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International Journal of Research in Exercise Physiology

Original Research Article

The Effect of Short-Term Single-Leg Balance Exercises on Balance Scores of Female Collegiate Athletes

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Abstract

Purpose: As athletic trainers, the correlation of injury and poor balance ignited an interest to uncover what can be done to improve balance and decrease the chance of injury among athletes. The purpose of this study was to test if a female collegiate athlete's balance can be improved by implementing a three week, single leg (SL) balance program. As observed in previous research studies, poor balance is a significant contributing factor to injury. **Methods:** In this study, 20 female, division three student-athletes, in pre/post season were randomly assigned into a control or experimental group. All athletes performed a SL balance pretest on their right/left legs as well as a fall risk assessment using the BIODEX SD Balance machine. The BIODEX produces quantitative data to compare the control and experimental groups' change in balance ability. Three weeks from the date of their pretest, participants completed a posttest on the BIODEX balance machine. Throughout the three weeks, the experimental group performed a balance program including five different SL balance exercises three times a week. The exercises were monitored by a member of the research group to ensure completion and proper technique. **Results:** Statistical measures that were utilized included an analysis of variance (ANOVA), two-way repeated measures ANOVA, independent sample t-test, and paired t-tests. Two-way repeated measures ANOVA indicated a significant improvement in mediolateral test from pre- to post-test, $F(1,18) = 6.12$, $p = .021$, but no group difference was seen, $F(1,18) = 0.82$, $p = .376$. **Conclusion:** It was evident that the 3 week balance program did not result in the improvements in the college-aged athletic female population; however various implications can be used in the future to replicate this study with modifications to find applicable results.

Key Words: BIODEX SD, injury prevention, fall risk

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Introduction

As a toddler begins to learn how to walk, more often than not they end up falling down after a few steps. This process of walking and falling repeats until they learn how to maintain a standing position. The ability to walk eventually develops as a combination of strength development in the legs, and just as importantly, a sense of balance[1]. Balance is an essential factor in day to day activities. Balance begins to improve as the individual grows and learns, but eventually worsens entering late adulthood. When an athlete has a lower balance score, they are almost 1.5 times more likely to sustain an injury such as a sprain, dislocation, or strain among other lower extremity injuries[2]. This lead us to further inquire about balance interventions in the athletic population and to observe the varying efficacy of different balance training programs based on various criteria. Previous research suggests that elite athletes respond better to balance training than sub-elite or recreational athletes[3].

When deciding on what factors to include to make this study more specific, the literature indicated a huge gap in regards to balance intervention training pertaining to the collegiate aged person, more specifically trained athletes. Looking further into the literature, more research has been conducted on males than females. This information guided the decision of conducting research on the female population in this study. It should also be noted that all the current literature prescribes longer term balance programs of 6 weeks or more[4].

The significance of this study will redound to society considering balance as an essential skill needed for activities of daily living along with athletic activities. Enhancing one's balance should not be focused solely on the elderly population. The elderly does need greater balance to reduce their risk for falling, but adults need to continue their balance skills as a preventative measure to decrease their chance of developing a high risk of falling as they age. Adolescents can benefit from greater balance because it can help them gain coordination and physical skills, and as an infant, increased balance can help gain motor control to learn how to mobilize oneself.

Overall, this knowledge can help us as the practitioners and researchers think of ways to target different populations balance concerns. The current literature focuses on the elderly population since they are notoriously at high risk, but we had desire to focus on the adolescent to adult stage in life due to minimal current research. This will help future studies compare our findings to additional findings with more significant data. Thus, an emphasis on importance in beginning a continua habit of balance training at an earlier age can be established.

The purpose of this study was to observe the effect of short term single leg balance

exercises on balance scores of female collegiate athletes. If balance is positively influenced by the program, injury may be prevented in the female's collegiate sport. We hypothesize that there would be a greater improvement in balance scores (both single-leg and fall risk) in female athletes who completed a three week single-leg balance program compared to the control group. The control group will have similar balance scores during their pre and post-testing results.

Methods

Participants

The study began with 23 participants. Inclusion criterion were detailed as female collegiate athletes at a Division III institution, while exclusion criterion was indicated as athletes with an injury or currently recovering from an injury. These female athletes came from either tennis, volleyball, track and field/cross country, or soccer teams. The subjects scheduled dates to have their pretest balance measured subsequent to reading the cover letter of the study, signing an informed consent, and completing a health questionnaire form. Three participants dropped out during the data collection period due to either sustaining an injury or discontinuation of participation in college athletics, leaving the study with 20 subjects.

Instrumentation and Testing

Instrumentation of the testing measures of this study were heavily dependent on use of the Biodex Balance System SD machine, but also included various tools for the experimental group. These tools included a stopwatch, plastic constructible steps, and coach athletic tape for the Star Excursion Balance Test. The Biodex SD is a multi-faceted balance assessment tool that provides feedback of a subject's balance capabilities in various functional movement planes. Previous studies have measured balance using static balance, the star-excursion test, and the Biodex SD[7]. Of all the available options for measuring balance, the Biodex SD is most effective as it allows for motion that mimic daily activities and records balance scores in an objective manner. The Biodex SD machine uses a circular platform that allows for movement in the anterior-posterior (sagittal plane) and medio-lateral (frontal plane) directions[5]. Analyzing the amount of movement in each of these directions has been suggested to be the best method to assign quantitative data to realistic and everyday balance scores[6]. The balance tests used in this research study were single leg balance test (bilaterally) and the fall risk assessment.

The single leg balance test was completed first. Prior to testing, each athlete was given a 20 second practice run to rule out bias of previous use of the Biodex SD machine and to allow the patient to become familiar with the nature of the tests. Proceeding the trial run, the athlete needed to complete 3 trials on each leg for 20 seconds. This test recorded values for anterior/posterior

instability, medial/lateral instability, and overall instability.

Fall risk assessment was completed after the single leg tests. This assessment also consisted of 3 trials that lasted 20 seconds each. The difference in the fall risk assessment compared to the single leg tests was the athlete was allowed to place two feet on the platform and they did not receive a practice test. This test only recorded values for overall instability.

Procedures

The recruitment of participants in the study started by emailing the coaches of various women's sports teams at the University of Wisconsin - Eau Claire, requesting permission for their athletes to participate in a balance student research study. Once permission was granted, emails were sent to the athletes to ask for their interest in participation. The email briefly explained the purpose of the study and the expectations as a participant. Prior to data collection, each investigator completed the Institutional Review Board training and was approved to conduct research to ensure the ethical treatment of all human subjects.

Once confirmation of participation was given by the individual athlete, an initial appointment was arranged. The initial appointment was set for 45 minutes and included the following: the student researchers introduced themselves, read the cover letter and the informed consent to the athlete, and then the athlete signed informed consent to ensure their participation and understanding of the time commitment of the study. After this was completed, the athlete filled out a medical questionnaire which entailed and reported any applicable medical injuries that they had endured. Once the initial 45-minute meeting was completed with each participant, the subject was randomly assigned into a control or an experimental group which was done in a spreadsheet, stratified by their sport. Both experimental and control groups completed a pretest using the Biodex SD, which involved a single leg stance test on their right and left extremities with bare feet. The athletes also completed a fall risk assessment which consists of a double leg stance. All of the aforementioned tests involved lining up their heels as well as their second metatarsals to the computer-designated spots on the platform grid, which placed the feet at more narrow than shoulder width and at slight external rotation.

After the trials began the platform would move and the athlete would try and keep their balance centered by keeping a dot on the screen inside the center of a circle. After the pretest, if the athlete was assigned to the control group, the student researcher would schedule their posttest date and time with them exactly three weeks from the pretest date and then their appointment was finished. If the athlete was in the experimental group, the student researcher would demonstrate the five exercises that this athlete would be

performing three times weekly, for the next three weeks under supervision of a student researcher. These five exercises were chosen from the investigator's clinical experience working with various collegiate athletes on single leg balance skill. The exercises were designed to target all key stabilizing muscles with movement as well as holding a position stationary.

The five exercises that were assigned to the experimental group in this research study are presented in Table 1. The designated researcher remained available during the exercise session to watch the athlete perform these exercises and answer any questions that might occur. Once these were completed, the athlete would schedule their future exercise times that were fifteen minute sessions three times per week for three weeks. After the three weeks had passed, posttesting ensued. This was done identically to the pretesting with the same tests and protocol being administered. After the posttest was completed, a student researcher would ensure that all of the data was entered for that particular athlete's randomized number, into a Microsoft Excel document for data collection and organization. Once the results were calculated, a debriefing email was drafted to be sent to the participants with an overview of the research findings.

Statistical analyses

This study is a pretest/posttest randomized group design. Improvement in balance scores from single leg balance and fall risk tests were the two dependent variables. The statistical method used to test the study's hypothesis was a two-way repeated measures ANOVA. The software used to compute the statistical method was SPSS version 19.0.

Results

At the start of the study there were a total of 23 participants that met the requirements to join the study. The research concluded with 20 participants due to injury, commitment, and schedule conflicts that accounted for 3 dropouts. These partakers were NCAA Division III female athletes, ranging from 18-22 years old. Seven of the athletes were tennis players, five volleyball, five soccer, and three track and field/ cross country athletes. To analyze the measurements, statistical measures that were utilized included an analysis of variance (ANOVA), two-way repeated measures ANOVA, independent sample t-test, and paired t-tests.

A group (control, experimental) x time (pretest, posttest) repeated measures indicated no significant time or group effects on overall balance scores of the right limb, $F(1,18) = 0.60$, $p = .449$ and $F(1,15) = 0.55$, $p = .465$, respectively. No effect was shown in the right limb anterior-posterior scores, $F(1,18) = 0.19$, $p = .692$ and $F(1,18) = 0.41$, $p = .53$, respectively. As for right limb mediolateral balance scores, the analysis

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resulted in no time and group effects, F(1,18) = 0.72, p = .406 and F(1,18) = 0.52, p = .475, respectively. When the standard deviation (SD) scores of each testing were examined, the two-way repeated measures ANOVA indicated a significant improvement in mediolateral test from pre- to posttest, F(1,18) = 6.12, p = .021, but no group difference was seen, F(1,18) = 0.82, p = .376.

The same analysis was repeated for the overall balance scores of the left limb, F(1,18) = 1.72, p = .206 and F(1,18) = 0.56, p = .558, respectively. (View Figure 2 to see the comparisons between overall stability score pre- to posttest of the right and left limb versus the control and experimental groups.) For the anterior-posterior test, there was a significant interaction effect, F(1,18) = 4.92, p = .040. A simple-effect analysis was conducted with a familywise alpha of .05 using paired samples t tests. There was no significant change from pre- to posttest for control group, t(9) = 2.98, p = .067 as well as for the experimental group, t(9) = -0.86, p = 0.41.

The independent samples t-tests indicated no difference in the anterior-posterior scores between groups both at pre-test, t(18) = -0.04, p = .972 and at post-test, t(18) = -0.96, p = .351. However, we found by examining the mean scores of each group, the control group has improved in the scores while the experimental group decreased in the anterior-posterior balance ability. With respect to the mediolateral scores, there were no time and group effects, F(1,18)= 2.25, p = .148 and F(1,18) = 0.12, p = .732, respectively.

Lastly, the two-way repeated measures ANOVA revealed no time or group effect on the fall risk scores, F(1,18) = 0.11, p = .743 and F(1,18) = 0.41, p = .528, respectively. However, there was a decrease in balance scores for the experimental group although it cannot be statistically concluded that there was significant improvement. Figure 3 shows the slight improvement of the experimental group, and no change in the control group.

Table 1. Exercise training program performed by the experimental treatment group.

Exercises	Reps per leg	Sets per leg	Visual
Star excursion	3 touches	5	Figure 1a
Bird dog	5	3	Figure 1b
Hip hike (touch ground with heel only)-2 purple blocks	10	2	Figure 1c
Single leg forward reach	5	3	Figure 1d
Hop-hop stick	5	1	Figure 1e

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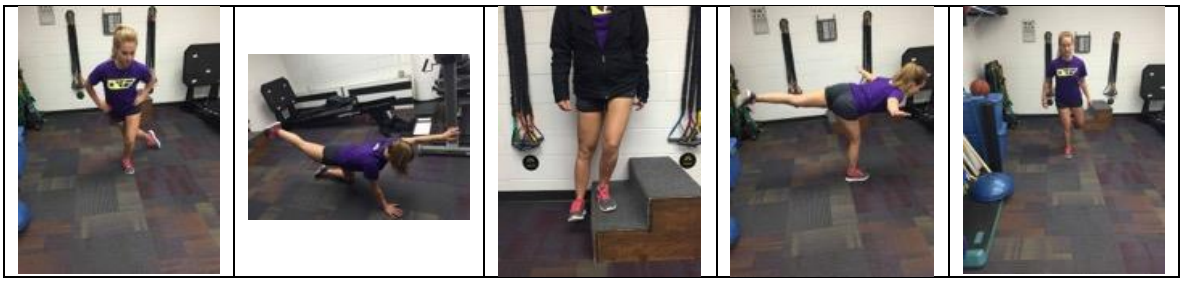

Figure 1a-e. Exercises performed by the experimental group. From left-to-right: a) start excursion, b) bird dog, c) hip hike, d) single leg forward reach, and e) hop-hop stick.

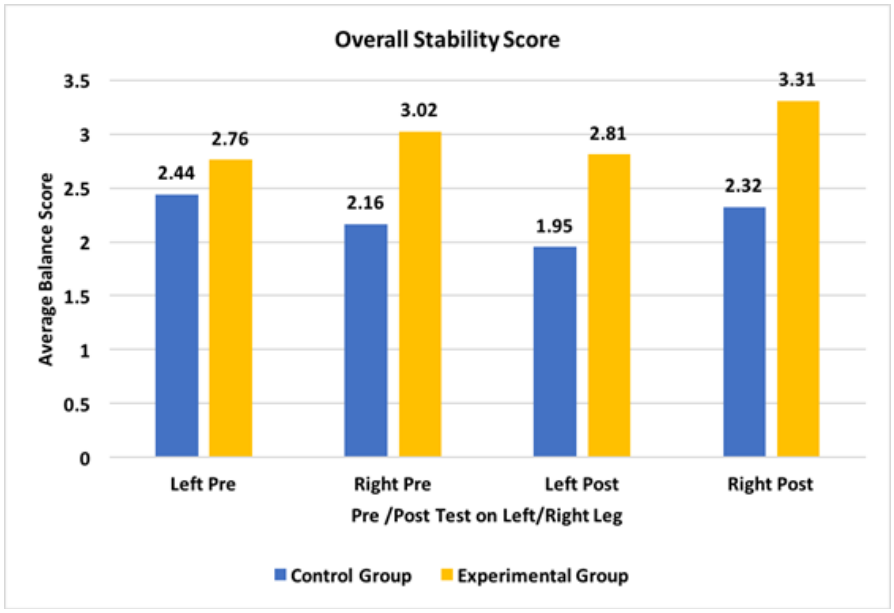

Figure 2. Overall Stability Score of bilateral single leg balance compared between two groups.

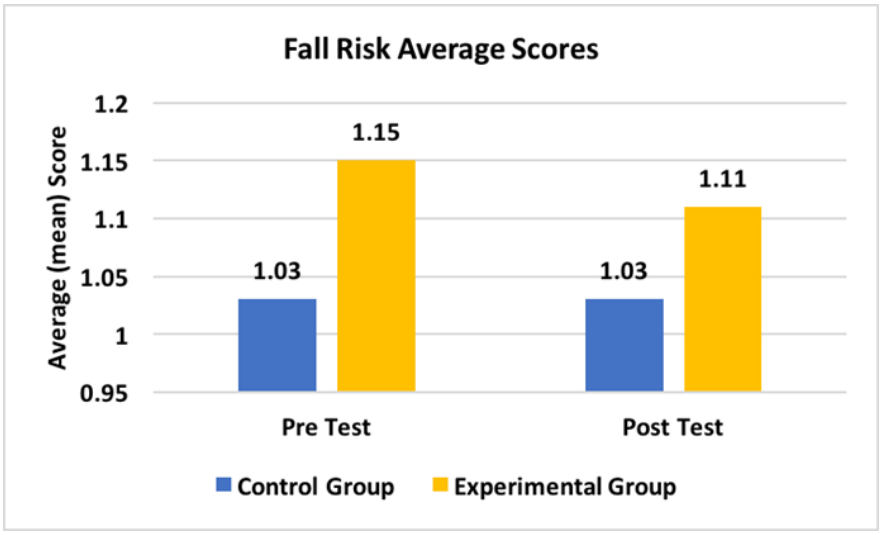

Figure 3. Comparison of Fall Risk Average Scores between control and experimental group.

Discussion

The study hypothesized that a greater improvement in balance scores (both single-leg and fall risk) would be found in female athletes that completed a three-week single leg balance program, compared to the control group who did not engage in any balance-based training. Throughout the study there was an increase in balance scores for pre and post testing of the mediolateral test of the right limb, but no group difference between experimental and control. There was a noted decrease in mean scores for the left limb control group, and an increase in scores for experimental in anterior-posterior balance ability. It should be noted that a decrease in scores is interpreted as an improvement in balance, not a deficit. The results concluded that the three-week single leg balance program was not effective to improve balance scores of female collegiate athletes.

Previously published data showed a positive response to balance training among high-caliber athletes versus recreational athletes[3]. Comparing previous studies to the current study, other programs had much longer balance training intervention durations than the 3 weeks that this study prescribed. A systematic review and meta-analysis were completed on previous balance programs, which suggested training programs should consist of 3 to 6 training sessions per week, equaling up to 19 training sessions to induce balance change[3]. Those involved in this study's experimental group were required to come in 3 times per week. The present study included 9 sessions in total, which is 10 less than the previous research design. Perhaps if this current study had increased the weekly frequency (while maintaining the length of the intervention), there would have been significant balance improvements in the experimental group.

One intention of this current study was to examine how collegiate level female athletes would respond to short term balance training. As suggested by Lesinski et al[3] in their study, approximately 19 training sessions are preferred for optimal changes in balance. The results of the current study supports the previous literature found, as no increase in balance scores were significant in either the control or experimental group. The design of this study challenged the current theory that longer term balance training (6-12 weeks) is the adequate length of time to see balance improve, but did not produce significant findings of improved balance for a 3-week long regimen. The short-term balance training implemented in this study indicated that longer than 3 weeks of balance training is suggested for proper facilitation of neuromuscular adaptations needed for balance improvements.

Understanding that the body needs more time to adapt to the balance stimulus gives the coach and trainers of a sports team considerable information that a balance training regimen should begin even before

most pre-seasons. This would allow when the athletes are in-season enough time to obtain optimal balance. Balance training should be continued throughout the in-season to maintain and continue balance gains. This study focused on balance training because better balance can decrease the chances of falling causing risk for injury as previously mentioned in Koenig's study[2].

The results from this study came from the Biodex SD, which is typically used on assessing balance in the elderly population. This study used it to assess the balance ability in the female collegiate population. Previous studies have used the Balance Error Scoring System and the Star Excursion Balance Test to assess static and dynamic balance, respectively[7]. These balance measurement modalities are more subjective in nature, thus influencing the decision to use the Biodex SD for balance assessment. Through the unique method of balance tracking on the Biodex SD for an athletic population, accurate and objective comparisons were made between the control and experimental group for this study.

Balance training should not be thrown-out or discontinued because of the findings in this study. One of the biggest questions when designing the study was whether 3 weeks of training would be enough to produce any of the desired outcomes. Some past studies that evaluated balance even suggest upward of 12 weeks of training to produce increased balance ability[4]. Though the 3 week balance program did not produce a significant increase in balance ability among the present sample, the results from the study can suggest that a longer duration for a balance program needs to be implemented for an athletic population. Another consideration for a contributing factor for lack of results supporting the hypothesis is that the prescribed exercises were not challenging enough to alter the balance ability of the experimental subjects. Another research study could be completed using different exercises for the same amount of time and frequency to determine if this is truly a confounding factor. The current study focused on athletes who were already active throughout the day, but previous studies on sedentary individuals, included physical activity into the balance training. One study done on elderly clients used a regimen targeting various factors of balance such as postural control, stability limits, sensory orientation, gait, and postural responses when a fall is about to occur[8].

A strength of this study is the objectivity of the balance assessment provided by the Biodex SD. A benefit of using the Biodex SD is that it is the most common and objective tool available to measure realistic balance scores[6]. This balance measurement tool decreases the occurrence of interrater variability during test conduction because the program evaluates each subject's balance in the same manner. Another strength of the study was that there were at

least one research member at every exercise session and pre/posttesting. By having a supervisor at each session, it could be ensured that the exercises were being completed with proper technique and that all the sets and reps were completed and that testing on the Biodex SD was implemented correctly.

One limitation with this research study was the sample size. In this study there were 20 total participants. Previous research has had anywhere from 34 participants[9] to upwards of 48 participants[10]. The concern is that such a small sample size is not enough to make generalizations about the rest of the athletic population. One limitation that challenged this study's internal validity was a psychological factor in the experimental group. The subjects that were randomly selected to be part of the experimental group were informed that they were the experimental group and were being assessed for balance increases from their pre to posttest on the Biodex SD. When the time came to measure their post-test values, it is possible that the subjects in the experimental group psychologically deterred the study by putting pressure on themselves to have great balance improvements. This factor is a confounding variable that affects internal validity because it could have possibly skewed the post-test results for the experimental group from recording their true balance improvement. Another threat to internal validity stemmed from the consideration of the effect of fatigue in the subjects. All of the participants were athletes that had time commitments to practices or weight lifting. When the participants performed these activities, it may have induced undue fatigue that could have deterred the efficacy on the balance exercises and possibly skewed the results of the pre or post test depending when the athlete worked out that day.

Conclusion

The study has various implications that can be used in the future to further replicate this study and modifications to find more applicable results. Through the results of this study, it was evident that the 3 weeks of balance program did not result in improvements in the college-aged athletic female population balance ability. Another potential route is to see if the same frequency and duration for the program would be successful if different exercises were used. This could be done by recruiting the same female collegiate sports, and keeping the methodology identical, but then switching the exercises out for different exercises that may be known to improve balance.

One possible future direction to take in this research is to see how male collegiate athletes from the same sports react to an identical balance training program. Results could be compared between the genders to see if the program was more effective for one over the other. One modification of the study that could potentially yield results is to increase the frequency/duration of

exercising within the three weeks, otherwise a balance program needs to be longer than three weeks to obtain improvements. Another suggestion would be to implement a balance program in the short-term basis among the non-athletic population and compare results to athletes to see if short term balance training affects populations of lower fitness levels differently.

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