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Comparisons of Static and Dynamic Balance Following Training in Aquatic and Land Environments

Aimee E. Roth, Michael G. Miller, Marc Ricard, Donna Ritenour, and Brenda L. Chapman

Context: It has been theorized that aquatic balance training differs from land balance training. ***Objective***: To compare the effects of balance training in aquatic and land environments. ***Design***: Between-groups, repeated-measures design. ***Setting***: Biomechanics laboratory and pool. ***Participants***: 24 healthy subjects randomly assigned to aquatic (n = 8), land (n = 10), or control (n = 6) groups. ***Intervention***: Four weeks of balance training. ***Main Outcome Measures***: Balance was measured (pre, mid, post, follow-up). COP variables: radial area, y range, x range in single leg (SL), tandem (T), single leg foam (SLF), and tandem form (TF) stance. ***Results***: A significant condition $\times$ time interaction for x range was found, with improvements for SL, SLF, and TF. Radial area improved, with post-test $1.01 \pm .23$ cm^2 and follow-up $1.06 \pm .18$ cm^2 significantly lower than pretest $1.18 \pm .23$ cm^2. Y range significantly improved, with posttest (4.69 ± 1.02 cm^2) lower than pretest (5.89 ± 1.26 cm^2). The foam conditions (SLF & TF) were significantly different from non-foam conditions (SL & T) for all variables. ***Conclusions***: Results of this study show that balance training can effectively be performed in both land and aquatic environments. ***Key Words***: balance, aquatic rehabilitation

During the post World War II era and the polio epidemic, aquatic therapy gained a wide scale of acceptance as a method of treatment of musculoskeletal and neurological disorders, disabling pain conditions, and balance disorders by allowing a patient to perform a comprehensive rehabilitative program in a low impact environment.[1-3] The contributing factors of hydrostatic pressure and buoyancy allow exercise in an aquatic environment to have several advantages over a gravity-influenced environment. First, buoyancy, the upward thrust acting in the opposite direction of gravity, can be utilized as an assistive force, a resistive force, or as a supportive force depending on the rehabilitation activity goal and

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contributes to a nearly weightless environment.[3] Second, hydrostatic pressure, the pressure exerted on all surfaces of an object immersed in water, may also create an ideal environment for activity.[3-4] When submerged, hydrostatic pressure promotes equal resistance to all muscle groups being worked and provides greater sense of stability.[3] It has been suggested that because there is no stationary resting position in water, muscles are activated continuously to stabilize the positions of the body.[3] The stabilization may allow a patient to gain more strength, flexibility, and more importantly, improve balance.

Balance is the ability to maintain a position and react to a perpetrating force.[3] These components are equally important for balance in athletic performance and are necessary in rehabilitation. By utilizing the properties of water, balance training may be more advantageous when performed in an aquatic environment. Aquatic therapy may contribute to neuromuscular coordination, proprioception, and balance efficiency. There is speculation that an aquatic environment will increase proprioceptive input to the immersed body by providing more stability and body alignment, leading to enhancement of balance.[1] Sensory feedback may also increase, promoting a sense of body awareness, because resistance to movement through a viscous fluid (water) is greater than resistance through air.[5] For these reasons, the aquatic environment may be an effective medium for balance training.

Although the popularity of aquatic therapy has increased, the effect of aquatic balance training on balance has not been well documented. Few studies have been conducted to examine how training in the water can affect balance performance on land.[2,6-15] These studies mostly pertain to the elderly population and those suffering from ankle and/or lower extremity injuries.[2,6-15] Little research is found pertaining to maintaining or improving a current level of balance in healthy, active individuals. The focus of many studies compared aquatic training during the early stages of rehabilitation and as a supplement to land.[2,6-15] Most fail to examine the difference of one environment over the other. The purpose of this study was to determine if differences exist between static and dynamic balance measurements following balance training in an aquatic versus land environment.

Methods

Design

This study used a $3 \times 4 \times 4$ mixed design ANOVA with one between subjects factor, training group (aquatic training group, land training group, and control group), and two within subjects factors, testing conditions (Single Leg Stance (SL), Tandem Stance (T), Single Leg Foam Stance (SLF), and Tandem Form Stance (TF), and time (pretest, mid-test, posttest, and follow-up test), and time (pre-test, mid-test, post-test, and 2 week follow up). This was used to compare the effects of training groups, testing conditions and time on the following dependent variables: x range, y range, and radial area. Subjects were randomly assigned to training groups. The balance measures (x range, y range, and radial area) were tested using a force platform at the following time points: pre-test, mid-test (2 weeks), post-test (4 weeks), and follow-up (two weeks after post-test). The aquatic and land training groups participated in a four-week balance training program.

Subjects

Twenty-four subjects (17 women: age = 21.18 ± 1.24 yr, mass = 64.63 ± 10.64 kg, Ht. = 166.37 ± 7.87 cm and 7 men: age = 22.43 ± 1.81 yr, mass = 80.91 ± 7.51 kg, Ht = 179.80 ± 6.79 cm), free of lower extremity musculoskeletal injuries, any documented balance disorder, or allergy to chlorine and other pool-related chemicals, volunteered to participate in this study. Using a Latin square, subjects were randomly divided into three groups: a land training group (n = 10), an aquatic training group (n = 8), and a control group (n = 6). All subjects were asked not to participate in any other balance training. The aquatic training was held at the Student Recreation Center pool in approximately 36 inches of water, and the land training was held on a ½ inch cushioned surface (carpet). This study was approved by the Human Subjects Institutional Review Board.

Procedures

All groups had a baseline balance measurement taken prior to taking part in the training sessions. Subjects were tested on performance variables based upon the Balance Error Scoring System (BESS) testing positions for static and dynamic balance, which has been reported to be valid for balance testing parameters.[16,17] Single leg stance (SL), tandem stance (T), single leg stance on medium density foam (SLF), and tandem stance on medium density foam (TF) were evaluated on a force platform.[17] Single leg stance tests were performed using the subject's dominant leg (the leg used to kick a soccer ball or football). The subjects performed this stance by raising their nondominant leg off the ground and maintaining it at knee level of the contralateral limb.[6] Tandem stance tests were performed with the subject placing their dominant foot in front of their nondominant foot in a straight line in the center of the force platform. Subjects followed a counterbalanced testing order and three trials for each testing positions (SL, T, SLF, and TF) were sampled. An average of the trials was used for statistical analysis.

Each test was administered with the subject's shoes and socks off. Subjects positioned themselves in the center of the force platform with their heads up and both hands on hips for the duration of the tests. Subjects were asked to maintain the given testing position for 10 seconds. Timing began when the nondominant foot was lifted. If subjects began to lose balance, they were allowed to make any necessary adjustments and return to the testing position as quickly as possible. The criteria for stopping the test included if subjects experienced a loss of balance that resulted in a stepping strategy to gain control, such as the subject's raised leg touching the ground.[5] Subjects had a practice trial for each one of the four testing positions prior to baseline measurements.

Three trials of each of the four testing positions were performed with a 1 min rest period provided between trials. Center of pressure data were collected at 100 Hz for 10 seconds using a Kistler 9421-A11 force plate and a Kistler 9861-A, 8-channel amplifier interfaced to a Dell computer equipped with a Keithley-Metrabyte (Taunton, MA) DPCA-3107, 16-bit analog-to-digital converter. Specially written Visual Basic software was used to sample and analyze the center of pressure data.[18] X range, range of the smallest to largest medial-lateral values, and y range, the smallest to largest anterior-posterior values, were calculated. Radial area, defined

as the area of the circle whose radius was the average of all radial distances of the center of pressure at each sampling interval from the mean position of the center of pressure was also recorded.[18]

A balance training program was developed based on recommendations of repetitions and intensity from Rozzi and Lephart[19] and Loundon and Weisner.[20] Wobble boards and an 8- inch aqua step were used in conjunction with other balance related exercises for training both static and dynamic balance. The exercises performed (see Table 1) were exactly the same regardless of the training environment. The investigators demonstrated each exercise and read a description from the training script initially and as needed throughout the study. The subjects were instructed to perform exercises with accuracy, concentrating on replicating the position demonstrated and described by the investigator, at each session. One of the study investigators was present at each one of the aquatic and land sessions in order to supervise and insure compliance with the training exercises. A lifeguard was present for all aquatic training sessions.

Following baseline testing, the aquatic and land groups trained 3 days per week for 4 weeks at approximately the same time of day. Each training session lasted approximately 30 minutes in duration. Subjects returned for balance measurements at each one of the 2-week marks: 2 weeks into training (mid-training test), at the conclusion of the 4-week training (posttest), and at 2 weeks following the training period (follow-up test). Subjects placed in the control group only performed the balance testing and were asked to carry out normal activities of daily function for the duration of the training and testing periods.

Statistical Analysis

A $3 \times 4 \times 4$ mixed design ANOVA with repeated measures on test and time was used to compare the effects of training group, testing condition, and time on the following dependent variables (Figure 1): x range (cm), y range (cm), and radial area (cm^2). The independent variables consisted of a between subjects factor training group (aquatic training group, land training group, and control group) and two within subjects factors testing conditions (SL, T, SLF, and TF) and time (pretest, mid-test, posttest, and follow-up test). The ANOVAs were done using the Number Cruncher Statistical Systems (NCSS, 2000, Kaysville, UT) statistical software. Post hoc analysis of significant main effects and interactions were performed using the Scheffe post hoc test. Alpha was set at 0.05.

Results

X Range

The means and SDs for x range by condition, training group, and time are shown in Table 2. There were significant differences between the groups: $F_{2,18} = 5.33$, $P = .02$, power = .77. Post hoc analysis of the group means (pooled) indicated that the aquatic group (2.9 ± .62 cm) had a significantly smaller x range than the land group (3.4 ± .55 cm) and the control group (3.57 ± .43 cm). The condition x time interaction for x range was significant: $F_{9,162} = 2.21$, $P = .02$, power = .88. The pooled means for x range condition and time are shown in Table 2. The x range

Table 1   Static Training Exercises

Static Activity	Description	Sets/ Repetitions
Single leg stance	standing on dominant leg with non-dominant leg at a 90°angle off the ground	3 X 30seconds
Single leg stance on wobble board	standing on dominant leg in center of wobble board, non-dominant leg at a 90° angle off the ground.	3 X 30 seconds

Dynamic Activity	Description	Sets/ Repetitions
Anterior/posterior tilt (A/P) on wobble board	standing on dominant leg in the center of wobble while performing front to back tilts	2 X 6
Medial/lateral tilt (M/L) on wobble board	standing on dominant leg in center of wobble board while performing side to side tilts	2 X 6
Clockwise/counter clockwise rotations (CW/CCW) on wobble board	standing on dominant leg in center of wobble board while performing rotations	1 X 10 in each direction
Step ups	standing with dominant leg on top of an 8 in step, lower non-dominant leg in front and behind step	1 X 20
Balance & reach	standing on dominant leg, non-dominant leg reaches in front of body until heel reaches floor and returns; body weight remains on dominant leg	3 X 30 seconds

for the posttest SL condition was significantly lower than the pretest x range. The x range for the mid test, posttest, and follow-up tests were all significantly lower than the pretest means for the SLF and TF conditions. Finally, both of the non-foam conditions (SL & T) were significantly lower than the foam conditions (SLF & TF), indicating that the foam conditions were more difficult.

Radial Area

The means and SDs for radial area condition, training group, and time are shown in Table 4. There were significant differences between the groups: $F_{2,18} = 4.78$, P
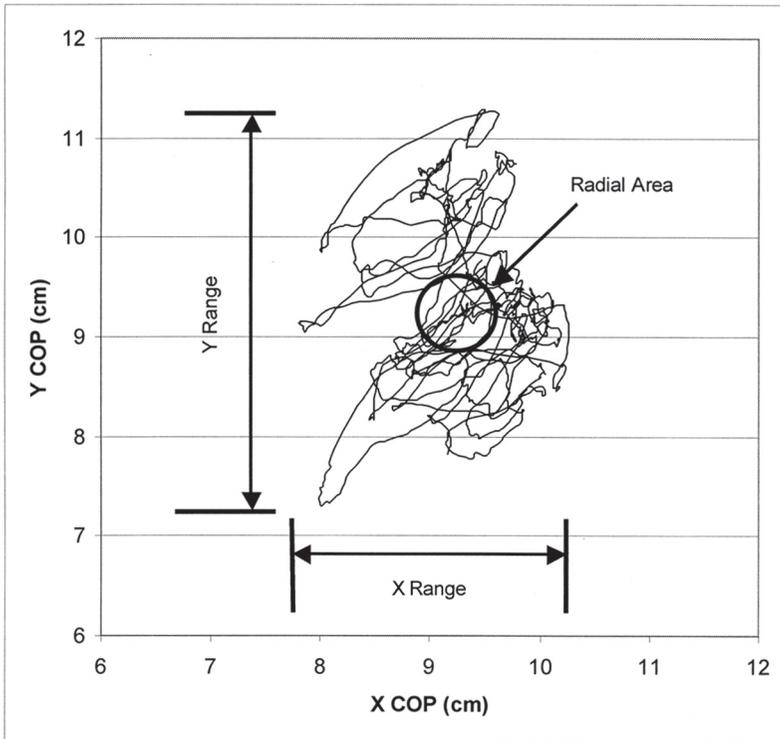
Figure 1—The X range (cm) represents the sway movement in medial-lateral direction. The Y range (cm) represents the sway movement in the anterior-posterior direction. The radial area (cm2) was defined as the area of the circle whose radius was the average of all the radial distances of the center of pressure from the mean position of the center of pressure.

= .02, power = .72. Post hoc analysis of the group means (pooled) indicated that the aquatic group (.91 ± .18 cm²) had a significantly smaller radial area than the land group (1.2 ± .21 cm²). There was a significant time effect (pooled) for radial area: $F_{3,54}$ = 4.60, P = .01, power = .87. Both the posttest (1.01 ± .23 cm²) and the follow-up (1.06 ± .18 cm² radial areas) were significantly lower than the pretest radial area of 1.18 ± .23 cm². Finally, there was a significant condition effect for radial area: $F_{3,54}$ = 44.41, P = .001, power = 1.00. Post hoc tests of pooled means indicated that the SLF (1.14 ± .28 cm²) and TF (1.39 ± .40 cm²) to be more difficult to perform than SL (.89 ± .20 cm²) and T (.93 ± .27 cm²).

Y Range

The means and SDs for y range condition, training group and time are shown in Table 5. There was a significant time effect for y range: $F_{3,54}$ = 10.22, P = .000, power = .99. The time means for y range were pretest (5.89 ± 1.26 cm), mid-test

Table 2   Means ± SD for X Range by Training Group, Condition, and Time (cm)

PreTest	Control	Aquatic	Land	PreTest Mean
SL	3.56 ± 0.44	2.50 ± 0.50	3.14 ± 0.50	3.07 ± 0.62
T	3.17 ± 0.64	2.72 ± 0.48	3.24 ± 0.63	3.05 ± 0.61
SLF	4.26 ± 0.99	3.71 ± 1.13	4.39 ± 0.76	4.13 ± 0.96
TF	4.63 ± 0.71	3.90 ± 0.89	4.36 ± 0.74	4.27 ± 0.81
Mid-Test	Control	Aquatic	Land	Mid-Test Mean
SL	2.96 ± 0.61	2.56 ± 0.54	2.92 ± 0.56	2.81 ± 0.57
T	3.19 ± 0.52	2.65 ± 0.49	3.17 ± 0.33	2.99 ± 0.49
SLF	3.87 ± 0.21	3.27 ± 0.59	3.64 ± 0.74	3.57 ± 0.61
TF	3.89 ± 0.47	3.30 ± 0.43	3.78 ± 0.73	3.64 ± 0.61
Post Test	Control	Aquatic	Land	PostTest Mean
SL	3.11 ± 0.31	2.05 ± 0.45	3.03 ± 0.61	2.69 ± 0.69
T	2.95 ± 0.52	2.61 ± 0.41	3.11 ± 0.40	2.90 ± 0.47
SLF	3.92 ± 0.36	2.61 ± 0.58	3.43 ± 0.86	3.27 ± 0.83
TF	4.32 ± 0.63	3.29 ± 0.50	3.67 ± 0.84	3.68 ± 0.76
Follow-up	Control	Aquatic	Land	Follow-up Mean
SL	3.01 ± 0.51	2.42 ± 0.53	2.94 ± 0.45	2.78 ± 0.54
T	3.13 ± 0.40	2.54 ± 0.51	2.87 ± 0.46	2.83 ± 0.50
SLF	3.63 ± 0.73	2.92 ± 0.66	3.58 ± 0.66	3.37 ± 0.73
TF	4.03 ± 0.36	3.35 ± 0.74	3.80 ± 0.86	3.71 ± 0.75

[*] indicates significant group by time by condition interaction ($P < 0.05$).

Table 3   Means ± SD for X Range by Condition and Time (cm)

Condition	Pre Test	Mid Test	Post Test	Follow Up Test
SL	3.07 ± .62[1,2]	2.81 ± .57[1,2]	2.69 ± .69[*,1,2]	2.78 ± .54[1,2]
T	3.05 ± .61[1,2]	2.99 ± .49[1,2]	2.90 ± .47[1,2]	2.83 ± .50[1,2]
SLF	4.13 ± .96	3.57 ± .61[*]	3.27 ± .83[*]	3.37 ± .73[*]
TF	4.27 ± .8	3.64 ± .61[*]	3.68 ± .76[*]	3.71 ± .75[*]

[*] indicates values are significantly different from pretest ($P < .05$)

[1] indicates significantly different from SLF ($P < .05$)

[2] indicates significantly different from TF ($P < .05$)

Table 4   Means ± SDs for Radial Area by Training Group, Condition, and Time (cm²)

PreTest	Control	Aquatic	Land	PreTest Mean
SL	1.05 ± 0.15	0.81 ± 0.17	0.96 ± 0.24	0.93 ± 0.19
T	0.98 ± 0.34	0.89 ± 0.28	1.06 ± 0.40	0.96 ± 0.32
SLF	1.29 ± 0.16	1.07 ± 0.24	1.45 ± 0.22	1.26 ± 0.27
TF	1.44 ± 0.14	1.40 ± 0.31	1.70 ± 0.53	1.54 ± 0.43
Mid-Test	Control	Aquatic	Land	Mid-Test Mean
SL	0.92 ± 0.17	0.81 ± 0.18	0.88 ± 0.15	1.02 ± 0.77
T	0.91 ± 0.15	0.91 ± 0.20	1.01 ± 0.32	0.91 ± 0.19
SLF	1.28 ± 0.20	0.98 ± 0.22	1.15 ± 0.25	1.12 ± 0.25
TF	1.39 ± 0.25	1.23 ± 0.22	1.56 ± 0.56	1.37 ± 0.38
PostTest	Control	Aquatic	Land	Post-Test Mean
SL	0.93 ± 0.12	0.69 ± 0.15	0.91 ± 0.16	0.77 ± 0.23
T	0.97 ± 0.29	0.72 ± 0.18	1.07 ± 0.25	0.87 ± 0.23
SLF	1.15 ± 0.15	0.78 ± 0.25	1.25 ± 0.24	1.03 ± 0.27
TF	1.41 ± 0.40	1.01 ± 0.22	1.53 ± 0.36	1.28 ± 0.40
Follow-up	Control	Aquatic	Land	Follow-up Mean
SL	0.90 ± 0.19	0.76 ± 0.23	1.00 ± 0.20	0.86 ± 0.21
T	0.90 ± 0.12	0.72 ± 0.14	1.00 ± 0.25	0.86 ± 0.20
SLF	1.07 ± 0.16	0.96 ± 0.26	1.26 ± 0.30	1.11 ± 0.28
TF	1.38 ± 0.31	1.15 ± 0.30	1.50 ± 0.43	1.35 ± 0.41

[*] indicates significant group by time by condition interaction ($P < 0.05$)

(5.23 ± 0.96 cm), posttest (4.69 ± 1.02 cm), and follow-up test (4.93 ± 1.07 cm). The post hoc analysis of the pooled time means indicated that the posttest (4.69 cm) was significantly lower than the pretest (5.89 cm) y range value. There was a significant condition effect for y range: $F_{3,54} = 71.54$, $P = .000$, power = 1.00. All four pooled conditions means for y range were significantly different from each other, SL (4.03 ± 0.79 cm), T (4.53 ± 1.04 cm), SLF (5.20 ± 1.11 cm), and TF (6.87 ± 1.26 cm).

Comments

The results of the current study indicated no significant therapeutic benefit of using one environment (land or aquatic) over the other for the balance training protocol

Table 5   Means ± SDs for Y Range by Training Group, Condition, and Time (cm)

PreTest				*PreTest* Mean
	Control	**Aquatic**	**Land**	
SL	4.65 ± 1.03	3.69 ± 0.88	4.52 ± 1.46	4.18 ± 1.17
T	5.10 ± 1.80	4.61 ± 1.63	5.37 ± 1.95	4.93 ± 1.76
SLF	6.55 ± 1.22	4.63 ± 0.72	7.30 ± 1.71	5.96 ± 1.64
TF	8.36 ± 1.08	6.69 ± 1.65	8.89 ± 2.70	8.11 ± 2.36
Mid-Test				*Mid-Test* Mean
	Control	**Aquatic**	**Land**	
SL	4.09 ± 0.98	5.00 ± 3.94	3.84 ± 0.93	4.32 ± 2.51
T	4.27 ± 1.54	4.29 ± 1.30	5.15 ± 2.06	4.44 ± 1.52
SLF	6.06 ± 0.46	4.51 ± 1.18	5.18 ± 0.94	5.16 ± 1.13
TF	6.65 ± 1.58	6.33 ± 0.91	7.05 ± 1.89	6.67 ± 1.35
PostTest				*Post-Test* Mean
	Control	**Aquatic**	**Land**	
SL	3.40 ± 1.73	3.21 ± 0.92	3.97 ± 0.76	3.45 ± 1.11
T	4.64 ± 1.26	3.21 ± 0.71	4.90 ± 1.51	4.00 ± 1.13
SLF	5.44 ± 0.68	3.56 ± 1.30	5.69 ± 1.09	4.73 ± 1.34
TF	6.40 ± 1.24	4.98 ± 0.89	7.36 ± 1.93	6.08 ± 1.73
Follow-up				*Follow-up* Mean
	Control	**Aquatic**	**Land**	
SL	4.16 ± 1.22	3.39 ± 1.07	4.41 ± 0.86	3.84 ± 1.02
T	4.87 ± 1.32	3.62 ± 0.79	4.83 ± 1.19	4.38 ± 1.12
SLF	4.79 ± 0.86	3.87 ± 0.88	5.64 ± 1.54	4.84 ± 1.44
TF	6.63 ± 1.30	5.73 ± 1.80	6.85 ± 2.22	6.44 ± 2.01

[*] indicates significant group by time by condition interaction ($P < 0.05$)

implemented. This suggests that healthy subjects without balance or injury deficits respond equally to either environment for balance training.

Additionally, studies have found strength gains in aquatic environments comparable to those made on land.[14,15] Although it was not tested in this study, it is speculated that the training protocol may have led to balance improvements due to a possible increase in lower leg musculature. As noted by Heitkamp,[14] strength gains may actually be attributed to an improvement of intramuscular and intermuscular coordination as well as a more economic recruitment rather than by hypertrophy. The improvement in balance experienced by the training groups may have been as a result of the contributing factors of strength, coordination, and control and not the training environment in healthy subjects.

For both land-based and aquatic-based training, included was the use of a wobble board training protocol supported by Rozzi et al[19] in order to enhance

balance as part of the training exercises. They suggested that the implemented training program effectively stimulated centrally mediated neuromuscular control mechanisms responsible for the maintenance of balance and posture.[19] The use of a wobble board for balance rehabilitation is also supported by Balogun.[6] Rhythmical movements of the wobble board were used to stimulate the joint mechanoreceptor feedback mechanism and to increase strength of lower leg musculature. As a result, improvement in balance performance has been noted.[5,15,27,28] Also implemented into the training protocol was the balance-and-reach test, described to specifically challenge single-leg balance,[20] as well as an aqua step. The subjects in the current study experienced balance performance improvements based upon our data following 4 weeks of exercise, suggesting the implemented protocol was an effective balance training program.

The Balance Error Scoring System is a clinical test that uses modified Romberg stances on different surfaces in order to assess postural stability.[16,17] Conflicting data exists pertaining to a possible practice effect. A significant practice effect has been found during the course of repeated administrations, especially in the SLF stance.[17] Conversely, Riemann, Guskiewicz, and Shields[16] reported no practice effect in their investigation. In this study, an overall improvement in performance was found in each of the training groups and the control group. This may be attributed to a practice effect given that subjects returned for repeat testing several times (pretest, mid-test, posttest, and follow-up) during the course of the study. Although improvement in balance performance was noted among each one of the groups, improvement did not occur in every condition. Finally, this study used a control group to determine differences. Several studies examining balance did not use control groups and results could have differed if included.[2,6,26,27] Further studies should explore more challenging protocols and use of control groups to determine if balance changes occur.

There is paucity of objective data in support of balance training and clinical use.[5] Single leg and tandem stances on both firm and foam surfaces using a force platform were used to measure displacement of an individual's center of pressure while standing in a stationary position.[25] These stances, derived from the BESS, reduce a person's base of support, making compensatory actions and falls frequent occurrences even in the absence of pathology.[22] An attempt at managing compensatory actions or falls was made by shortening the length of testing trials. The 20-second testing duration was decreased to enhance the success of the subject and make it more applicable to a situation they may encounter in everyday life. The researchers of this study felt that it would be more beneficial to investigate a 10-second test of balance rather than a 20-second test.

The BESS was developed using an error scoring system with several criteria for obtaining error points including lifting hands off of hips, remaining out of testing position for more than five seconds and moving hip into more than 30° of flexion or abduction.[16] The stopping criteria used in this study involved only the "stepping strategy." Subjects were allowed to make adjustments throughout the testing trials as long as their nondominant foot did not contact the force platform. However, as a result, each compensatory movement may have affected force platform sway measures,[16] making it difficult to conclude that this was an accurate test for this study. Additionally, the BESS was not designed to be used with a force platform

and other testing methods, and time parameters on the force platform should be explored.

The foam conditions were implemented to establish a dynamic test of balance activity where the patient must adapt to a changing surface. The current study confirmed that the foam conditions (TF and SLF) were more difficult to perform than the non-foam conditions. Riemann, Guskiewicz, and Shields [16] noted similar findings with single leg stances more difficult than the tandem stances performed on the firm surface. The relationship between the two stances was just the opposite (tandem more difficult than single leg) on the foam surface. [16] The single leg stance was included in the balance training protocol and was performed on a stable surface and an unstable surface (wobble board) in this study. Tandem stance was not a training variable. The single leg foam condition may have improved because it was incorporated into both stable and unstable training surfaces. Future studies may consider using testing parameters and positions not incorporated as part of the training protocol.

A 4-week training protocol was used based on the results of related balance training studies. [5,19] Improvements in single-leg balance ability following the completion of 4 weeks of balance training appear to be consistent with other studies involving balance training programs for individuals with functionally unstable ankles as well as healthy, uninjured individuals. [6,19,26] Balogun [5] reported no difference in balance performance between the measures at the end of the fourth and sixth weeks of training. Because no balance deficits or differences were found beyond the 4-week training period, the prescribed training protocol supported by past research proved to be appropriate. However, our data also demonstrated that balance was maintained after two weeks of training, suggesting that balance training may have lasting effects over time. More research is needed to determine the length of time balance improvements may be maintained after specific training.

A balance training program can be implemented in both aquatic and land environments effectively. Although a progression from aquatic-based to land-based rehabilitation has customarily been suggested for functional purposes, the current study shows that training in a gravity dependent environment may not be necessary to see functional gains on land. Aquatic rehabilitation, when used during the early stages of injury rehabilitation, is very beneficial to the healing process. [1-5,13,15,21-22,24]

Results of this study demonstrate that when pertaining to a healthy individual, either environment can be used. More research is needed to address the effect of training on sport specific and job related activities. Also, more research is needed to examine the effect of the training environment on balance in individuals with lower extremity injuries.

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