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Ankle Stability and Single-Leg Balance Control in Collegiate Female Soccer Players versus Non-Soccer Players

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ABSTRACT

International Journal of Exercise Science 17(6): 1406-1415, 2024. Ankle sprains are common in female soccer players. Ankle injuries have the potential to impact balance control, which can further contribute to recurrent injuries. This study aimed to examine if female collegiate soccer players exhibited worse ankle stability and single-leg balance than female non-soccer players, and whether there was a correlation between ankle stability and single-leg balance. Eighteen female collegiate soccer players and 22 female non-soccer players participated in the study. The Cumberland Ankle Instability Tool (CAIT) was used to evaluate ankle stability. The Athletic Single Leg Stability Test (ASLST) of the Biodex Balance System was used to examine static single-leg balance, and the Y-Balance Test (YBT) was used to examine dynamic single-leg balance. Results show that 55.56% of soccer players and 9.09% of non-soccer players exhibited chronic ankle instability. The CAIT score of soccer players was significantly lower than non-soccer players ($p = .031$). There were no significant differences between the two groups in the ASLST and the YBT. Very low correlations were found between the CAIT score and any static or dynamic balance measures ($r < .094$). Female soccer players who exhibited worsened ankle stability did not exhibit compromised static or dynamic single-leg balance. Future studies should examine if soccer players have established better motor control of single-leg standing through years of training to compensate for worse ankle stability. In addition, the CAIT score alone might not accurately represent static or dynamic balance control in female collegiate soccer players.

KEY WORDS: Proprioception, neuromuscular, motor control, athletes

INTRODUCTION

Lateral ankle sprains are common in athletes, with 70% of sports-related injuries involving the ankle joint (19). The ankle joint provides considerable mobility to facilitate dynamic adjustments, which inherently compromises its stability. Moreover, the ankle is constantly under a high amount of stress during sports activities that involve running, jumping, quick movements, and direction changes (25). As a result, lateral ankle sprains are common in athletes such as basketball and soccer players. After the initial ankle sprain, compromised ligaments, joint capsules, muscles, and mechanoreceptors can impact the function of the ankle and hamper sports performance (10). In addition, ankle proprioception, range of motion, neuromuscular control (such as balance control), and strength could be further compromised with

chronic/recurrent injuries (4). All of these factors can prevent athletes from returning to play or playing to their full potential.

The recurrence rate of ankle sprains is high due to compromised mechanical constraints and neuromuscular control after the initial injury (4). It was reported that individuals with a sprained ankle are 34% more likely to experience a recurrent ankle sprain (24). Moreover, 56% to 74% of these recurrences will happen before the symptoms of the first sprain have subsided completely (19). As a result, 20% of acute ankle sprains would develop into chronic ankle instability (CAI) (1). CAI is defined as a lingering sense of instability and intermittent "giving way" at the ankle that continues for over a year after the original injury (4, 15). Previous research has found that atypical initiation of muscle contractions, diminished muscle strength, reduced dorsiflexion range of motion, an influx of movement at the subtalar and midfoot, and decreased proprioception at the ankle can be found in individuals with CAI (15). Without proper treatment, individuals with CAI are more likely to experience recurrent ankle injuries, activity limitations, and compromised sports performance (15).

While CAI is a common problem in all athletes, soccer players are even more susceptible to lateral ankle sprains due to the movements involved in the sport. Soccer is a multidirectional sport that is played for long periods and on different fields at times, all of which increase a player's chances of an ankle sprain (14). Ekstrand and Tropp (6) reported that 17-20% of all soccer injuries are ankle sprains, and a follow-up study from Ekstrand et al. (5) found that 13.7% of elite soccer players suffer recurrent lateral ankle sprains. To be more sex-specific, researchers recruited participants from their local elite female soccer leagues and found ankle sprains were the most common injuries (7, 18, 21, 22). In addition, studies have shown females exhibited greater hip adduction angles during running and single-leg landing maneuvers than males, which could contribute to ankle injuries and balance deficits (8, 11, 13). However, it is unclear if female soccer players exhibit worse ankle stability and single-leg balance control than non-soccer players, and if there is a strong correlation between ankle stability and single-leg balance control. Considering the ankle joint is part of the lower extremity kinematic chain the ankle strategy is commonly used in balance control after a perturbation, static and/or dynamic single-leg balance may also be different in individuals with or without CAI.

Due to the high prevalence of ankle sprains in female soccer players, it is beneficial to explore the relationship between CAI and single-leg balance control in those athletes. Such information will be very helpful for clinicians in selecting proper testing and rehabilitation protocols for female soccer players. The first aim of the study was to examine if female collegiate soccer players have worse ankle stability and single-leg balance (static and dynamic) than female non-soccer players. The second aim of the study was to examine the correlation between ankle stability and single-leg balance control. We hypothesized that female soccer players would have worse ankle stability and single-leg balance control than non-soccer players. We also hypothesized that individuals with worse ankle stability would also exhibit worse single-leg balance control.

METHODS

Participants

Eighteen female collegiate soccer players (aged 18-21 years) and 22 female non-soccer players (aged 19-27 years) participated in the study. Participants were included if they 1) were female, 2) were 18 years or older, and 3) had no pain or discomfort over their lower extremities during single-leg stance. Participants were excluded from the study if they 1) had any current ankle, knee, or hip injuries that would prohibit them from performing single-leg stance, 2) had undergone orthopedic surgery over the lower extremity within the past 6 months, and 3) did not meet criteria to be physically active in accordance with the Physical Activity Readiness Questionnaire (PAR-Q+). Soccer players were recruited from the female soccer team at Angelo State University (ASU). The "non-soccer" group consisted of college students who participated in other collegiate or recreational activities regularly, stating they worked out at least twice a week but had not participated on a soccer team competitively or recreationally in the past. All participants signed the informed consent form approved by the Institutional Review Board of Angelo State University. This research was carried out fully in accordance with the ethical standards of the International Journal of Exercise Science (16).

Protocol

The primary outcome measure to compare female soccer vs. non-soccer players was ankle stability status, and the secondary outcome measure of the study was static and dynamic balance performance. The Cumberland Ankle Instability Tool (CAIT) questionnaire was used to examine ankle stability. The possible scores range from 0 (worst) to 30 (best), with all questions based on individual perception of pain and unstable or giving-way feeling. If the earned score on the CAIT questionnaire is less than or equal to 25, the individual is considered to have CAI. The CAIT is a valid and reliable outcome measure with a sensitivity of 96.6% and a specificity of 86.8% (15). The Athletic Single Leg Stability Test (ASLST) of the Biodex Balance System (BBS) was used to examine static single-leg balance. The BBS provides objective measures for single-leg balance and consists of a multiaxial testing platform that can be set to different degrees of instability. The results of the ASLST show the stability index of the overall performance, in the anterior-posterior direction, and in the medial-lateral direction. A greater numerical value of the stability index indicates a greater degree of difficulty in controlling their balance (23). The BBS has shown great reliability for the overall stability index (OSI). One study produced reliable measures across 8 trials (r=0.94) (3). The OSI also has a high test-retest intraclass correlation coefficient of 0.85 for static testing (2). The Y-Balance Test (YBT) was used to examine dynamic single-leg balance in three different directions: forward (anterior), backward away from the body (posteromedial), and backward across the body (posterolateral). The YBT was created to enhance the reliability and clinical availability of the Star Excursion Balance Test (17). The intra-rater reliability ranged from 0.85-0.91 in adult populations, and inter-rater reliability ranged from 0.81-1.00 (17).

Prior to collecting data, all participants completed an informed consent form approved by the Institutional Review Board (IRB) of Angelo State University. The CAIT questionnaire was

completed first, and the ASLST and YBT protocols were performed in a randomized order and only included each participant's dominant leg. All participants performed the static and dynamic balance tests barefoot to minimize the balance and stability provided by shoes and socks. This is very important as the somatosensory system works to inform individuals about their external environment via various ways such as conscious perception of touch through skin contact.

The ASLST measured the participant's ability to maintain static balance at the default platform setting (median difficulty) for 20 seconds for three consecutive trials, preceded by three practice trials (Figure 1). There was a 10-second break between trials. Extrinsic visual feedback (the knowledge of performance and the knowledge of results) from the monitor was available throughout all trials. Participants were instructed to step onto the platform to their specific position/location based on their height, regulated by the BBS operations manual. The leg not being tested was off the platform in a slightly flexed position of the participant's preference. Each trial score was recorded, and the average score was calculated at the end of the 3 trials.

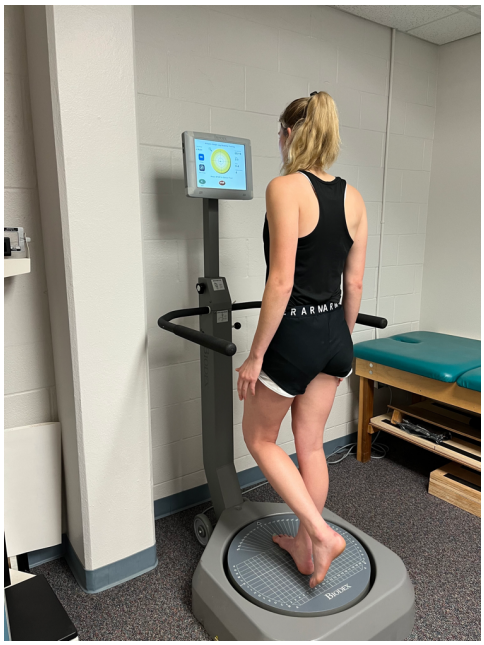

Figure 1. Participant performing the ASLST on the Biodex Balance System.

Prior to performing the dynamic YBT, all participants were instructed to place their hands on their hips and stand on the center block with the dominant leg, which was referred to as the standing leg. The participants pushed three 'reach indicator' blocks as far as they could in anterior, posteromedial, and posterolateral directions with the non-dominant leg, referred to as the reaching leg (Figure 2). The participants were allowed to raise the heel of the stance foot, but they were not allowed to touch down with their reaching leg (17). Each participant was allowed four practice trials prior to performing three test trials with their dominant leg in every direction (9). The distance the 'reach indicator' blocks were pushed away from the center block was measured and recorded to the nearest half-centimeter. A test trial was to be redone instantly if the participant failed to return to the starting position, touched down on the floor or 'reach

indicator' blocks with the reaching leg at any moment, or if they removed their hands from their hips. Considering leg length discrepancies, reaching distance was normalized to each participant's limb length, which was measured from the anterior superior iliac spine (front of hip bone) to the medial malleolus (prominence on inner ankle) in supine.

Figure 2. Participant performing the YBT in the three different directions per protocol, anterior (left), posteromedial (bottom right), and posterolateral (top right) directions.

Statistical Analysis

Statistical analyses were performed using IBM SPSS version 26 (IBM Corp, Armonk NY). A Shapiro-Wilk test was first used to examine data normality. To compare soccer and non-soccer players, a Mann-Whitney U test was performed to evaluate the data without a normal distribution (CAIT and ASLST test scores). In addition, an independent-sample t-test was performed to evaluate the data with a normal distribution (YBT test scores). Hedges' g was used to identify the effect size for the data with a normal distribution, and Rank-Biserial correlation was used to evaluate the effect size for the data without a normal distribution. Spearman's rank-order correlation was used to examine the correlation between ankle stability condition (CAIT) and static/dynamic single-leg balance measures. The significance level (p-value) was set at 0.05 for all comparisons.

RESULTS

Results of the CAIT showed that 55.56% of soccer players and 9.09% of non-soccer players exhibited CAI. Moreover, the CAIT score of soccer players was significantly lower than non-soccer players [z = -2.152, p = .031; Figure 3]. Rank-Biserial correlation identified no significant relationship between the 2 groups [r_{rb} = .158, p = .532] with a small effect size. For the ASLST, there were no significant differences between the 2 groups in all three measures [z = -1.136, p =

.256 overall; z = -.839, p = .401 A-P; z = -1.203, p = .229 M-L; Figure 4]. Rank-Biserial correlation also identified no significant relationship between the 2 groups [r_{rb} = .004, p = .987 overall; r_{rb} = -.025, p = .922 A-P; r_{rb} = .198, p = .431 M-L] with a small effect size. For the YBT, the three normalized direction scores and overall composite scores were not significantly different between the 2 groups [t (38) = 1.279, p = .209 anterior; t (38) = .784, p = .438 posteromedial; t (38) = .737, p = .466 posterolateral; t (38) = 1.039, p = .305 composite; Figure 5] with small to medium effect sizes of 0.407, 0.249, 0.234, 0.330, respectively. Lastly, Spearman's rank-order correlation analyses showed no significant correlations between the CAIT score and any static or dynamic single-leg balance measure (r < .094 for all comparisons).

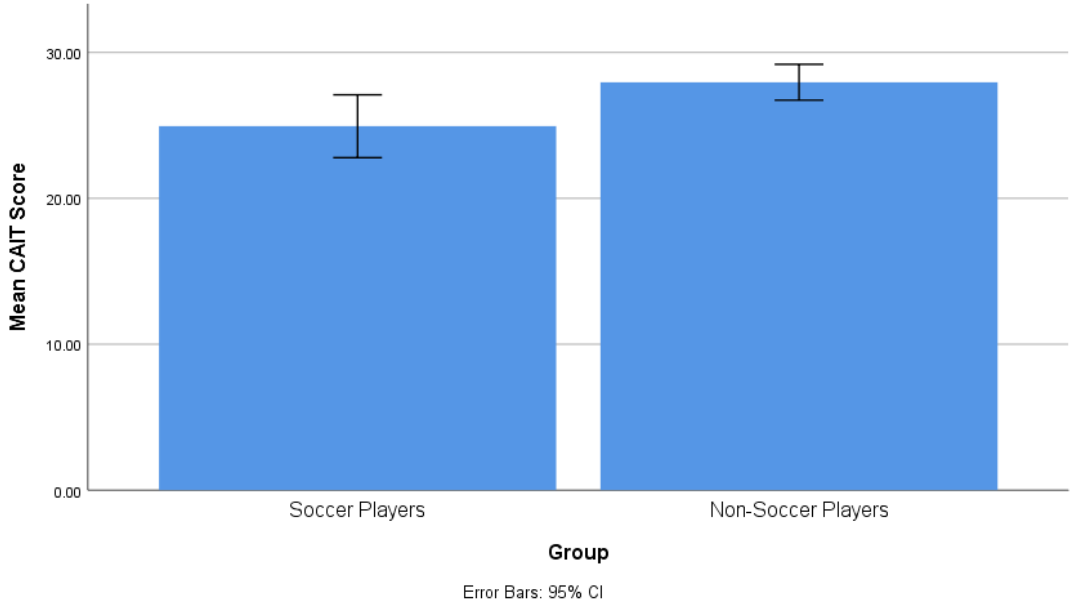

Figure 3. Mean Cumberland Ankle Instability Tool (CAIT) results. The error bars denote 1 SD.

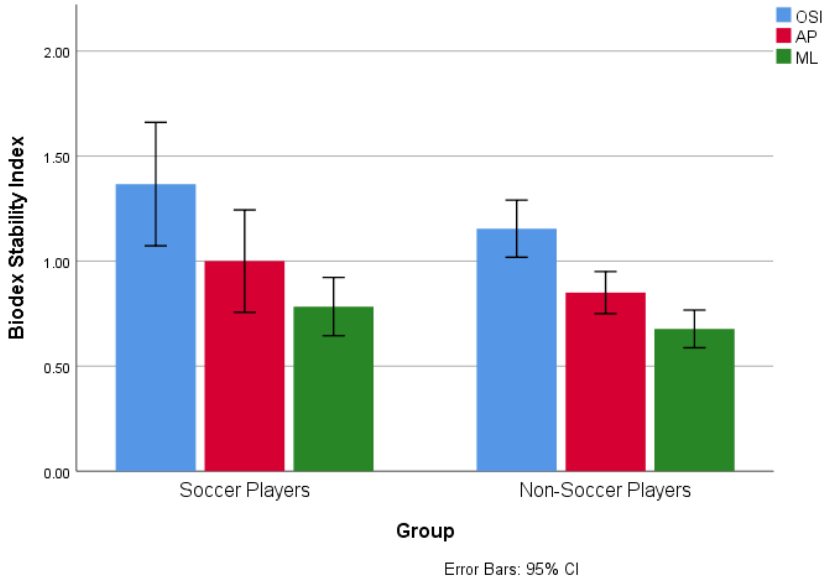

Figure 4. Results for the Biodex ASLST Indexes. The error bars denote 1 SD.

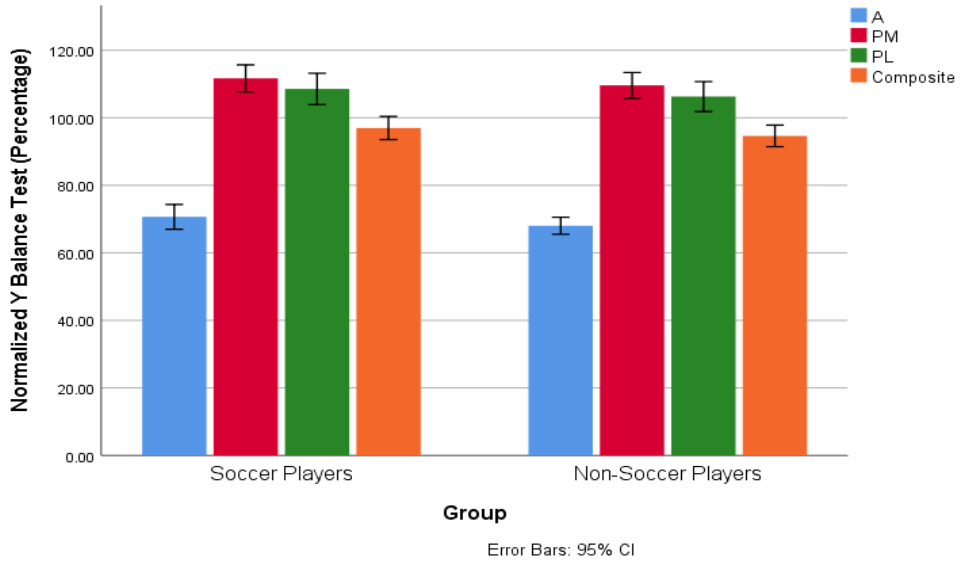

Figure 5. Normalized results for the YBT in the three different directions and overall composite. The error bars denote 1 SD.

DISCUSSION

More female collegiate soccer players were classified as having chronic ankle instability than non-soccer players. In addition, female collegiate soccer players also had a significantly lower CAIT score indicating worse ankle stability compared to non-soccer players. These results support our hypothesis that female collegiate soccer players would exhibit worse ankle stability when compared to non-soccer players. Because there is a high prevalence of initial and recurrent ankle injuries in soccer players (6, 7, 22), compromised passive stabilizers (such as ligaments and the joint capsule), active stabilizers (such as muscles), and proprioceptors around the ankle joint could contribute to ankle instability (12). To reduce the chance of initial and recurrent ankle injuries, clinicians who work with female soccer players may consider proper training and/or treatment protocols to enhance ankle stability in soccer players.

Despite soccer players having more CAI, no significant differences were observed between the two groups in the ASLST or the YBT. This does not support our hypothesis that soccer players would have worse single-leg balance control than non-soccer players. One possible explanation is that soccer players may have better motor control and proprioception in single-leg balance than non-soccer players through years of practice and training (26). Thus, the superior balance control capability of soccer players could dampen the potential deficits caused by compromised ankle joint stabilizers and ankle instability. This potential explanation could be further supported by Zhang et al. who suggested that the central nervous systems of these soccer players have made remarkable adaptations that allowed them to establish "task-solving strategies" to maintain a competitive performance (27). In addition to the motor learning effects through training, many soccer players who have experienced ankle sprains have likely sought treatment from athletic trainers or physical therapists and worked on improving their static and

dynamic balance through treatment protocols similar to the ASLST and the YBT. This motor learning factor could also contribute to the lack of balance control difference between the two groups. Lastly, another potential explanation for the lack of group difference in balance control could be explained by an observation noted throughout testing. All female soccer players, maybe due to their competitive nature, gave more effort during both the ASLST and the YBT procedures when compared to non-soccer players. Giving more effort during each procedure could be a compensatory strategy that helped those individuals with CAI perform just as well as those without CAI. Further investigation may be needed to examine how soccer players compensate for their ankle instability for balance control.

No significant correlations were found between CAIT scores and static/dynamic single-leg balance measures. This result does not support our hypothesis that individuals with worse ankle stability could also perform worse in balance control. Although the ankle joint is part of the lower-extremity kinematic chain and the ankle strategy could be used to regain balance after a perturbation, it is suggested that the hip strategy is more commonly used in fast and large perturbations and when the base of support is limited (20). Considering the base of support is limited in single-leg balance testing, and soccer players commonly engage a large hip range of motion for the sport, it is possible that the integrity of the ankle joint may not be as significant as the hip joint for soccer players. According to this study, ankle joint integrity did not correlate well with single-leg balance. Furthermore, the CAIT is a fast and valid measure for ankle stability; however, the CAIT alone may not be a good indicator of single-leg balance control. Lastly, static and dynamic single-leg balance control should be examined and incorporated into prevention and treatment protocols.

One potential limitation of the study could be a lack of standardization of the fitness level between soccer and non-soccer players. Although the non-soccer participants were college students who participated in recreational activities (other than soccer) regularly, it is unknown if their exercise duration, intensity, and mode were comparable to soccer players. In addition, prior injury frequency and severity could impact group comparisons and this factor was not accounted for.

For the YBT, participants moved their non-supporting legs in a slow and controlled motion. Future studies could incorporate a faster movement that mimics soccer biomechanics to gain insight into single-leg balance control between female soccer and non-soccer players. In addition, the YBT and the ASLST might not be challenging enough to detect single-leg balance control deficits in our collegiate participants. Future studies should consider implementing functional performance tests with an agility and speed component, such as the figure-of-eight hop test.

Female soccer players exhibited worse ankle stability than non-soccer players. However, no significant difference was found between the two groups in single-leg balance control. Moreover, there was no strong correlation between ankle stability and single-leg balance. Clinicians should continue to develop prevention and treatment protocols for female soccer

players to enhance their ankle stability. Although the CAIT is a valid and reliable tool for ankle instability analysis, it should not be the sole indicator for balance control.

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