error bar indicates 95% CI. * denotes a statistically significant difference from the group with CAI ($p < .05$).



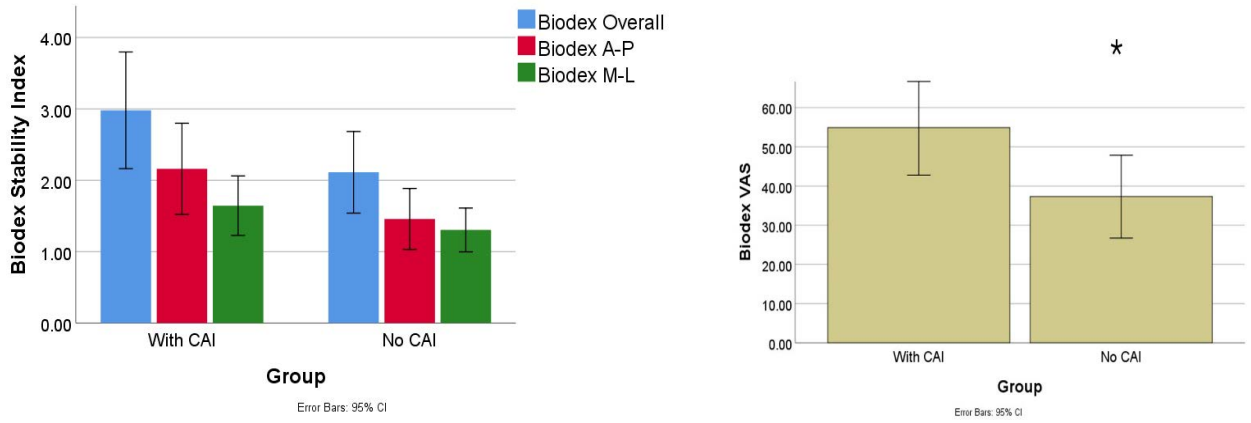
A. **B.**

Figure 4. Time-in-Balance Test scores (4A) and perceived stability Visual Analog Scale (VAS) scores (4B) for participants with and without Chronic Ankle Instability (CAI). The error bar indicates 95% CI.



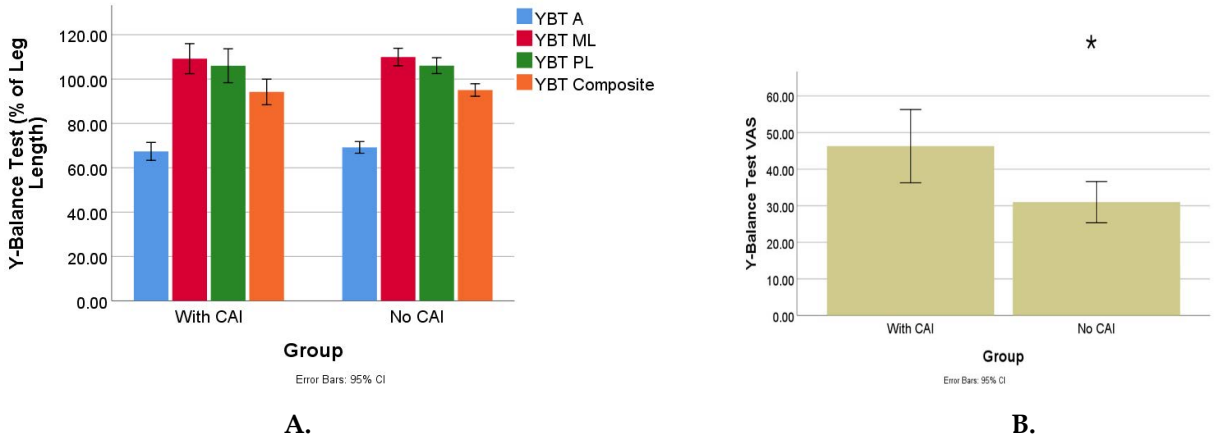
A. **B.**

Figure 5. Side Hop Test scores (5A) and perceived stability Visual Analog Scale (VAS) scores (5B) for participants with and without Chronic Ankle Instability (CAI). The error bar indicates 95% CI.



A. **B.**

Figure 6. Biodex Stability Index (in degrees) of the Athletic Single-leg Stability Test (6A) and perceived stability Visual Analog Scale (VAS) scores (6B) for participants with and without Chronic Ankle Instability (CAI). The error bar indicates 95% CI. * denotes a statistically significant difference from the group with CAI ($p < .05$).



A. **B.**

Figure 7. Y-Balance Test (YBT) scores (7A) and perceived stability Visual Analog Scale (VAS) scores (7B) for participants with and without Chronic Ankle Instability (CAI). The error bar indicates 95% CI. * denotes a statistically significant difference from the group with CAI ($p < .05$).

Discussion

This study examined whether participants with CAI exhibit differences in static/dynamic balance, functional performance, and perceived stability compared to those without CAI. Using CAIT as the classification tool, participants with CAI demonstrated significantly worse ankle stability than participants without CAI. Despite this, their performance on assessments of static balance (Time-in-Balance test and ASLST), dynamic balance (YBT), and functional performance (Side Hop Test) was comparable to participants without CAI. Those results contradict the hypothesis of the current study. However, this observation is consistent with Aguilar et al.[25] and Garza et al.[26], who reported similar balance performance between athletes (collegiate soccer players and jumping athletes, respectively) with and without CAI. Although the ankle joint is part of the lower extremity kinematic chain, its stability may not play a significant role in overall balance control in healthy young adults.[27] It is also possible that compensatory strategies, such as increased reliance on hip and core stabilization or effects from training and motivation, may reduce the impact of CAI on balance control in young adults.[25]

Participants with CAI perceived less stability on the YBT and the ASLST, which agrees with the hypothesis. Given that the CAIT classification relies on self-reported symptoms, it is reasonable for participants experiencing ankle discomfort or instability to also perceive reduced stability during single-leg balance tasks. In addition, the YBT and ASLST are not common functional activities. Anxiety related to unfamiliar movements may have influenced perceived stability ratings. Contrary to the hypothesis, similar perceived stability was reported between groups for the Time-in-Balance and Side Hop Tests, possibly reflecting the lack of difference in their physical performance.

Correlation analysis did not identify strong associations between physical/perceived balance test scores and ankle stability status (CAIT scores). This result contradicts the hypothesis. One potential explanation is that perceived ankle integrity may not play a significant role in single-leg balance control. Future studies will be beneficial to examine the correlation between single-leg balance performance and the integrity of ankle stabilizers (such as using the anterior drawer test and/or the talar tilt test to examine the ligaments that stabilize the ankle joint). It is also possible that the balance tests implemented in the study were not challenging/specific enough to address ankle stability deficits. Future research should explore the inclusion of more sport-specific or reactive balance tasks, such as agility-based movements, to better assess functional deficits in individuals with CAI.

One limitation of this study is the potential variability in participants' activity levels and ankle sprain history. That information was not collected or standardized across groups. Additionally, implemented balance tests might not fully replicate the real-world demands placed on individuals with CAI during sports or functional activities. Future studies should consider incorporating more functional and ecologically valid assessments to better understand the relationship between ankle instability, perceived balance, and physical performance outcomes.

In conclusion, this study found that although participants with chronic ankle instability (CAI) reported significantly lower ankle stability on the CAIT, their physical performance on static and dynamic balance tests and functional tasks did not differ from those without CAI. However, participants with CAI perceived significantly lower stability on the Y-Balance Test and the Athletic Single-Leg Stability Test, suggesting a disconnect between objective balance outcomes and subjective experiences of instability. These findings indicate that ankle integrity may not substantially influence balance control in healthy young adults, but perceived stability remains an important factor in understanding the impact of CAI. Clinically, incorporating both objective and subjective assessments may provide a more comprehensive evaluation of ankle stability, supported by literature that shows injury-related fear in individuals sustaining ankle sprains or CAI.[28] Future studies may be beneficial to incorporate the Fear-Avoidance Beliefs Questionnaire and Tampa Scale of Kinesiophobia in their design.[28] In addition, it may be beneficial to implement more demanding or sport-specific balance tasks, as well as physical measures of ankle stability (such as using the Anterior Drawer Test), to examine deficits associated with CAI.

References

1. Herzog MM, Kerr ZY, Marshall SW, Wikstrom EA. Epidemiology of ankle sprains and chronic ankle instability. *J Athl Train*. 2019;54(6):603-610. https://doi.org/10.4085/1062-6050-447-17

2. Kucera KL, Marshall SW, Wolf S, Padua DA, Cameron KL, Beutler AI. Association of injury history and incident injury in cadet basic military training. *Med Sci Sports Exerc*. 2016;48(6):1053-1061. https://doi.org/10.1249/mss.0000000000000872

3. Mugno AT, Constant D. Recurrent ankle sprain. *StatPearls* - NCBI Bookshelf. Published August 8, 2023. https://www.ncbi.nlm.nih.gov/books/NBK560619/

4. Gribble PA, Bleakley CM, Caulfield BM, Docherty CL, Fourchet F, Fong DT, Hertel J, Hiller CE, Kaminski TW, McKeon PO, Refshauge KM, Verhagen EA, Vicenzino BT, Wikstrom EA, Delahunt E. Evidence review for the 2016 International Ankle Consortium consensus statement on the prevalence, impact and long-term consequences of lateral ankle sprains. *Br J Sports Med*. 2016;50(24):1496-1505. https://doi.org/10.1136/bjsports-2016-096189

5. Han J, Anson J, Waddington G, Adams R, Liu Y. The role of ankle proprioception for balance control in relation to sports performance and injury. *Biomed Res Int*. 2015;2015:1-8. https://doi.org/10.1155/2015/842804

6. Blenkinsop GM, Pain MTG, Hiley MJ. Balance control strategies during perturbed and unperturbed balance in standing and handstand. *R Soc Open Sci*. 2017;4(7):161018. https://doi.org/10.1098/rsos.161018

7. Pickenbrock H, Diel A, Zapf A. A comparison between the Static Balance Test and the Berg Balance Scale: validity, reliability, and comparative resource use. *Clin Rehabil*. 2015;30(3):288-293. https://doi.org/10.1177/0269215515578297

8. Linens SW, Ross SE, Arnold BL, Gayle R, Pidcoe PE. Postural-Stability tests that identify individuals with chronic ankle instability. *J Athl Train*. 2014;49(1):15-23. https://doi.org/10.4085/1062-6050-48.6.09

9. Cook G, Burton L, Hoogenboom BJ, Voight M. Functional movement screening: the use of fundamental movements as an assessment of function - part 1. *Int J Sports Phys Ther*. 2014;9(3):396-409.

10. Madsen LP, Hall EA, Docherty CL. Assessing outcomes in people with chronic ankle instability: the ability of functional performance tests to measure deficits in physical function and perceived instability. *J Ortho Sports Phys Ther*. 2018;48(5):372-380. https://doi.org/10.2519/jospt.2018.7514

11. Safavi PS, Janney C, Jupiter DC, Kunzler D, Bui R, Panchbhavi VK. A systematic review of the outcome evaluation tools for the foot and ankle. *Foot Ankle Spec*. 2018;12(5):461-470. https://doi.org/10.1177/1938640018803747

12. Serdar CC, Cihan M, Yücel D, Serdar MA. Sample size, power and effect size revisited: simplified and practical approaches in pre-clinical, clinical and laboratory studies. *Biochem Med (Zagreb)*. 2021;31(1):010502. https://doi.org/10.11613/BM.2021.010502

13. Navalta JW, Stone WJ, Lyons TS. Ethical issues relating to scientific discovery in exercise science. *Int J Exerc Sci*. 2019;12(1):1-8. https://doi.org/10.70252/EYCD6235

14. Martin RL, Davenport TE, Fraser JJ, Sawdon-Bea J, Carcia CR, Carroll LA, Kivlan BR, Carreira D. Ankle stability and movement coordination impairments: Lateral ankle ligament sprains revision 2021. *J Orthop Sports Phys Ther*. 2021;51:CPG1-CPG80. https://doi.org/10.2519/jospt.2021.0302

15. Plisky P, Schwartkopf-Phifer K, Huebner B, Garner MB, Bullock G. Systematic review and meta-analysis of the Y-balance test lower quarter: Reliability, discriminant validity, and predictive validity. *Int J Sports Phys Ther*. 2021;16:1190–1209. https://doi.org/10.26603/001c.27634

16. Testerman C, Vander Griend R. Evaluation of ankle instability using the Biodex Stability System. *Foot Ankle Int*. 1999;20:317-21. https://doi.org/10.1177/107110079902000510

17. Cachupe WJ, Shifflett B, Kahanov L, Wughalter EH. Reliability of biodex balance system measures. *Meas Phys Educ Exerc Sci*. 2001;5:97–108. https://doi.org/10.1207/S15327841MPEE0502_3

18. Arifin N, Abu Osman NA, Wan Abas WA. Intrarater test-retest reliability of static and dynamic stability indexes measurement using the Biodex Stability System during unilateral stance. *J Appl Biomech*. 2014;30:300-4. https://doi.org/10.1123/jab.2013-0130

19. Maricot A, Lathouwers E, Verschueren J, De Pauw K, Meeusen R, Roelands B, Tassignon B. Test-retest, intra- and inter-rater reliability of the reactive balance test in patients with chronic ankle instability. *Front Neurol*. 2024;15:1320043. https://doi.org/10.3389/fneur.2024.1320043

20. Kamonseki, DH., Cedin L., Tavares-Preto J, Calixtre LB. Reliability, validity, and minimal detectable change of Side Hop Test in male children and adolescents. *Phys Ther Sport*. 2018;34(1):141-147. https://doi.org/10.1016/j.ptsp.2018.09.009

21. Powden CJ, Dodds TK, Gabriel EH. The reliability of the star excursion balance test and lower quarter y-balance test in healthy adults: a systematic review. *Int J Sports Phys Ther*. 2019;14(5):683-694. https://doi.org/10.26603/ijspt20190683

22. Chrintz H, Falster O, Roed J. Single-leg postural equilibrium test. *Scand J Med Sci Sports*. 1991;1(4):244-246. https://doi.org/10.1111/j.1600-0838.1991.tb00305.x

23. Docherty CL, Arnold BL, Gansneder BM, Hurwitz S, Gieck J. Functional-performance deficits in volunteers with functional ankle instability. *J Athl Train*. 2005;40(1):30-34.

24. Cohen J. Statistical power analysis for the behavioral sciences. Second edition. New York, NY: Lawrence Erlbaum Associates/Routledge; 1988.

25. Aguilar J, Cano C, Cunningham M, Hung Y. Ankle stability and single-leg balance control in collegiate female soccer players versus non-soccer players. ankle stability and single-leg balance control in collegiate female soccer players versus non-soccer players. *Int J Exerc Sci*. 2024;17(6):1406-1415. https://doi.org/10.70252/CQMP3296

26. Garza G, Harrison B, O'Meara T, Potts Z, Hung Y. Ankle stability and dynamic single-leg balance in collegiate jumping athletes versus non-athletes. *Biomechanics*.2024;4(3): 542-550. https://doi.org/10.3390/biomechanics4030038

27. Shumway-Cook A, Woollacott MH, Rachwani J, Santamaria V. Motor control: translating research into clinical practice. Sixth edition. Philadelphia, PA: Lippincott Williams & Wilkins; 2022

28. Suttmiller AMB, McCann RS. Injury-related fear in individuals with and without chronic ankle instability: A systematic review. *J Sport Rehabil*. 2021;30(8):1203-1212. https://doi.org/10.1123/jsr.2021-0015