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EFFECTS OF BALANCE TRAINING ON SELECTED SKILLS

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ABSTRACT. Yaggie, J.A., and B.M. Campbell. Effects of balance training on selected skills. *J. Strength Cond. Res. 20(2):422–428. 2006.*—The purpose of this study was to determine the effect of a 4-week balance training program on specified functional tasks. Thirty-six subjects (age = 22.7 ± 2.10 years; height = 168.30 ± 9.55 cm; weight = 71.15 ± 16.40 kg) were randomly placed into control (C; $n = 19$) and experimental groups (Tx; $n = 17$). The Tx group trained using a commercially available balance training device (BOSU). Postural limits (displacement and sway) and functional task (time on ball, shuttle run, and vertical jump) were assessed during a pretest (T1), a posttest (T2), and 2 weeks posttraining (T3). Multivariate repeated measures analysis ($\alpha = 0.05$) revealed significant differences in time on ball, shuttle run, total sway, and fore/aft displacement after the exercise intervention (T2). T3 assessment revealed that total sway and time on ball remained controlled; however, no other measures were retained. Balance training improved performance of selected sport-related activities and postural control measures, although it is unclear whether the effect of training would transfer to general functional enhancement.

KEY WORDS. core stability, exercise, proprioception, fitness

INTRODUCTION

Competitive and recreational sports are dependent on multiple components of training and the development of strength, power, and endurance (13, 15, 19). Balance training is a relatively recent phenomenon in the fitness industry that has developed into a primary point of interest for consumers and fitness professionals (5, 14, 16, 23). Balance is comprised of the dynamic reactions of involuntary sensations and impulses that maintain an upright stance and is necessary for most functional movements (7, 10, 17, 19). Success in athletic and recreational activities depends on both balance and functional movements. The proper function of all active muscles and the velocities at which these muscular forces are applied are crucial (23). Many recreational activities require lateral, forward, and backward movements during which the center of gravity (COG) is often at the edge of the base of support (BOS) (23). To maintain balance, it is necessary to have a functional awareness of the BOS to better accommodate the changing COG (6). The goal of balance training is to improve balance through perturbation of the musculoskeletal system that will facilitate neuromuscular capability, readiness, and reaction (5, 21, 33).

In recent years, several commercial products have been developed to enhance and improve proprioceptive training. The development of the Biomechanical Ankle Platform System (BAPS) board mirrored the uniaxial and multiaxial boards that were designed for rehabilitative purposes to increase proprioceptive activity in injured ankles (9, 29). Reebok's Core board was designed to increase proprioception and core stability and was targeted for those outside the commercial rehabilitative setting. The Kinesthetic Ability Trainer (KAT) (18) and the Balance Master (12, 14, 27) are computerized mechanical platforms designed to enforce calculated perturbations and visual stimulations to challenge the muscular and visual systems.

The Both Sides Up balance trainer (BOSU; Fitness Quest, Canton, OH) is an apparatus that was designed for balance training within the athletic and recreationally active population. The design of the BOSU provides a solid plastic base integrated with an inflatable rubber bladder that resembles a halved Swiss ball. The BOSU has a solid surface facing down that provides an unstable surface on stable ground (Figure 1). Furthermore, it is designed to improve stability not only while the user maintains an upright position, but also when the user is in a horizontal position (i.e., during abdominal exercises).

Functional ability can be exemplified by the performance of a sport-related task (35). These tasks require appropriate control of the neuromuscular and musculoskeletal systems, including the proprioceptive system. It is presumed that balance training has the most profound effect on the somatosensory and proprioceptive control systems (2, 23, 25, 35); however, conventional means of assessment must quantify the training effects gained by proprioceptive control, and not proprioception itself. Through skill assessment, inferences regarding interventions may offer insight into the effects on the proprioceptive system (23, 24, 32).

Several studies (2, 9, 23, 24, 32) have found that balance training enhances proprioceptive control. Most of these studies have investigated subjects with chronically unstable or injured joints of the lower extremities compared with untrained healthy subjects. Few investigations have examined the effects of balance training in noninjured individuals (5, 14, 16, 33). Rozzi et al. (28) found that a 4-week balance training program was an effective means of improving joint proprioception and single-leg standing ability in subjects with unimpaired ankles. The limited usage of the noninjured population in this context characterizes an underrepresentation of healthy, physically active individuals interested in stability training.

The purpose of this study was to determine the influence of a balance-training protocol, using the BOSU, on dynamic stance and functional performance in healthy, recreationally active individuals.

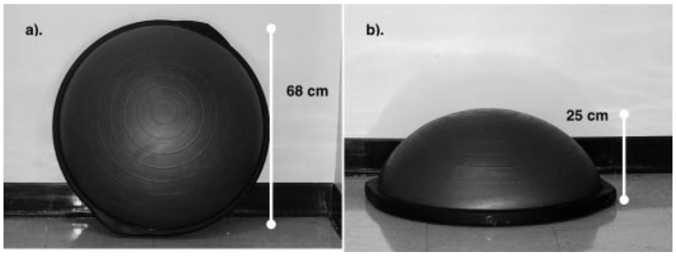

FIGURE 1. Photographs of the Both Sides Up balance trainer. (a) Diameter of the base is 68 cm. (b) Approximate height when inflated is 25 cm.

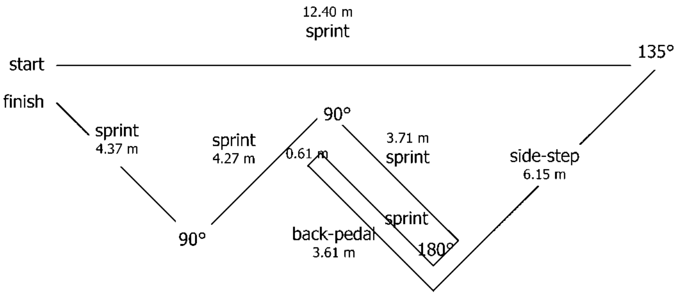

FIGURE 2. Schematic of shuttle run.

METHODS

Experimental Approach to the Problem

All subjects completed a pretest (T1), a posttest (T2), and a retention test (T3) designed to determine whether individuals experienced a positive response from a balance-training program and whether they retained those positive effects 2 weeks after training was terminated. Prior to the inception of training, postural sway, postural limits, vertical jump height, shuttle run time, and time on the BOSU were assessed (T1). Repeated assessments were performed following a 4-week training protocol (T2) and again following a 2-week suspension of training (T3). Previous research indicates that a 2-week cessation of training can result in a significant reduction of training effects, related to physiological and neuromuscular implications of deconditioning (4).

Subjects

Thirty-six healthy recreationally active volunteers (mean age = 22.47 ± 2.10 years; height = 168.30 ± 9.55 cm; weight = 71.15 ± 16.40 kg) participated in this investigation. In compliance with Institutional Review Board procedures, all subjects were required to read and sign informed consent documents. Subjects were screened via interview and self-report regarding activity behavior and injury status. Those participating in vigorous activity and cardiovascular training (3 to 5 times per week) and musculoskeletal resistance activity (2 to 3 times per week) were considered recreationally active. Subjects reported having no lower extremity trauma within the 2 years prior to the investigation. All were free of known balance disorders and were considered to be in good health, according to the Physical Activity Readiness Questionnaire (PAR-Q). Those with corrective lenses were encouraged to wear them for each testing and training session. Subjects were paired for gender and self-reported activity level and were randomly assigned to BOSU-trained (Tx; $n = 17$) and untrained (C; $n = 19$) groups.

Procedures

Limb Dominance and Postural Sway Assessment. Prior to pretesting, lower limb dominance was determined by having participants complete a ball-kick test and the step-up test.

To assess postural sway parameters, the subjects were instructed to stand on an Advanced Medical Technologies, Inc. (AMTI) force platform (Model OR-6; Advanced Medical Technologies, Inc., Watertown, MA) using their dominant leg with the nondominant leg flexed at a 45° angle at the knee joint and the arms placed across their chest. A visual target was placed approximately 3 m in front of the subjects as a focal point. Subjects were then instructed to lean forward as far as possible without lifting any part of their foot off the platform, attempting to maintain hip and knee extension at all times. Following a familiarization trial, 3 15-second trials were performed, with the first 10 seconds standing upright and the last 5 seconds leaning forward. Subjects were given 2 minutes of rest between trials. This method is similar to those found in the literature (3, 34).

Functional Tasks. Three functional tasks were used in this investigation, balance on the BOSU (TOB), vertical jump (VJ), and shuttle run (SR). These assessments were selected because of the specificity of the balance device (TOB) and the ability to assess the influence the training on power (VJ) and agility (SR).

Time on Ball. Subjects were instructed to stand on the BOSU using their dominant leg. Once comfortable, they were asked to close their eyes and maintain that position without falling or touching the ground or the BOSU with their nondominant leg. If the subject lost control of that posture, the investigator stopped the watch and recorded the time spent on the BOSU.

Shuttle Run. The shuttle run course used in this investigation (Figure 2) was similar to that found in the literature (34). The course included several directional changes and involved sprinting, backpedaling, sidestepping, and starting-and-stopping patterns. The time taken to complete this running course was measured by the investigator using digital timing pads placed at the start and finish (DT2819, Melbourne, FL). Subjects completed several practice trials to familiarize themselves with the course. Following the practice trials, 3 running trials were performed by each subject with 2 minutes of rest between each trial.

Vertical Jump. The vertical jump protocol used in the current investigation has been described in the literature (34). Subjects performed a standing vertical jump with their preferred arm adjacent to the wall. The subjects reached up with the selected hand, keeping their heels on the floor and firmly marked the wall by touching the inked finger to the wall. The height was recorded.

Subjects were instructed on the proper form of a vertical jump. Each participant was allowed a countermovement prior to take off as long as a step approach was not used. The subjects were instructed to touch the wall with their inked hand at the peak of the jump. The distance between the standing reach and vertical jump marks was calculated. The average from 3 vertical jump trials was calculated and used for the analyses.

Training Procedure. The balance training on the BOSU began within 2 days following the pretest. The

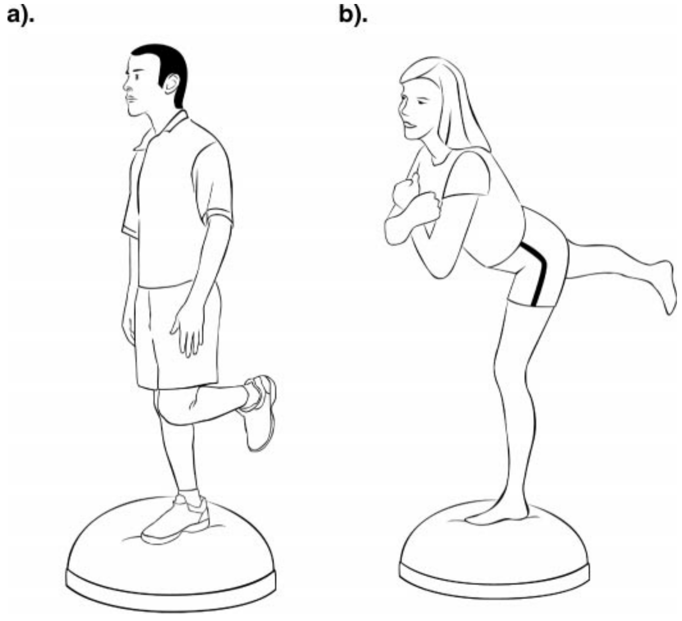

FIGURE 3. Example of exercise progression of ball stance with (a) unilateral stance on ball, and (b) unilateral stance with trunk excursion on ball.

training protocol consisted of exercises progressing from the simplest to most complex sessions. The protocol that was used in the current investigation was a commercially developed training program that is provided with the BOSU at the point of sale (8). The prescribed protocol included activities that are consistent with exercises described in the literature (2, 21, 23, 31).

The Tx group trained on the BOSU 3 times per week for approximately 20 minutes. Each week the subjects were presented with more difficult variations of exercises to replace those already mastered. Mastery was defined as remaining on the BOSU for a period that was more the 2 times longer than the previous session without falling off or adding support. The selected exercises were designed to challenge one or more of the sensory systems integral in maintaining balance. Additions and modification to the battery of exercises included rotating the head laterally, tilting the head upward, keeping the eyes open or closed, and using the trunk excursion or lean (Figure 3).

All subjects were asked to maintain a log to track the amount and intensity of elective activity during the testing period. Inclusion of each subject was based on the frequency of activity (3 to 5 sessions per week) and the number of average hours logged (1 to 3 hours per occurrence). Those that cataloged the minimum hours without exceeding a maximum value (15 total hours per week) were included in the study. Activity included total time in participation of recreational activities and sports, strength and resistance training, exercises classes, flexibility training, and cardiovascular exercise. Initially, evenly numbered groups were recruited for the study; however, these criteria lead to the exclusion of data from 4 subjects (C = 1; Tx = 3).

Instrumentation. Each subject's balance was assessed using the AMTI force platform in conjunction with BalanceTrak software (Motion Analysis Corporation, Santa Rosa, CA) to determine specific sway patterns. The BalanceTrak software produced a trial duration of 15 seconds and sampled data at a rate of 200 Hz. The force plate was calibrated prior to data collection before each session.

Quiet Stance. Total sway (TS), medial-lateral sway (MLS), fore-aft sway (FAS), fore-aft displacement (FAD), and medial-lateral displacement (MLD) were collected for each subject during each testing session (T1, T2, and T3) and were compared across time and treatment.

Lean Test. During the unilateral forward lean test described by Blaszczyk et al. (3), voluntary MLD and FAD of the center of foot pressure was established while the subject maintained a rigid body posture and leaned forward at the ankle joint. Correct body posture was verbally explained, demonstrated, and observed by the investigator prior to the testing sessions. The software calculated the excursion of the x and y values and determined the maximum FAD and MLD. Trials exhibiting incorrect leaning posture were discarded and not included in the analysis.

Statistical Analyses

SPSS for Windows (Version 13.0; SPSS, Inc., Chicago, IL) was used for statistical analyses. Data were recorded and coded for gender and treatment group. A repeated measures multivariate analysis of variance (MANOVA; $\alpha \leq 0.05$) was computed to determine significant differences between the Tx and the C groups, as well as between T1, T2, and T3 testing time points. The dependant variables that were examined were TOB (seconds), VJ height (cm), SR time (seconds), TS (cm), MLS (cm), FAS (cm), FAD (cm), and MLD (cm). Bonferroni pairwise comparisons were used to test main effects.

RESULTS

Means and standard deviations for all variables may be viewed in Table 1. Analysis of variance (ANOVA) revealed that no main effects of gender were observed across time and condition ($p < 0.001$).

Time on Ball

Intraclass correlation coefficients (ICCs) were calculated for the TOB values to examine the internal consistency of the data across time and condition. Consistency assessment was run using a 2-way mixed model set for absolute agreement of measures. ICCs for the C group for TOB were considered acceptable ($R = 0.86$).

Repeated measures MANOVA revealed a significant difference in time and treatment ($F = 25.98$; observed power = 1.00). In the C group, pairwise comparison noted a significant difference between T1 and T3 while differences between T1 and T2 and between T2 and T3 were not significant.

In addition, pairwise comparison revealed significant differences in the Tx group across T1 and T2 and across T1 and T3; however T2 and T3 did not differ. It should be noted that both groups displayed a progressively longer TOB across sessions (T1-T2-T3), albeit not statistically significant. Figure 4 illustrates these findings.

Shuttle Run

Intraclass correlation coefficients for SR were calculated and considered acceptable ($R = 0.84$) for the C group.

A significant main effect in time and treatment ($F = 4.82$; observed power = 0.764) was observed. Bonferroni

TABLE 1. Mean (± *SD*) for functional and sway parameters across session and group.*

		T1	T2	T3
Functional Tasks				
TOB (s)	Tx	2.35 ± .698	3.71 ± 1.86	3.96 ± 1.55
	C	2.75 ± 1.06	3.11 ± 1.27	3.38 ± 1.57
VJ (cm)	Tx	41.30 ± 10.21	40.40 ± 9.24	41.28 ± 9.55
	C	47.91 ± 13.31	48.98 ± 14.21	49.24 ± 13.93
SR (s)	Tx	13.16 ± 1.47	12.45 ± 1.87	12.77 ± 1.38
	C	12.62 ± 2.01	12.70 ± 2.07	12.38 ± 2.08
Sway Parameters				
TS (cm)	Tx	32.25 ± 11.4	27.9 ± 9.6	29.25 ± 7.6
	C	33.18 ± 10.2	33.56 ± 7.5	31.89 ± 9.1
MLS (cm)	Tx	.65 ± .26	.59 ± .28	.64 ± .27
	C	.62 ± .26	.67 ± .34	.62 ± .25
FAS (cm)	Tx	1.41 ± .25	1.46 ± .33	1.4 ± .24
	C	1.46 ± .25	1.5 ± .34	1.45 ± .25
FAD (cm)	Tx	1.59 ± .92	2.35 ± .91	2.02 ± .8
	C	1.5 ± .73	1.58 ± .62	1.65 ± .75
MLD (cm)	Tx	.610 ± .217	.660 ± .323	.584 ± .224
	C	.626 ± .232	.544 ± .326	.640 ± .381

* TOB = balance on the Both Sides Up balance trainer; VJ = vertical jump; SR = shuttle run; TS = total sway; MLS = medial-lateral sway; FAS = fore-aft sway; FAD = fore-aft displacement; MLD = medial-lateral displacement; Tx = experimental group; C = control group; T1, T2, T3 = testing sessions.

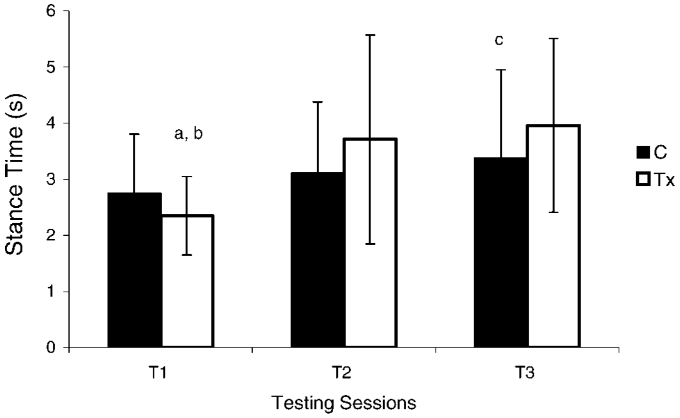

FIGURE 4. Mean (± *SD*) of time on ball (TOB) task. Significant differences were found in the experimental (Tx) group between sessions (a) T1-T2 and (b) T1-T3. (c) Significant differences were noted between T1-T3 in the control (C) group. These comparative results may indicate a learning effect of TOB.

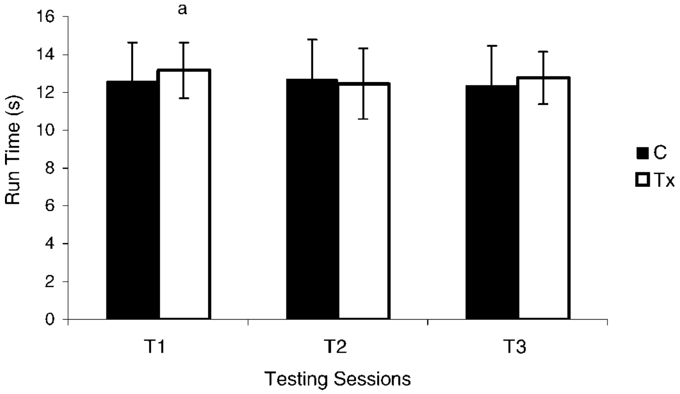

FIGURE 5. Mean (± *SD*) of shuttle run time. (a) A significant difference was found in the experimental (Tx) group between sessions T1 and T2. C = control group.

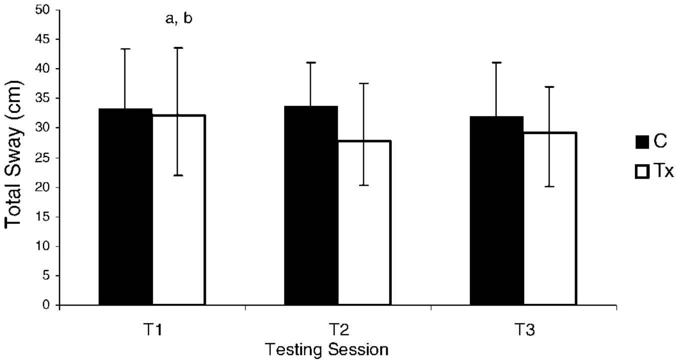

FIGURE 6. Mean (± *SD*) of total sway (TS) parameters across sessions T1, T2, and T3. (a) A significant decrease in TS was observed in T2 and (b) T3 when compared to T1 in the experimental (Tx) group. However, no differences were noted in T2 to T3. No significant differences were noted in the control (C) group.

pairwise comparisons indicated that the Tx group experienced a significant decrease in shuttle run time between T1 and T2; however no discernable differences were observed between T1 and T3 or between T2 and T3. No differences were observed in the C group (Figure 5).

Vertical Jump

Intraclass correlation coefficients for VJ were calculated and considered acceptable ($R = 0.91$) for the C group.

Results revealed no significant differences between times or treatments ($F = 2.43$; observed power = 0.669).

Sway Values

Intraclass correlation coefficients for force plate data were calculated and considered acceptable ($R = 0.72$) for the C group.

Significant main effects for time (T1, T2, and T3) and treatment (Tx and C) were noted ($F = 4.01$; observed power = 0.710) for TS (Figure 6). A significant decrease in

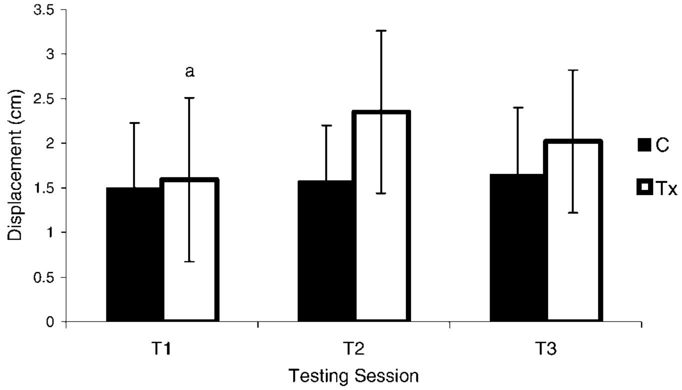

FIGURE 7. Mean (± *SD*) of fore-aft displacement (FAD) values across testing session. (a) A significant increase in FAD was noted between T1 and T2 in the experimental (Tx) group; however, the effects of training were not retained. No differences were observed in the control (C) subjects.

TS was observed in the Tx subjects immediate posttraining (T2 = 27.91 ± 9.7 cm) compared to the pretraining values (T1 = 32.25 ± 11.4 cm). Mean retention scores (T3 = 29.24 ± 7.6 cm) of TS for trained subjects also showed a significant decrease in sway when compared to those of T1 and did not significantly differ from those of T2, indicating that the skill was retained following 2 weeks of suspended activity. No differences were noted in the C subjects across time.

No significant main effects were noted in the MLS (F = 0.022; observed power = 0.053) and FAS (*F* = 0.415; observed power = 0.111) data for either the trained or untrained groups.

Lean Test Parameters

MANOVA exhibited significant main effects in FAD (*F* = 38.80; observed power = 1.00) for both treatment and time. Pairwise comparisons noted a significant increase in FAD from pretraining (T1 = 1.59 ± 0.6 cm) to posttraining (T2 = 2.34 ± 0.9 cm) in the Tx participants. The changes in FAD were not statistically significant following the retention test (T3 = 2.02 ± 0.9 cm), but they displayed a tendency toward preservation of enhanced skill ($p = 0.55$) (Figure 7). No significant differences were noted in the C group across time. MANOVA did not reveal main effects for MLD (*F* = 0.792; observed power = 0.591) values across time or treatment.

DISCUSSION

The results of TOB performance indicated the presence of a training effect relative to the differential data from T1 to T2 in BOSU-trained subjects. Furthermore, the Tx group had no significant difference between the posttest and retention test when training concluded. TS data revealed a similar response to training. In both instances, comparative T2-T3 values did not differ, suggesting that the acquired skill level was retained following 2 weeks of inactivity. The retention of these skills was not expected but seems reasonable considering the nature of the activities. The additional quiet-stance parameters did not exhibit significant results and were relatively consistent across session and treatment.

Each assessment was modeled to represent a dynamic posture or stance. The sway values were measured on the force platform and were a familiar type of activity for an active, healthy subject. The familiarity of the posture may have influenced the quiet stance assessment. The stance of the TOB assessment typically exhibited a posture that requires the rear foot to sink due to the compliance of the BOSU, causing a slight dorsiflexion angle in the ankle. With the joint in this closed-packed orientation and loaded in a single-legged stance, the proprioceptive influence of the joint may have been agitated to meet the demand of stressed joints, eliciting a more controlled stance. This notion could be tested by including individuals with unstable or chronically injured ankles. It could be predicted that the information from the sensory systems may have been confounded, eliciting alternate results due to proprioceptive loss.

Research has shown that individuals with decreases in postural-sway parameters (better balance) may experience fewer lower extremity injuries. Likewise, those with poor balance (higher sway values) experience increased injury rates (26). Tropp et al. (32) found that when using uniaxial and multiaxial ankle disks in balance training, there was a significant decrease in postural sway of soccer players with known ankle injuries. This is further supported by Rozzi et al. (28), who found that balance training may be used to restore ankle stability, presumably by training altered afferent neuromuscular pathways after an injury. Therefore, balance training may improve the ability of proprioceptive pathways that were previously injured, resulting in improvement in balance and a decrease in sway parameters.

Although no significant differences were observed in the C group, a trend of enhanced performance had developed across sessions, indicating a learning effect associated with assessment. The Tx group also displayed the trend of increasing the TOB with each session. Therefore, it is possible that both training and learning of this specific skill could have enhanced the performance of the TOB task across sessions. The learning effect observed in balance assessment has been addressed in the literature (1, 11, 25, 35). However, covariation of these effects was considered through the use of multivariate analysis.

Training also influenced performance of the SR in trained subjects. A significant decrease in SR time was observed between the pretest (T1) and posttest (T2) for the Tx group, but not for the C group. Furthermore, the training effect was diminished as the SR times returned toward the pretest values after a 2-week retention interval (T3). A similar result was noted in the FAD in Tx subjects, suggesting that BOSU training was influential in enhancing dynamic sway parameters involving excursion of the center of gravity or mass.

It is well documented that consistent activity and training of the lower extremities may influence the reaction time, proprioception, and muscle activation of crural musculature (1, 2, 22, 24, 25, 35). Peroneal muscle reaction time has been examined in multiple research models and disease states. One of the hallmarks of a chronically unstable ankle is the loss of reactionary control of the lateral musculature of the crurum. This type of condition leads to poor muscle activation, joint motion, and alteration of the center of pressure of the foot (20). Furthermore, Lentell et al. (22) reported that instability of the ankle is not a result of muscle weakness but is associated with the presence of proprioceptive deficits. These kinematic outcomes result in modifications throughout the kinetic chain that alter the inverse dynamics of the knee and hip. This results in a delay in the inherent mechanisms and reflex loops used to control posture and balance. Therefore, the training of these muscles, among others, will enhance reaction and proprioceptive influences of the lower extremity and will result in improved postural control.

The objectives of balance training are to augment the afferent pathways to enhance the sensation of joint movement (23). The influence of sensory enhancement is more obvious in those that have impairment or are unfamiliar with specific tasks. In the present study, it was observed that the dynamic tasks of SR and FAD improved with training (T1-T2) and returned toward baseline once training had been suspended (T2-T3). Improvements in performance of dynamic or functional tasks may not be as apparent when examining the uninjured, competitive athlete. Therefore, the specificity of athletic performance and the level of competition should be considered when designing programs for highly trained individuals, or those participating in athletics.

This idea was supported by Soderman et al. (30), who investigated the use of balance board training in the prevention of traumatic lower extremity injuries. Although, no traditional balance measures were assessed, the results revealed that there were no significant changes in soccer players receiving balance-training intervention with respect to the number, incidence, or type of traumatic injury to the lower extremities. The lack of statistical findings may have been masked by the rigor of the soccer training regimen. The authors contend that balance board training may not have sufficiently stressed the neuromuscular system to notice any significant improvements when examined during the soccer season. Although changes were expressed in the present study, the influence of training on dynamic performance may be difficult to discern in young healthy populations.

Furthermore Häkkinen and Myllyla (13) reported that force production and reaction in athletes training for activities using power and strength are significantly more forceful and responsive than those athletes that are endurance trained. This paradigm seems reasonable considering the demand of muscle activation for power and strength activity. However, the current investigation lacks support of enhancement of strength and power given the nonsignificant findings in vertical jump performance for both the Tx and C groups. If the increases in agility skill (SR) were coupled with those of VJ, the improvement in performance could be explained through muscular adaptations and strength gains. The presence of significant improvements in dynamic tasks indicates that agility, skill, and excursion may be attributed to neurological adaptation to activity and proprioceptive action of the trained joints and soft tissues. This model is consistent with the observational gains in ability following short-term training (less than 4 weeks). Perhaps gains in strength and power would become apparent with modification to the training protocol.

The recruitment of recreationally active participants included those participating in sport and exercise 3–5 times per week but excluded those in training or competition. The exclusion of the highly trained allowed a more homogeneous model representative of the fit, young, and able population that predominates the membership of fitness centers and gyms. It was also assumed that this group represented a target market of commercially developed exercise products. Future studies may find cause to investigate the differential effects of balance training in those in competitive sports, including power, strength, and endurance athletes.

Practical Applications

These data denote that balance training improves performance of selected activities. The absence of such effects upon retention assessment (T3) suggests that benefits are transient and subject to issues related to compliance of training. The improvements in TS and FAD in the Tx group indicate that training may influence proprioceptive input, reaction time, and specified muscular strength, in existing postural control mechanisms via neuromuscular adaptation to activity. There was no observable change in the performance of vertical jump posttraining, which may suggest that BOSU training may not affect those activities that relate to power skills. BOSU balance training may improve performance of dynamic skills and sway parameters; however, it is unclear if those skills are transferable to the performance of recreational or competitive sport and activity. Practically, the benefits of balance training may provide an enhanced sense of control to the client or user, warranting its use as a training technique or a prescriptive activity for the exercise professional.

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