International Journal of EXERCISE SCIENCE

Original Research

Immediate Effect of Warm-Up on Single-Leg Balance in Individuals with and without Functional Ankle Instability

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ABSTRACT

International Journal of Exercise Science 15(3): 1019-1027, 2022. Ankle sprains account for about 20% of all sports injuries in the United States. About 5-10 minutes of general warm-up is recommended to enhance performance and reduce injuries. However, its immediate impact on single-leg balance is unclear. The purpose of the study was to examine if different warm-up protocols could impact single-leg balance in individuals with and without functional ankle instability. Thirty volunteers (aged 19-29 years) participated in the study. The Cumberland Ankle Instability Tool was used to examine functional ankle stability and the Athletic Single-leg Stability Test of the Biodex Balance System was used to examine single-leg balance. Subjects were examined in three separate sessions (no warm-up, 5-minute warm-up, or 10-minute warm-up) with one week apart. Results show warm-up conditions had a significant impact on single-leg balance (p = .021). Pairwise comparisons showed the balance after the 5-minute warm-up was significantly worse than the no warm-up condition (p = .000). It is possible that warm-up makes the tissues surrounding lower extremity joints more flexible, therefore making single-leg balance control more challenging. In addition, subjects with functional ankle instability exhibited significantly worse single-leg balance than those without functional ankle instability (p = .003). However, the immediate effect of warm-up on balance control was similar between individuals with and without functional ankle instability. Clinicians should consider implementing single-leg balance testing and training for those who are identified as having functional ankle instability. Despite its known benefits of enhancing performance and reducing injuries, general warm-up activities may have an immediately negative effect on single-leg balance control.

KEY WORDS: Chronic ankle instability, ankle sprains, athletes, ankle injuries

INTRODUCTION

Ankle sprains have consistently remained one of the most common musculoskeletal injuries in the United States. It was estimated two million ankle sprains occurred each year in the United States, which account for 20% of all sports injuries (26). However, this number is most likely an underestimation because many injured people may not understand the severity and do not seek medical attention (10). This number is extremely concerning as ankle sprains left untreated or treated improperly can lead to multiple chronic problems such as functional ankle instability and anterolateral impingement (3). After the injury has occurred, weak muscles, overstretched ligaments and joint capsules can hinder proprioception of the ankle immensely. Compromised proprioception can ultimately lead to functional ankle instability and/or balance deficits (12). Only 50% to 85% of subjects who previously had ankle injuries reported a full recovery after 3 years (25). Moreover, individuals with prior ankle injuries are highly likely to have recurrent injuries (11).

A warm-up before physical activity is designed to physically and mentally prepare the individual while reducing the risk of injury. Before the task/sport specific warm-up, it is important to engage 5-10 minutes of general warm-up with low intensity aerobic activities with an emphasis on elevating core and muscle temperature (9, 24). Passive and active are two categories of a warm-up that differ in the means of increasing overall core and muscle temperature. A passive warm-up uses external devices to raise the temperature of the tissue while conserving energy. An active warm-up, however, uses energy released from muscle contraction to increase body temperature (8). Overall, it has been shown that warm-up effects are more prominent with an active warm-up than with a passive warm-up (6). Elevation of one's core temperature, passively or actively, can facilitate oxygen release from hemoglobin/myoglobin and enhance neural function (16). Other positive effects of warm-up include having faster muscle contraction, increasing muscle force, decreasing reaction time, improving muscle strength and power, and lowering resistance in muscles and joints (9). In addition, warm-up may improve proprioception because mechanoreceptors are being activated throughout a warm-up (24).

Balance control relies on multiple factors including proprioceptors, muscle strength, endurance, and experience (12). A warm-up essentially enhances all these factors and could in turn affect balance control overall (9, 24). Research examining the connection between a warm-up and balance control is scarce. Erkut et al. (7) found that there was a significant increase in balance control when a 5-minute low intensity run was combined with static stretching. Conversely, Behm (2) reported a significant decrease in static balance scores when a static stretching component was added to a 5-minute aerobic cycling warm-up. In addition, the ideal duration for a general dynamic warm-up has not been established. In the literature, the recommended duration for a general warm-up ranged from 5 to 25 minutes (4, 19, 20). It is unclear how long a general warm-up should be to maximize its impact on balance control without contributing to fatigue, especially for those individuals with functional ankle instability.

Balance training is commonly used in an athletic and/or rehabilitation setting for those who have or are prone to ankle sprains (13, 15). The ankle joint is an important part of the lower extremity kinematic chain and the ankle strategy can be used to regain balance control against expected perturbations. Therefore, it is possible that individuals who have functional ankle instability may also exhibit balance control deficits (5, 22). The first goal of the study was to examine which warm-up protocol (no warm-up, 5-minute warm-up, or 10-minute warm-up) can best enhance single-leg balance control in those individuals with and without functional ankle instability. The second goal of the study was to examine whether individuals with functional ankle instability would have worse single-leg balance than those without functional ankle instability. We hypothesized that the 10-minute warm-up protocol would enhance single-leg balance control more when compared to the 5-minute warm-up and no warm-up protocols. This increased duration would allow the body to further elevate its temperature, thus facilitating oxygen release, neural function improvement, and better physical performance. We also hypothesized that participants without functional ankle instability would have better single-leg balance than those with functional ankle instability. Individuals with functional ankle instability may exhibit mechanical constraint and neuromuscular control deficits of their ankle joint. As a result, the overall single-leg balance control could also be compromised in those individuals.

METHODS

Participants

Thirty volunteers (12 females and 18 males, aged 19-29 years) participated in the study. Inclusion criteria included 1) being able to stand and balance on the dominant leg for a minimum of 1 minute without pain or discomfort, 2) being able to run at his/her own pace without pain for a minimum of 10 minutes, and 3) having proper lower extremity function for activities such as sitting, standing, walking, running, and squatting. The Physical Activity Readiness Questionnaire for Everyone (2020 PAR-Q+) form was used to screen the subject's ability to participate in warm-up protocols of the study. Should the participant answer yes to any of the 7 questions on the first page (indicating the need for follow-up examinations to be cleared for participation in physical activities), he/she was excluded from the study. This study was approved by the Angelo State University Institutional Review Board and all participants provided informed consent prior to participating in the study. This research was carried out fully in accordance to the ethical standards of the International Journal of Exercise Science (18). The partial eta squared for the result is 0.147 for the warm-up condition comparison and 0.271 for the ankle condition comparison, indicating a large effect size.

Protocol

The Cumberland Ankle Instability Tool (CAIT) was used to examine functional ankle instability. The CAIT consists of nine questions which allows the subject to give insight on how he or she perceives his or her ankle stability during functional activities. According to the new Clinical Practice Guidelines for physical therapists from 2021, a total score of 25 or less indicates having functional ankle instability (14). The scoring for the CAIT ranges from 0 (worst) to 30 (best), and it has a minimum clinically important difference of 3.05 (29). The CAIT has a sensitivity of 0.966 and a specificity of 0.868 (28). The Athletic Single-leg Stability Test (ASLST) of the Biodex Balance System (BBS) was used to assess single-leg balance. The BBS uses a multi-axial testing platform with different levels of stability, including a maximal of 20-degree surface tilt. The Biodex calculates various scores including the overall stability index (OSI). Scoring of the OSI indicates balance abilities with a higher score indicating worse balance control. The ASLST has a good test-retest reliability (ICC: 0.77) (1).

Single-leg balance control was examined in three separate settings with one week apart to avoid motor learning effects and fatigue (both physical and mental). For each testing session, subjects started with the designated warm-up protocol before taking the ASLST. Order of the warm-up conditions were randomized among subjects. For the 5-minute and 10-minute warm-up session, subjects were asked to run on an indoor track with a self-selected comfortable speed. Upon finishing the warm-up session, subjects returned to the motor control laboratory to complete the ASLST of the BBS. The time elapsed between finishing the warm-up and stepping onto the BBS was approximately 2 minutes.

For the ASLST, subjects were asked to maintain balance with a single-leg stance without footwear on the BBS (Figure 1). Only the dominant leg (the leg subject uses to kick a ball with) was examined for all subjects to eliminate the leg dominance effect. Foot position during testing was determined using the subject's body height and the manufacturer's recommendation. This foot position was marked on the platform and rechecked before each trial to ensure consistency throughout the testing. During testing, subjects were instructed to maintain slight knee flexion, relax their arms, and grab the rails if they lose their balance. Subjects were also asked to look at the screen in front them to receive extrinsic visual feedback about the knowledge of performance. The goal was to maintain their center of gravity (represented by a black dot on the screen) at the center of the target during the trial (Figure 2). The ASLST was set at the default setting (dynamic level four) with moderate balance control difficulty. For practice, the subject performed three 20-second trials with 10-second rest in between while receiving extrinsic visual feedback from the monitor to establish a stable performance. The official testing also included three 20 second trials with a 10 second rest in between. The overall Biodex Stability Index scores were then obtained for further analysis.

Figure 1. Subject testing position for the Athletic Single-leg Stability Test on the Biodex Balance System.

Figure 2. Extrinsic visual feedback given to subjects during the Athletic Single-leg Stability Test.

Statistical Analysis
Two-way mixed ANOVA (analysis of variance) with one between group factor (ankle stability status) and one within group factor (three warm-up protocols) was used to analyze the data. The Greenhouse-Geisser correction was used for within group comparison. Significance level (p-value) was set at 0.05 for all comparisons. Statistical analyses were performed using IBM SPSS version 26 (IBM Corp, Armonk NY).

RESULTS

Using the CAIT protocol scoring, 11 subjects were found to have functional ankle instability while 19 subjects did not have ankle instability. Warm-up conditions had a significant impact on single-leg balance ($F = 4.821$, $p = .021$, Figure 3). Pairwise comparisons showed balance control after the 5-minute warm-up was significantly worse than the no warm-up condition ($p = .000$). However, there was no difference between the 5-minute and 10-minute warm-up conditions ($p = 1.000$). Subjects with functional ankle instability exhibited significantly worse single-leg balance than those without functional ankle instability ($F = 10.389$, $p = .003$). No significant interaction was found between warm-up condition and ankle stability status ($F = 2.022$, $p = .155$). This suggests the impact of various warm-up protocols on single-leg balance is similar between individuals with and without functional instability.

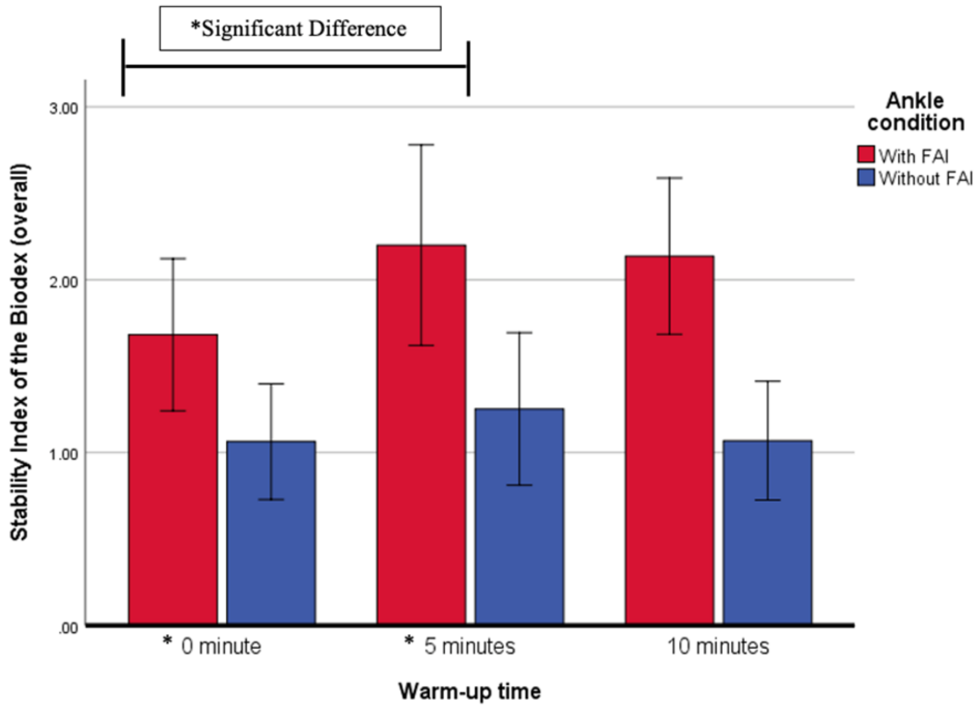

Figure 3. Overall Stability Index of the Athletic Single-leg Stability Test. A larger number in Stability Index represents worse single-leg balance. The error bar denotes 1 SD.

DISCUSSION

Results of the present study indicate that static single-leg balance control was worsened shortly after engaging a general warm-up activity such as running, especially in the condition of having 5-minute warm-up. In addition, the impact of warm-up was similar between subjects with and without functional ankle instability. This finding does not support the hypothesis of improving balance control with a warm-up. It also disagrees with Erkut et al (3) who reported better balance control after a 5-minute low intensity run combined with static stretching. One possible explanation for the discrepancy between the two studies could be the nature of the balance test. Erkut used the Star Excursion Balance Test (SEBT), which is a dynamic single-leg balance test with subjects maintaining their balance with one leg while reaching towards 8 different directions with the other non-weight supporting leg. In the SEBT, subjects need extensive coordination of various lower extremity joints, thus having a warm-up activity such as running can benefit the performance. In addition, adequate quadriceps strength of the supporting leg is essential to dynamic single-leg balance tests such as the SEBT. Having a proper warm-up protocol prior to those testing can further enhance performance. As for the present study, the ASLST is a static single-leg balance test and the performance is highly depending on the control (ankle strategy) and integrity of the ankle joint. Considering the ankle joint relies heavily on its static stabilizers (such as ligaments) for its stability, it is possible that warm-up made those static stabilizers more flexible, therefore making the ankle joint less stable. Furthermore, mechanoreceptors in ligaments and joint capsule could become less sensitive with more lax surrounding tissues after warm-up. As a result, it could compromise proprioception of the ankle joint and the overall balance control.

Results also show single-leg balance after the 10-minute warm-up was not better than after the 5-minute warm-up. This finding contradicts the hypothesis of having better balance control with a longer warm-up. Having 5-10 minutes of general warm-up with low intensity aerobic activities prior to a sport specific warm-up has been well documented and supported in the literature (9, 24). However, it is unclear about the ideal warm-up duration for balance control. Having a longer warm-up can enhance core and muscle temperature, therefore improve performance and/or reduce injuries. As described in the prior paragraph, having a longer warm-up may not have a positive impact on balance control because mechanoreceptors could be less capable of providing accurate proprioceptive information to maintain single-leg balance.

Subjects with functional ankle instability exhibited significantly worse single-leg balance then those without functional ankle instability. This finding supports the hypothesis of the study, suggesting having mechanical constraint and neuromuscular control deficits may hamper single-leg balance control. The present study used the well validated CAIT to classify ankle instability (28). This is further supported by the Clinical Practice Guideline for physical therapists published by the Journal of Orthopaedic & Sports Physical Therapy in 2021, indicating the CAIT as a reliable and discriminative outcome measures for chronic ankle instability (13, 14). Although the ankle joint is only a part of the lower extremity kinematic chain and other strategies (such as the hip strategy) can also be used for balance control, our study suggests the integrity of the ankle joint can significantly impact static single-leg balance. Future studies will be beneficial to examine if functional ankle instability would also impact dynamic single-leg balance.

All participants were relatively young and healthy in this study. For future research, it will be beneficial to examine and classify the subject's fitness level to have homogeneity. On the other hand, it will also be beneficial to examine the impact of warm-up for individual with various fitness levels or engage different exercise modes and/or intensities. Moreover, it will be beneficial to conduct a study with a longer duration between warm-up and balance testing to examine if the negative effect we observed is only transient. Lastly, researchers can consider examining and comparing the impact of warm-up on both static (such as the ASLST) and dynamic (such as the SEBS and the Y-balance Test) balance control, which may yield a better functional significance.

ACKNOWLEDGEMENTS

This study was supported by the Graduate Research Fellowship of Angelo State University.

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