Effects of Unstable Surface Training on Measures of Balance in Older Adults

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Abstract

Schilling, BK, Falvo, MJ, Karlage, RE, Weiss, LW, Lohnes, CA, and Chiu, LZF. Effects of unstable surface training on measures of balance in older adults. *J Strength Cond Res* 23(4): 1211–1216, 2009—The purpose of this investigation was to examine the effects of a 5-week, low-cost unstable surface balance training program in sexagenarians. Nineteen men and women (60–68 years; 83.7 ± *SD* kg) were randomly assigned to a control or training group. The training group performed various balance activities on air-filled rubber disks for 5 weeks. Each thrice-weekly session was supervised, and progression was based on proficiency. While in an upright position, static balance (length of path [LOP] of the center of pressure) was assessed in both eyes-open and eyes-closed states for each leg separately as well as for both legs. Participants also performed the timed up-and-go (TUG) test and completed the Activity-specific Balance Confidence (ABC) questionnaire. A significant group × time effect for the ABC questionnaire was found ($p = 0.04$). Tukey post hoc analysis indicates that the balance training program increased self-perceived balance confidence ($p < 0.01$). No significant group × time interactions were noted for TUG or LOP. Because no objective measure of balance or function was changed, the increase in ABC may be spurious. Unstable surface training may not be effective in improving balance among persons for whom balance is not problematic. However, the large number of acute training variables in such a program leaves opportunity for further research in this paradigm.

Key Words aging, balance, falls

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23(4)/1211–1216

Journal of Strength and Conditioning Research

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Introduction

Unstable surfaces such as air-filled rubber disks have become popular as a training aid for increasing balance capabilities. Regardless of the form (wobble boards, stability balls, foam surfaces, etc.), such unstable surfaces reduce or effectively remove the person's foot contact with the solid ground (7). The underlying theory is that balancing on such surfaces will lead to heightened proprioception when the foot is on solid surfaces during normal activities. The purpose of this preliminary investigation was to determine the effects of a 5-week unstable surface balance training (USBT) program on various measures of balance and function in older adults.

Balance training may be beneficial for reducing the incidence of falls in older persons. Falls are a major cause of morbidity for the elderly, resulting in a reported 250,000 hip fractures per year in the United States. It has been reported that 33% of adults over the age of 65 will have a fall in the next year, with 80% of those resulting in fracture, and many of these will fall recurrently (12,17,31). As of 2000, the economic impact of fall-related problems was estimated to be $19 billion (29). Falls are attributable to multiple factors that have both intrinsic and extrinsic components. This includes changes in single or multiple physiological systems and environmental hazards. Research on age-related changes in balance control has shown an increase in body sway during quiet stance, both with eyes open and eyes closed (35). This reduced balance ability, reflected by increased sway, has been identified as one of the physiologic factors causing falls (22). Increases in proprioception and strength during USBT are proposed to cause adaptations in the intrinsic component of balance (2) and could, thereby, decrease fall risk. To date, no research has substantiated this hypothesis in a healthy, aging population.

Greater muscle activity and body movement are observed when standing on an unstable surface (10). Such surfaces require an increase in lower-leg muscle activity during standing to a much greater extent than a rigid floor (16). The increase in muscle activity is on both sides of the joint, suggesting cocontraction as a means for the body to maintain balance (11), and this cocontraction is often initiated before movement as an anticipatory response (28). Such

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neuromuscular responses to unstable surfaces suggest a plausible mechanism by which a training adaptation may occur, leading to better balance on stable surfaces.

Although frequently promoted as a means of improving balance for both athletic (27) and aging populations (26), relatively little empirical evidence exists on the efficacy of USBT. Increases in rate of force development have been seen with USBT (5,13), even when maximum strength is not affected (13). This same investigation showed increased EMG activity of the vastus medialis in the first 30–50 milliseconds of an explosive isometric leg extensor action. Increased rate of force development has been touted as a critical factor in responding to balance perturbation (1)–a reaction that is essential in avoiding falls (22). In addition to reactive ability, measures of postural sway have been shown to be reduced via USBT (15,32), and 1-leg balance time has shown increases (14). It is noteworthy that older subjects were not the target population of these interventions. One intervention using older subjects demonstrated that exercise on a wobble board increased the ability to discriminate differing degrees of ankle inversion (34). Other methods of USBT have been used for rehabilitation of ankle instability, with positive results (9,18). Additionally, USBT has been used in healthy populations as a basis for ankle injury prevention (8) and prevention of reinjury (33).

Not all investigations support the benefits of USBT; in the study by Bruhn et al. (5), strength training was demonstrated to be superior to balance training in increasing balance, and balance training alone did not significantly affect postural stabilization. Cressey et al. (7) also have noted that unstable surfaces used during weight training actually attenuated performance improvements induced by a normal-surface weight training program in athletes. No assessment of static balance was used in this investigation, but jumping performance increased more in the normal surface groups, with a similar trend in sprinting as well (7).

Table 1. Balance training program.

Weeks 1–2*			Weeks 3–4*			Week 5*		
Exercise	Sets × reps	Rest period	Exercise	Sets × reps	Rest period	Exercise	Sets × reps	Rest period
Body squat	2–3 × 10–12	10–15s	Body squat	3 × 8–10	20–30 s	Overhead squat	4 × 6–8	60 s
Leg circles	2–3 × 10–12		Split squat	3 × 8–10		Body squat	4 × 6–8	
Extended reach	2–3 × 10–12		Directional leg kicks	3 × 8–10		Box step-ups	4 × 6–8	
Standing balance	2–3 × 10–15 s		Diagonal disc step-ups	3 × 8–10		Trunk twist and knee-up	4 × 6–8	
Sit-to-stand	2–3 × 10–12	10–15 s	Sit-to-stand	3 × 8–10	20–30 s	Alternate lunge	4 × 8–10	60 s
Split squats	2–3 × 10–12		Forward trunk lean	3 × 8–10		Alternate side lunge	4 × 6–8	
Forward trunk lean	2–3 × 10–12		Side lunge	3 × 8–10		Sit-to-stand	4 × 8–10	
Standing balance	2–3 × 10–15 s		Standing balance	3 × 8–10		Standing balance	4 × 25 s	
Body squat	2–3 × 10–12	10–15 s	Overhead squat	3 × 8–10	20–30 s	Overhead squat	4 × 6–8	60 s
Trunk rotation	2–3 × 10–12		Alternate lunge	3 × 8–10		Extended reach	4 × 6–8	
Diagonal trunk lean	2–3 × 10–12		Trunk twist and knee-up	3 × 8–10		Box step-ups	4 × 8–10	
Extended reach	2–3 × 10–12		Extended reach	3 × 20 s		Directional leg kicks	4 × 8–10	

Methods

Experimental Approach to the Problem

For USBT to be a viable intervention strategy, a detailed analysis of viability and efficacy must be established. To our knowledge, USBT alone has not been substantiated in aged individuals; our aim was to examine USBT preliminarily in this population with a repeatable, documented training program. Herein, we use a test-retest design with a training group and nontraining control group. Variables of interest include those related to static balance as well as functional mobility. All subjects were tested on the timed up-and-go (TUG), length of path (LOP) of the center of pressure during static balance tasks, and the Activities-specific Balance Confidence scale (ABC).

Subjects

Nineteen men and women (60–68 years) were randomly assigned to a control (4 women, 5 men; 172.0 ± 11.1 cm,

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80.9 ± 11.8 kg) or training group (5 women, 5 men; 173.0 ± 14.4 cm, 86.3 ± 15.4 kg). Subjects were apparently healthy with no orthopedic limitations or vestibular problems. All subjects reported being active but not participating in structured exercise programs. All procedures were approved by the primary author's university institutional review board (H05-45-01), and all subjects provided written informed consent before participation.

Procedures

Training sessions were 15–30 minutes in length depending on progression, consisting of standing balance training using unstable surfaces. The training group performed balance exercises on VersaDisc and CorDisc devices 3 times per week for 5 weeks. Controls were instructed to perform their normal routines during the 5-week study period, after which they also would perform 5 weeks of training if they so desired (data not presented herein). The VersaDisc and CorDisc are adjustable air-filled rubber discs that can be used lying, sitting, kneeling, or standing. The training had progressively challenging balance exercises beginning with solid surface and progressing quickly to use of unstable surfaces (Table 1). Air volume was constant for the 5-week intervention so that the support surface was the same for all training sessions. Each training session was supervised by a Certified Strength and Conditioning Specialist (CSCS), and subjects were secured in an overhead harness (SOLO-STEP) to prevent falls (Figure 1).

Subjects performed static balance tests on a 6-component force platform (AMTI; Watertown, Mass) under 4 standing

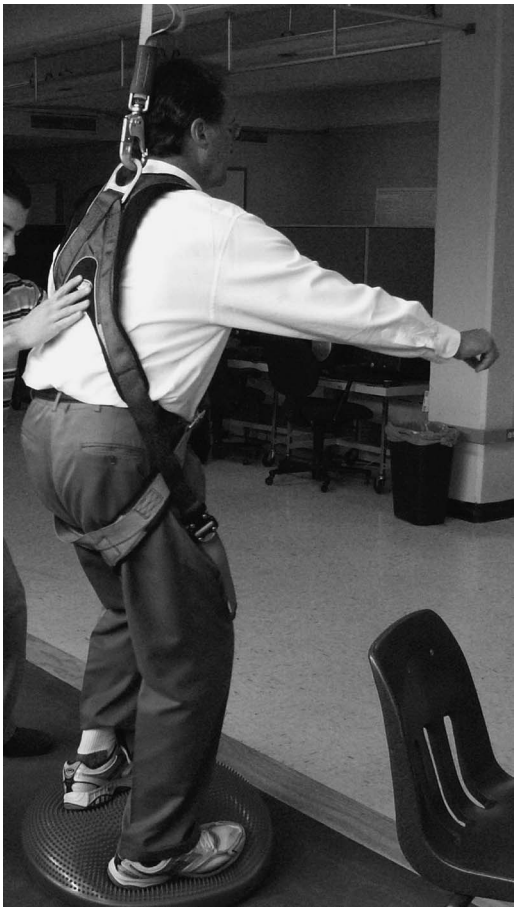

Figure 1. Subject being assisted in getting on Cordisc secured in overhead harness (SOLOSTEP).

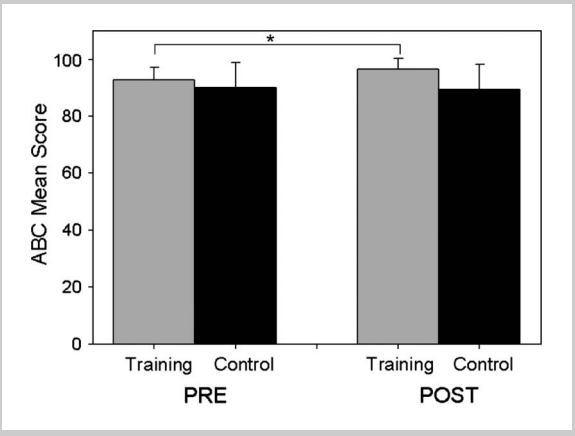

Figure 2. Mean comparisons of Activity-specific Balance Confidence (ABC) questionnaire for training subjects ($n = 10$) and controls ($n = 9$) pre and post intervention (mean ± *SD*). *Significant increase between pre and post intervention ($p < 0.01$). Preintervention training mean = 92.8%, control = 90.0%. Postintervention training = 96.6%, control 89.4%.

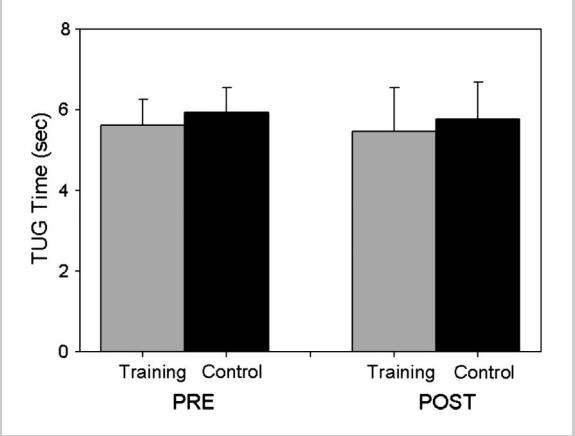

Figure 3. Mean comparisons of timed up-and-go (TUG) for training subjects ($n = 10$) and controls ($n = 9$) pre and post intervention (mean ± *SD*). There were no significant effects of the intervention. Preintervention training mean = 5.6 seconds, control = 6.3 seconds. Postintervention training = 5.4 seconds, control = 6.1 seconds.

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conditions: right leg only and left leg only, in both eyes-open and eyes-closed states. Subjects were not given specific instructions on arm or raised leg position, but they were asked to be consistent. All subjects indicated that their right leg was dominant (the one they would use to kick a ball). Data were collected at 500 Hz using a Measurement Computing PCI-DAS1200/JR A/D board (Norton, Mass) and analyzed using the stability analysis of DataPac 2K2 (v. 3.17; Mission Viejo, Calif). The LOP of the center of pressure was averaged for 3 × 15-second trials in each of the 4 conditions. Center of pressure excursion has been show to predict nonfallers (3). Two practice sessions were conducted before the initial testing session to familiarize each subject with the testing modalities, and 3 × 15-second trials were conducted for each subject in each condition. A harness system (SOLO-STEP) was used to ensure the safety of subjects during all trials.

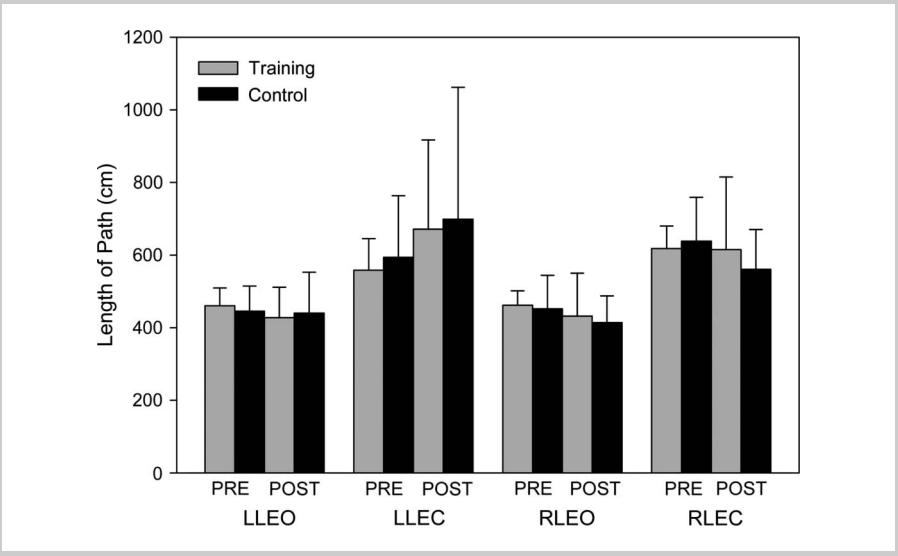

Figure 4. Mean comparisons for length of path for the center of pressure under various stance conditions for training subjects ($n = 10$) and controls ($n = 9$). The large variability in the left-leg, eyes-closed conditions is likely attributable to the fact that this is the nondominant leg for all subjects. LLEO = left leg, eyes open; LLEC = left leg, eyes closed; RLEO = right leg, eyes open; RLEC = right leg, eyes closed. No significant effects of the intervention were noted.

All subjects were tested on the TUG (23) and ABC questionnaire (25). For the TUG, subjects were asked to rise from a chair at a "go" signal, walk 8 feet, and return to sit in the chair (23). The time, assessed using a stopwatch, started at the command of "go" and ended when the subject was seated in the chair. Subjects were instructed to move as quickly and safely as possible without running, and use of the hands was prohibited. In addition to the TUG, the ABC scale was used to evaluate subjects' confidence levels of daily activities (25). The percentage scores of 16 questions were summed to yield a single ABC score for the data analysis, ranging from 0 to 100%. The higher the score, the more confident a patient perceives his or her balance abilities. This scale has been shown to be a good indicator of balance ability and a predictor of fall likelihood (19,20).

Statistical Analyses

The tests herein have demonstrated coefficients of variation below 15% (30). In addition, intraclass correlation values for those same variables have exceeded 0.7 when obtained in our laboratory. All statistical analyses were performed with SPSS version 15.0. Comparisons for the training vs. control group used group × time repeated-measures analyses of variance (2 × 2) for each outcome variable, and Tukey post hoc tests were used in cases for which interactions were noted. Cohen's d was used as an effect size comparison for all pairwise comparisons (6). Statistical significance was set at $p \leq 0.05$.

Results

All subjects were able to complete the training program and testing protocols without adverse events. Mean values (± *SD*) for the training group and controls for ABC pre intervention were 92.8 ± 4.3 and 90.1 ± 6.4, respectively. Postintervention scores for ABC were 96.6 ± 3.6 and 89.4 ± 4.7, respectively. Preintervention scores for training group and controls for TUG were 5.6 ± 0.6 and 5.9 ± 0.6 and postintervention scores were 5.5 ± 1.1 and 5.8 ± 0.9, respectively. A significant group × time effect for the ABC questionnaire was found ($p = 0.04$). Tukey post hoc analysis indicates that the USBT program significantly increased self-perceived balance ability in this population ($d = 0.93$; Figure 2). No significant group × time interactions were noted for TUG (Figure 3) or LOP (Figure 4), and no main effects were found for time.

Discussion

Short-term unstable surface training as performed herein does not seem to affect measures of static balance and TUG for sexagenarians. However, because the ABC was positively affected, there is at least the perception by the subjects that this mode of training is beneficial. Because the control group participants maintained their normal activities and were not systematically attended to during the control period, it is likely that the increase in ABC results in the training group could indicate a subconscious attempt to please the

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investigators. The lack of change in static balance tests support this belief, but it is conceivable that the measures of sway in this investigation are not sensitive to the training intervention and, thus, not related to balance confidence. Measures of sway have shown improvements with USBT (15,18,32), but none used LOP as a performance indicator.

Because it is likely that age and fall risk are positively related (24), whether this training would be more beneficial in an even older population is unclear. Because our subjects were relatively high-performing (based on ABC and TUG data), the lack of effect herein could be attributable to the inability to improve already good scores. However, it is also possible that, once balance deteriorated past a certain threshold, USBT would be impossible because of the potential for a fall during training. Because of the supervision and support device necessity, this type of training may prove impractical to the average individual. If instituted as a preventative exercise, longer studies must be carried out across a time frame in which balance is expected to deteriorate. Our study was 5 weeks long, which is similar to previous investigations (4,5,13,34) but shorter than others (10 weeks) (7,15,32). It is unclear whether a "ceiling effect" is present, in which further gains are unlikely, or whether drastically diminished returns are manifested after a given period of training. Perhaps maintenance training would be needed after such a point because balance may continue to decline with age.

Inherent difficulties exist when comparing USBT protocols because of the large number of potential variables that can be manipulated. Such variables include lability of surface, stance, time of exposure to surface, length of session, frequency of sessions, visual feedback, strength requirements, and, perhaps most important, the length of the intervention. In addition, there is evidence that additional cognitive demand may enhance learning of postural skill (21). Because of these differences and the lack of detail given to the intervention programs in many published studies, it is difficult to recommend a precise training program. Although some investigations have used relatively simple and/or well-documented training protocols (7,8,15,32,33), other interventions have been somewhat vague in the descriptions of their training (4,5,13). The results of this investigation suggest that the balance training performed herein does not affect objective measures of sway in older adults. Because of the large number of variables that could be manipulated in the design of such studies, many unanswered questions remain about the utility of this type of training. However, the relative efficacy of unstable surface training needs to be established as a method of balance training before the comparison can be made.

Practical Applications

Five weeks of unstable surface training does not seem to increase balance capabilities in older persons with normal balance. Thus far, the widespread use of such programs seems questionable in those who do not have balance difficulty. The large number of modifiable variables in such a program leaves opportunity for research manipulating such variables.

Acknowledgments

Sponsored by the Life Fitness Michael L. Pollock Memorial Grant, University of Memphis Faculty Research Grant, and Power Systems, Inc. None of these entities played any role in the design, execution, analysis, or interpretation of the data. This study and all procedures were approved by the University of Memphis institutional review board.

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