

## Research article

# EFFECTS OF BALLATES, STEP AEROBICS, AND WALKING ON BALANCE IN WOMEN AGED 50-75 YEARS

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### ABSTRACT

This study examined the effectiveness of Ballates training (strengthening of the central core musculature by the inception of balance techniques) compared to more traditional exercise programs, such as step aerobics and walking, on balance in women aged 50-75 years. Participants were randomly assigned to one of three supervised training groups (1 hour/day, 3 days/week, 13 weeks), Ballates (n = 12), step aerobics (n = 17), or walking (n = 15). Balance was measured by four different methods (modified Clinical Test for the Sensory Interaction on Balance – mCTSIB; Unilateral Stance with Eyes Open – US-EO or Eyes Closed – US-EC; Tandem Walk – TW; Step Quick Turn - SQT) using the NeuroCom Balance Master. A 2-way (Group and Trial) repeated measures ANOVA and post-hoc Bonferroni Pairwise Comparisons were used to evaluate changes in the dependent variables used to describe stability and balance (sway velocity, turn sway, speed, and turn time). Measures of static postural stability and dynamic balance were similar for the three groups prior to training. Following the different exercise interventions, sway velocity on firm and foam surfaces (mCTSIB) with eyes closed ( $p < 0.05$ ) increased for the Ballates group while the other two exercise groups either maintained or decreased their sway velocity following the training, therefore suggesting that these two groups either maintained or improved their balance. There were significant improvements in speed during the TW test ( $p < 0.01$ ), and turn time ( $p < 0.01$ ) and sway ( $p < 0.05$ ) during the SQT test for each of the three groups. In general, all three training programs improved dynamic balance, however, step aerobics and walking programs resulted in better improvements in postural stability or static balance when compared to the Ballates program.

**KEY WORDS:** Exercise intervention, static balance, dynamic balance, aging.

### INTRODUCTION

As the percentage of older American adults steadily increases, it has been estimated that approximately 30% of individuals aged 65 years and older fall at least once a year, and 15 % will have recurring falls (Liu-Ambrose et al., 2004). Among older adults, the most common cause of bed-ridden conditions, injury related morbidity, and mortality, is falling

(McMurdo and Harper, 2003; Shigematsu et al., 2002; Stevens and Olson, 2000). The number of fall-related hip fractures resulting in the need for hospital care and increased risk of mortality continues to increase yearly, especially as the baby-boomer generation becomes older. In 1991, Medicare estimated that 2.9 million dollars was spent for hip fractures and that by the year 2040 it is estimated that the annual cost of hip fractures in the United

States will be between \$82 and \$240 billion dollars (Stevens and Olson, 2000). Therefore, there is an immediate need for fall prevention strategies targeted towards the older population.

As the body ages, changes in the musculoskeletal, sensory, and neural systems (motor control) can begin to affect mobility. For example, muscular strength is needed to maintain postural stability during walking due to the constant dynamic imbalance of the body, while vision is needed to detect external environmental factors and help the sensory motor system to react, especially in fast-paced situations (Sakari-Rantala et al., 1998). It is imperative that these systems work together to maintain a system of balance, especially as the body ages and these systems decline in function (Era et al., 2002; Hobeika, 1999; Judge et al., 1995; Luchies et al., 1999; Mecagni et al., 2000; Woollacott, 2000).

The obvious importance of being able to improve balance has resulted in a number of balance intervention studies, which initially focused on task-specific exercises and every day activities such as getting in and out of a chair, or stepping up and down from one level to another (Harada et al., 1995; Judge, 2003; Lord et al., 2003; Nelson et al., 2004; Nitz and Choy, 2004; Steadman et al., 2003). These studies demonstrated that balance could be improved greatly, especially in rehabilitation and nursing home environments. Researchers then began to examine the effects of task-specific exercises in combination with strength training (Binder et al., 2002; Harada et al., 1995; Shaw and Snow, 1998). They found that not only did the combination of the two exercises improve balance, but strength training alone also improved balance (Barrett and Smerdely, 2002; Becker et al., 2003; Brill et al., 1998; Harada et al., 1995; Hauer et al., 2001; Karlsson, 2002; Liu-Ambrose et al., 2004). Recent advances in balance training include aerobic exercises, such as biking, stepping, walking, structured danced-based aerobic classes, and Tai Chi, alone, or in combination with weight training (Buchner et al., 1997; Gardner et al., 2001; Carter et al., 2002; Malbut et al., 2002; Shigematsu et al., 2002; Wu, 2002; Judge, 2003; LaStayo et al., 2003).

Another recent advance in balance exercises is use of the stability ball. These exercises are used to strengthen the core abdominal muscles (Cosio-Lima et al., 2003; DiBrezza et al., 2005; Schlicht, 2002; Urbscheit and Wiegand, 2002). In the 1960's the stability ball was first used for physical therapy rehabilitation with patients in Switzerland. This type of exercise did not become prevalent in the United States until the 1990's and now it has become a popular exercise accessory in the American fitness industry (Schlicht, 2002). However, few attempts to

systematically study the effectiveness of these stability balls have been conducted. One study that compared stability ball exercises with floor exercises reported the stability ball to be more effective for improving balance (Cosio-Lima et al., 2003), however, comparisons to other types of more traditional exercise, like aerobic training, have not been investigated. There is a need for more research to examine if exercises that focus on core strength training, through the stability ball, can be as effective as other aerobic based programs for improving balance. Therefore, the purpose of this study was to assess the effects of stability ball training (Ballates), step aerobics, and walking on balance in women aged 50 to 75 years.

## METHODS

### *Subjects*

Once Institutional Review Board approval was obtained for this study, sixty, sedentary, females, aged 50-75 years, from the Oklahoma City Metropolitan area, were recruited via flyers, e-mail, and newspaper ads. If potential subjects were classified as healthy (no serious medical illness), sedentary (Baecke physical activity questionnaire), and obtained medical clearance from their own personal physicians, they were then randomly assigned to one of three supervised training groups, ballates, step aerobics, or walking.

Only two of the subjects were premenopausal and 42 subjects were perimenopausal or postmenopausal, with 11 subjects on hormone replacement therapy. Over 50% of the women were taking a one-a-day vitamin or calcium supplements. There were also many subjects who were taking natural herbal supplements as well as other forms of medications for blood pressure, cholesterol, etc, however this was not taken into account for group randomization. Table 1 outlines the baseline characteristics of each exercise group. Groups did not significantly differ in age, height, weight, and body composition (DXA – Lunar Prodigy). The study began with 60 participants and 44 women completed the 13 weeks of training. Reasons for dropping out included time commitment, family emergencies, or excessive absences. None of the women dropped out as a result of injury during the exercise programs.

### **Pre and Post Test Measurements**

#### *Body composition*

Dual Energy X-Ray Absorptiometry (DXA - Lunar Prodigy) was used to assess body composition (fat and bone-free fat free mass – BF-FFM) as well as bone mineral density (total body, proximal femur,

**Table 1.** Baseline characteristics for each group. Data are means ( $\pm$ SD).

Variable	Ballates (n=12)	Step Aerobics (n=17)	Walking (n=15)
Age (yrs)	59.5 (1.9)	58.3 (1.4)	56.9 (1.1)
Height (m)	1.63 (.02)	1.63 (.02)	1.62 (.02)
Weight (kg)	74.3 (4.0)	73.3 (2.4)	80.4 (5.0)
Total % Fat	42.6 (2.4)	44.4 (1.6)	47.0 (1.6)
Arm % Fat	37.5 (2.4)	38.6 (1.0)	39.9 (1.7)
Leg % Fat	43.5 (2.3)	45.7 (1.8)	47.1 (2.1)
Trunk % Fat	42.7 (2.6)	44.2 (1.9)	47.7 (1.6)
Total BF-FFM (kg)	39.9 (.13)	38.6 (1.0)	39.9 (1.7)
Arm BF-FFM (kg)	4.3 (.2)	4.1 (.2)	4.2 (.1)
Leg BF-FFM (kg)	12.8 (.5)	12.3 (.4)	12.6 (.6)
Trunk BF-FFM (kg)	19.7 (1.3)	19.1 (.6)	19.9 (1.1)

No significant differences between the groups at baseline.

lumbar spine). A trained DXA technician performed and analyzed each scan using the encore 2002 software (GE Medical Systems, version 6.70.021). Subject height was measured using a wall stadiometer and weight was measured using a TANITA BWB-800 digital scale.

### **Balance**

Four different measurements of static and dynamic balance were analyzed by the NeuroCom Balance Master. Since there are several different components which contribute to balance, the NeuroCom gives an objective assessment of the sensory and voluntary motor control of balance. This system is comprised of fixed 18" X 60" dual force plate which measures the vertical forces exerted by one's feet. These tests were broken into two different categories: 1) Impairment Tests (Modified Clinical Test for Sensory Integration of Balance - mCTSIB) which looked at the effective use of visual, vestibular, somatosensory, automatic and voluntary motor skills that aid in balance and mobility during a variety of changing task conditions; and 2) Functional Limitation Tests (Unilateral Stance - US; Tandem Walk - TW; and Step Quick and Turn - SQT) which looked at the ability of one to safely and efficiently perform mobility tasks in every day activities. In order to maintain consistency and for subject convenience, each of the balance tests were administered in the same order and by the same technician. Subjects were able to watch an instructional video of each required task on a computer screen before each individual test was administered. All tests began by placing the feet according to the foot placement instructions given on the computer screen. The analysis of each test was given in both a numeric version using percentages, ratios, etc, and a comprehensive version using graphs and pictures of movement patterns.

### **Modified Clinical Test for Sensory Integration of Balance (mCTSIB)**

This test measures several components of functional balance by quantifying postural sway velocity while changing the subject's sensory condition. This is accomplished by changing the surface on which the subject stands, from a firm to a foam surface, and by asking the subject to stand on these surfaces with eyes opened and eyes closed. By asking the subject to perform this test with the changing conditions, both the sensory and visual components of balance were accurately assessed. The force plate detected sway patterns outside the subject's center of gravity during a 10 second trial period, therefore giving a measurement of sway velocity in degrees/second. The greater absence of postural sway after being told to hold still would indicate better postural stability and balance. The variables obtained from this test include Sway Velocity Firm Composite score, Sway Velocity Foam Composite score, Mean Center of Gravity (COF) Sway Velocity, and COF Alignment. Composite Sway Velocity is found by adding the two scores for eyes opened and closed and dividing by two for each condition (firm and foam) which creates two variables. The Sway Velocity for each variable is the ratio of the distance traveled by the center of gravity to the time of the trial. The average of the Sway Velocities for each condition gives a Mean COG Sway Velocity, with lower scores indicating greater balance. COG Alignment reflects the subject's center of gravity over their base of support. Three trials were obtained for each condition and an average used in latter analyses.

### **Functional Limitation Tests**

#### **Unilateral Stance (US)**

This test measures balance by quantifying postural sway velocity while the subject stands on either the right or left foot, with eyes opened and with eyes closed, for 10 seconds. The greater absence of postural sway after being told to hold still would indicate better postural stability and balance. Sway Velocity Eyes Open and Sway Velocity Eyes Closed

are the two variables used in this analysis. The sway velocity for each variable is the ratio of the distance traveled by the center of gravity to the time of the trial. A mean of three trials was used in latter analyses.

### ***Tandem Walk (TW)***

This test quantifies characteristics of gait as the subject walks the length of a force platform, walking heel to toe. The measured parameters include step width, speed, and end sway velocity. A mean of three trials was used in later analyses.

### ***Step Quick and Turn (SQT)***

This test measures balance by quantifying turn performance after taking two steps forward and pivoting 180 degrees and taking two steps back to the original starting position. The measured parameters are turn-time and turn-sway velocity. A mean of three trials was used in later analyses.

### ***Interventions***

There were three different supervised interventions that the subjects were randomly assigned, Ballates, step aerobics, and walking. Each subject was required to exercise three days per week (Monday, Wednesday, and Friday) from 7:00am to 8:00am for 13 weeks.

*Ballates:* The Ballates training was a body weight resistance class using a stability and medicine ball. It concentrated on core muscle groups that are imperative for maintaining balance. The subjects performed a combination of aerobic exercises focusing on the lower extremities and abdominal core as well as several forms of abdominal crunches using both the medicine and stability ball. Exercises for this class included a combination of standing and sitting designed to emphasize kinesthetic awareness. Unilateral weight shifts with accompanying rotation of the stability ball to strengthen ankle stability. Resistance moves were performed to increase muscle strength; standing exercises included: side twists, walking side twists, ball sweeps from side to side, ball bounce and shuffle from left to right, ball toss and catch, plie' squats while bringing the ball up and over the head. Seated exercises included: alternating leg lifts, while lying on the ball walking hands out to a bridge and walking back in, ball straddles, and lateral hip moves. As the exercises got easier the subjects were asked to increase the intensity of exercise by means of situating the body/torque position so that more resistance was created.

*Step aerobics:* Step aerobics was a low to moderate intensity aerobics class, involving both simple and complex step and dance combinations as

well as muscle toning with hand-held weights. This class was designed so that the subject could choose their own exercise intensity by choosing the height of the step used (6 to 12 inch or 15.24 to 30.48 cm). The equipment needed for this class was one step bench, two to five pound hand held weights, and a soft mat. Each class began with a 5 minute warm-up. The warm-up consisted of exercises such as side-stepping, hamstring curls, modified jumping-jacks, marching high and low, stretch lunges, calf, hamstring, and quadriceps stretches. After the warm-up was complete there was a 10 minute series of stepping exercises as well as step combinations: basic left/right, curb walking, step up and over, step up and straddle, step and kick, step and lunge, walking around the step. Following the first series of step exercise, time was allotted for a water break. Next, another 10 to 15 minutes of step combinations were performed. After the participants were comfortable with the steps, hand-held weights were added and a series of bicep curls, tricep extensions, lateral raises, etc. were performed while adding in basic lunges for 10 minutes. A cool-down of exercises consisting of low-intensity basic left/right stepping and side steps were performed for five minutes. Finally, there was five minutes of core conditioning, which consisted of crunches, sit-ups, and leg lifts followed by five minutes of stretching and breathing exercises. The intensity of this program was increased by speeding up the cadence of the music over the thirteen weeks of exercise.

*Walking:* The walking group, who were used as an 'exercise control group', walked around an indoor track (six laps, equaled one mile) at each individual's own pace, but were constantly encouraged to complete as many laps as possible during the exercise session. Heart rates were recorded at the beginning, midpoint and end of each exercise session as well as the total number of laps completed.

### ***Statistical analyses***

Statistical analyses were performed using SPSS® for Windows® (version 12.0). Descriptive statistics (means  $\pm$  standard errors) were performed for all variables to describe each group's body composition and balance measurements. Baseline comparisons between the three groups for physical characteristics (age, height, weight, body composition) and pre-training measures of balance were determined by a one-way ANOVA. A two-way repeated measures ANOVA [group (3)  $\times$  trial (2)] was also performed on all measurements. A Bonferroni post hoc procedure was used if there was a significant group effect. When significant group by trial interaction effects were found, dependent t-tests within each

training group were used to determine significant pre to post training differences. The level of significance was set at  $p \leq 0.05$ .

*Effect size:* By examining the means and standard deviations of previous studies (Cosio-Lima et al., 2003; Liu-Ambrose et al., 2004; Shigematsu et al., 2002) the effect size of those studies were calculated. Assuming that a power of 0.80 was needed and the calculated effect size for most standard measures of balance was 1.00, it was determined that a minimum of 13 subjects would be needed for each of the three training groups (Cohen, 1988).

## RESULTS

As mentioned earlier in the subject section, there were no baseline differences between the three groups for any physical characteristic (age, height, weight, body composition). Additionally, there were no group differences for any pre-training balance measure with the exception of one value. Only end sway velocity for the Tandem Walk was statistically significant ( $p = 0.017$ ) between the three groups with the Ballates group starting out significantly worse ( $5.9 \text{ deg}\cdot\text{sec}^{-1}$ ) than the other two groups (Step

Aerobics =  $4.2 \text{ deg}\cdot\text{sec}^{-1}$  and Walking =  $3.9 \text{ deg}\cdot\text{sec}^{-1}$ ).

There were significant trial effects for percent fat variables, with small but significant decreases occurring in total body ( $p = 0.018$ ), legs ( $p = 0.001$ ) and trunk ( $p = 0.029$ ) percent fat (Table 2). Additionally, there were small but significant increases in total bone free fat-free mass (BF-FFM) ( $p = 0.038$ ) and in trunk BF-FFM ( $p = 0.019$ ) for all three groups (Table 2). However, since there is a two to three percent measurement error associated with body composition measurements from DXA, most of these changes, although statistically significant, may not reflect a true biological change with training.

There were four pre and post-test measurements of balance, mCTSIB, Unilateral Stance, Tandem Walk and Step Quick and Turn, which looked at both sensory and functional balance. A mean was taken of each of the three trials performed for each test.

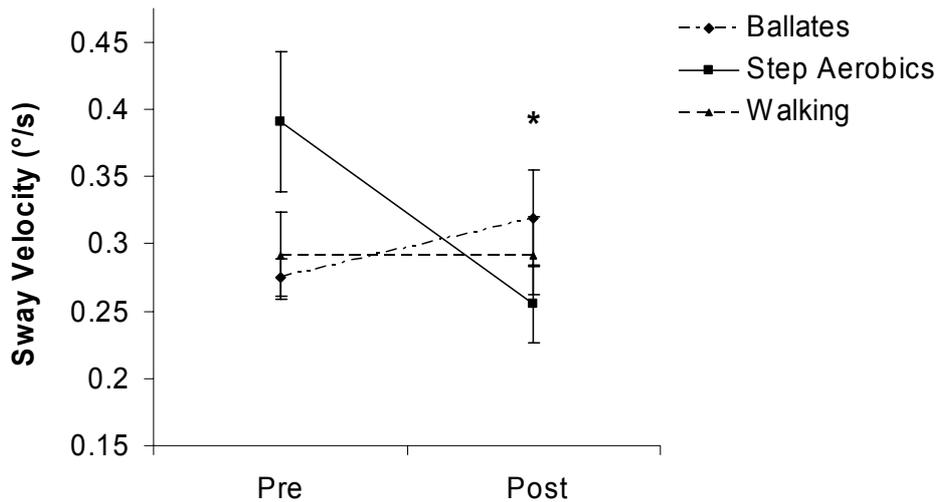
### *Modified Clinical Test for Sensory Integration of Balance (mCTSIB)*

“The mCTSIB analyzes one’s sensory ability to compensate when one of the contributing factors, from the nervous, visual, vestibular, and somatosensory systems, are taken away. This test

**Table 2.** Changes in body composition following each training intervention. Data are means ( $\pm$ SE).

Variable	Ballates (n=12)	Step Aerobics (n=17)	Walking (n=15)
Pre Weight (kg)	74.3 (4.0)	73.3 (2.4)	80.4 (5.0)
Post Weight (kg)	74.6 (4.1)	73.9 (2.4)	79.8 (4.9)
Pre Total % Fat	42.6 (2.4)	44.4 (1.6)	47.0 (1.6)
Post Total % Fat	42.4 (2.5) *	43.4 (1.7) *	46.1 (1.4) *
Pre Arm % Fat	37.5 (2.4)	38.6 (1.0)	39.9 (1.7)
Post Arm % Fat	36.9 (2.2)	36.9 (1.5)	40.6 (1.4)
Pre Leg % Fat	43.5 (2.3)	45.7 (1.8)	47.1 (2.0)
Post Leg % Fat	43.2 (2.5) **	44.9 (1.8) **	46.6 (1.8) **
Pre Trunk % Fat	42.7 (2.6)	44.2 (1.9)	47.7 (1.6)
Post Trunk % Fat	42.5 (2.6) *	43.2 (2.1) *	46.3 (1.5) *
Pre Total BF-FFM (kg)	39.9 (.13)	38.6 (1.0)	39.9 (1.7)
Post Total BF-FFM (kg)	40.1 (1.4) *	39.4 (.9) *	42.2 (1.8) *
Pre Arm BF-FFM (kg)	4.3 (.2)	4.1 (.2)	4.2 (.1)
Post Arm BF-FFM (kg)	4.3 (.2)	4.1 (.2)	4.2 (.2)
Pre Leg BF-FFM (kg)	12.8 (.5)	12.3 (.4)	12.6 (.6)
Post Leg BF-FFM (kg)	12.7 (.5)	12.5 (.6)	13.1 (.7)
Pre Trunk BF-FFM (kg)	19.7 (.6)	19.1 (.6)	19.9 (1.1)
Post Trunk BF-FFM (kg)	20.2 (.7) *	19.8 (1.0) *	20.2 (.9) *

\* significant ( $p < 0.05$ ) trial effect, \*\* significant ( $p < 0.01$ ) trial effect.



**Figure 1.** MCTSIB - Sway Velocity on Firm Surface - Eyes Closed. \*  $p \leq 0.05$  significant group X trial interaction.

was simulated on a firm surface and then on a foam surface with eyes opened and eyes closed. There was a significant group by trial interaction for sway velocity on a firm surface with eyes closed ( $p < 0.05$ ; Figure 1) and for sway velocity on a foam surface with eyes closed ( $p < 0.05$ ; Figure 2).

Sway velocity on a firm surface with eyes closed remained unchanged for the walking group after the intervention ( $0.291 \text{ deg}\cdot\text{sec}^{-1}$ ) while the step aerobics group improved their balance as demonstrated by a decreased sway velocity ( $0.391$  to  $0.255 \text{ deg}\cdot\text{sec}^{-1}$ ), whereas the Ballates group had greater sway velocity after the intervention when compared to pre-training values ( $0.275$  to  $0.319 \text{ deg}\cdot\text{sec}^{-1}$ ) indicating a decrease in static balance performance. On the other hand, sway velocity decreased (improved balance) for both the walking and step aerobics groups ( $1.49$  to  $1.23 \text{ deg}\cdot\text{sec}^{-1}$  and  $1.46$  to  $1.29 \text{ deg}\cdot\text{sec}^{-1}$ , respectively) on a foam surface with eyes closed, while the Ballates group

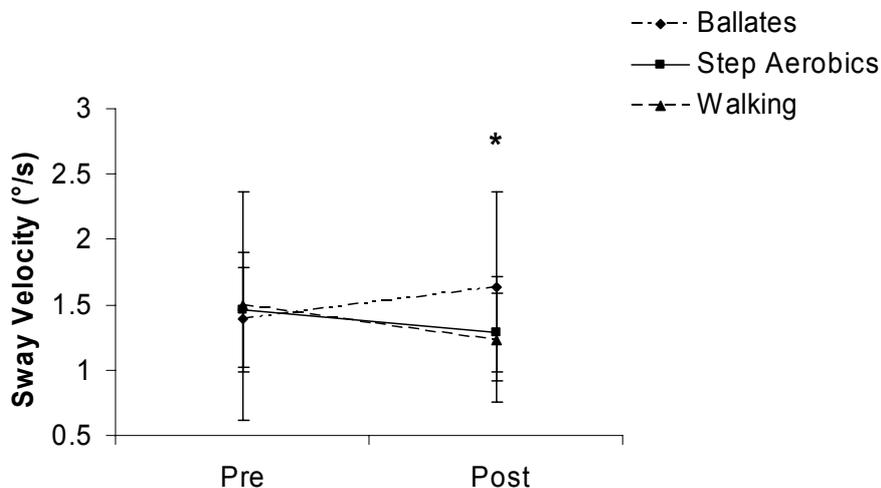
once again increased sway velocity (decreased balance) following the training ( $1.39$  to  $1.64 \text{ deg}\cdot\text{sec}^{-1}$ ).

**Unilateral stance**

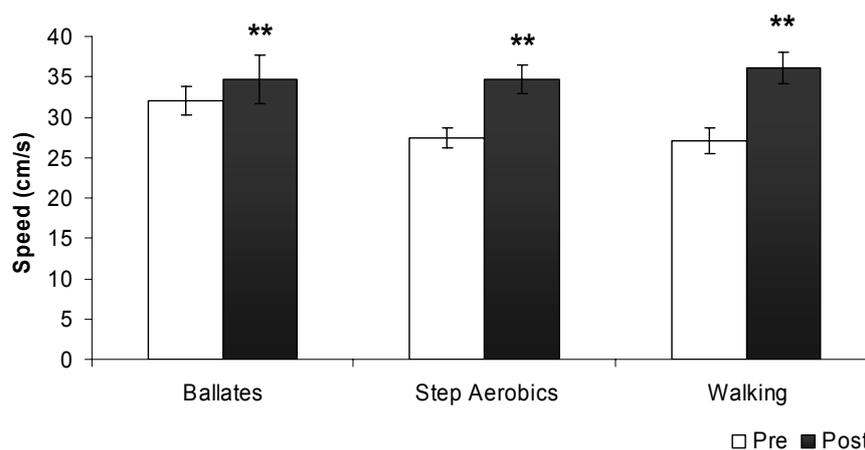
Unilateral stance not only measures one’s ability to compensate when senses are taken away, but also one’s functional ability to stand on one leg. Sway velocity and length of time on the right foot, with eyes closed both approached statistical significance for the group effect ( $p < 0.062$  and  $p < 0.074$ , respectively) but there were no statistically significant group, trial, or group by trial interactions for any of the static balance variables measured during the unilateral stance test.

**Tandem walk**

There was a significant trial effect ( $p < 0.01$ ) but no group or group by trial interaction for the distance covered in centimeters during the 10 second tandem



**Figure 2.** MCTSIB - Sway Velocity on Foam Surface - Eyes Closed. \*  $p \leq 0.05$  significant group X trial interaction.



**Figure 3.** Tandem Walk - Changes in Speed. \*\*  $p \leq 0.01$  significant trial effect.

walk (Figure 3). All three groups improved in this aspect of dynamic balance (Ballates: 32.11 to 34.69  $\text{cm}\cdot\text{sec}^{-1}$ ; step aerobics: 27.37 to 34.66  $\text{cm}\cdot\text{sec}^{-1}$ ); and walking: 27.00 to 36.14  $\text{m}\cdot\text{sec}^{-1}$ ).

#### Step quick turn

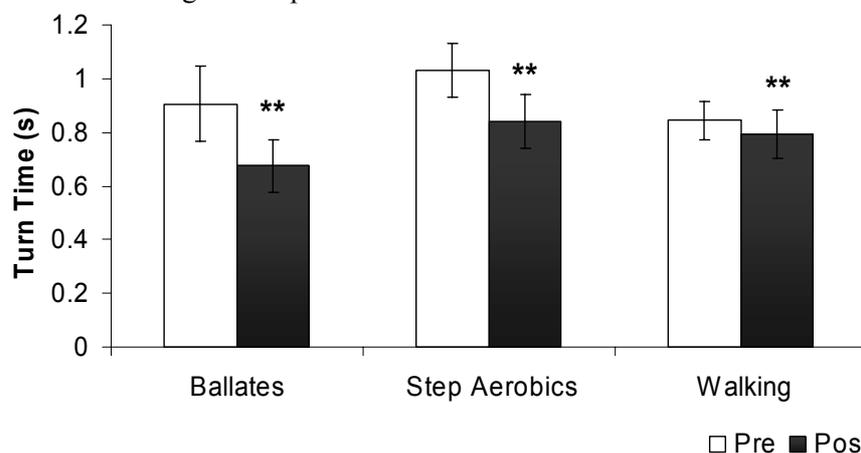
After analyzing turn time on the right foot, a significant trial effect ( $p < 0.01$ ) but no group or group by trial interaction was determined indicating that all groups improved in turn time following their respective training intervention (Ballates, 26%; step aerobics, 18.9%; and walking, 6.3%; Figure 4). There was also a significant trial effect for turn sway on the right foot ( $p < 0.05$ ) but no significant group or group by trial interaction, once again indicating that all three groups improved dynamic balance following the training (Ballates, 19%; step aerobics, 1.8%; and walking, 9.3%; Figure 5).

## DISCUSSION

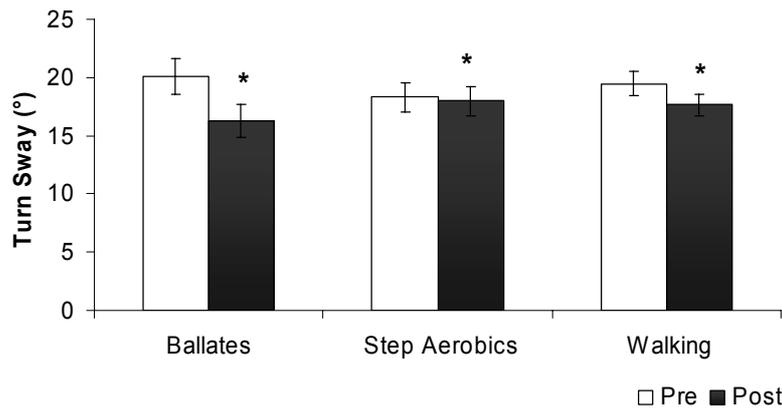
The fact that the modified clinical tests for sensory integration of balance (mCTSIB) reflected improved measures of static balance for the walking and step aerobics groups but not for the Ballates group may be due to the fact that the walking and step aerobics

interventions focused on leg strength and endurance whereas the Ballates intervention, which utilized stability ball exercises, focused on strengthening the abdominal core. These results are similar to findings of Urbscheit and Wiegand (2002) but contrary to a study by Rogers et al. (2001) who reported a significant decrease in sway velocity and improved static balance following training with a stability ball. Possible differences between the current study and the Rogers et al. (2001) study included the size, gender, and ages of the subjects. The previous study reported results based on 17 subjects (5 men and 12 women) between the ages of 61 and 77 years, whereas the current study utilized 44 females between the ages of 50 and 75 years (mean age approximately 58 years). Although, subjects were screened using the Baecke physical activity questionnaire the younger subjects in the current study may have been more fit and or healthy than the subjects in the Rogers et al. (2001) study, prior to the interventions, which would make improvements in balance more difficult to detect.

We did not find any improvements in the variables associated with unilateral stance following all three exercise interventions. Cosio-Lima et al. (2003) reported significant improvements in



**Figure 4.** Step Quick and Turn - Turn Time. \*\*  $p \leq 0.01$  significant trial effect.



**Figure 5.** Step Quick and Turn - Turn Sway. \*  $p \leq 0.05$  significant trial effect.

unilateral stance scores with eyes open and eyes closed following a program of sit-ups and back extensions using the stability ball compared to performing these same exercises on the floor, however, their subjects had a mean age of 23 years, whereas the mean age of the current study was 58 years.

Even though all three exercise groups significantly improved the distance covered during the tandem walk test following the training, the walking group and the step aerobics groups had larger improvements when compared to the Ballates group. This finding might be expected considering the nature of the training that each group completed, for example the walking group was encouraged to walk during training at a faster pace than normal as well as for the stepping group to increase the intensity or speed of cadence in which they were stepping. On the other hand, even though all three groups improved their turn sway during the step quick and turn test, the Ballates group now had the largest improvements again emphasizing the specificity of the training programs (Cosio-Lima et al., 2003; DiBrezzo et al., 2005), which in this case would be the effects of the core strengthening of the training exercise and use of core muscles when making a 180 degree turn.

One possible limitation of this study was that the younger age of the subjects, which ranged from 50 to 75 years (11 subjects were older than 63 years and only 2 subjects were greater than 70 years of age), with a mean age of 58, when compared to many of the other studies which recruited men and women aged 65 years and above. This could explain why there were no group differences or group by trial interactions following the training since these subjects already had good postural stability and balance even prior to training. Another limitation of the current findings when trying to compare the results to previous studies is the fact that most other studies measured balance using the Berg Balance Scale as well as functional field tests.

There are almost 400 potential fall risk factors that have been identified, but the most important of these are the intrinsic factors. This study and other studies have demonstrated that exercise can have a positive effect on the risk factors associated with balance. It seems as though no particular type of exercise is superior to the other forms of balance training, with the exception of prescribing a combination of these exercises, i.e. stability ball plus weight training. Additional research needs to investigate the effectiveness of stability ball training in combination with dance based or step aerobics, or in combination with walking exercises. If similar improvements in balance can be realized when combining home based exercise using the stability ball with walking compared to the traditional resistance based weight training programs, then more elderly individuals may be able to enhance their balance and reduce their risk of falling without having to train at a gym. Before 2001, no studies were found that looked at the efficiency of stability ball training. In 2002, Schlicht et al. examined the safety and/or injury risk of using the stability ball in an exercise routine. Since there is a limited number of research papers that have used the stability ball in balance training and the results that have been presented are somewhat contradictory (Cosio-Lima et al., 2003; Rogers et al., 2001; DiBrezzo et al., 2005) more research is needed that compares the stability ball to balance based exercise programs like Tai Chi or to traditionally based resistance training programs.

## CONCLUSIONS

In conclusion, the Ballates training program was effective for improving dynamic balance (TW and SQT) but not for measures associated with static balance (mCTSIB tests involving the measure of sway velocity on firm and foam surfaces). In contrast, the step aerobics and walking programs improved measures of both static and dynamic

balance. Therefore, our findings suggest that increasing physical activity levels, in general, may improve measures of both static and dynamic balance.

## REFERENCES

- Barrett, C. and Smerdely, P. (2002) A comparison of community-based resistance exercise and flexibility exercise for seniors. *Australian Journal of Physiotherapy* **48**, 215-219.
- Becker, C., Kron, M., Lindemann, U., Sturm, E., Eichner, B., Walter-Jung, B. and Nikolaus, T. (2003) Effectiveness of a multifaceted intervention on falls in nursing home residents. *Journal of the American Geriatric Society* **51**, 306-313.
- Binder, E., Schechtman, K., Ehsani, A., Steger-May, K., Brown, M., Sinacore, D., Yarasheski, K. and Holloszy, J. (2002) Effects of exercise training on frailty in community-dwelling older adults: results of a randomized, controlled trial. *Journal of the American Geriatric Society* **50**, 1921-1928.
- Brill, P., Probst, J., Greenhouse, D., Schell, B. and Macera, C. (1998) Clinical feasibility of a free-weight strength-training program for older adults. *Journal of the American Board of Family Practice* **11**, 445-451.
- Buchner, D., Cress, M., de Lateur, B., Esselman, P., Margherita, A., Price, R. and Wagner, E. (1997) The effect of strength and endurance training on gait, balance, fall risk, and health services use in community-living older adults. *Journal of Gerontology Series A* **52**, M218-224.
- Carter, N., Khan, K., McKay, H., Petit, M., Waterman, C., Heinonen, A., Janssen, P., Donaldson, M., Mallinson, A., Riddell, L., Kruse, K., Prior, J. and Flicker, C. (2002) Community-based exercise program reduces risk factors for falls in 65- to 75-year-old women with osteoporosis: randomized controlled trial. *Canadian Medical Association Journal* **167**, 997-1004.
- Cohen, J. (1988) *Statistical power analysis for the behavioral sciences*. 2nd edition. Lawrence Erlbaum Associates, Publishers, New Jersey.
- Cosio-Lima, L., Reynolds, K., Winter, C. Paolone, V. and Jones, M.T. (2003) Effects of physioball and conventional floor exercises on early phase adaptations in back and abdominal core stability and balance in women. *Journal of Strength and Conditioning Research* **17**, 721-725.
- DiBrezza, R., Shadden, B., Raybon, B. and Powers, M. (2005) Exercise intervention designed to improve strength and dynamic balance among community-dwelling older adults. *Journal of Ageing and Physical Activity* **13**, 198-209.
- Era, P., Heikkinen, E., Gause-Nilsson, I. and Schroll, M. (2002) Postural balance in elderly people: changes over a five-year follow-up and its predictive value for survival. *Ageing and Clinical and Experimental Research* **14**(Suppl 3), 37-46.
- Gardner, M., Buchner, D., Robertson, M. and Campbell, A.. (2001) Practical implementation of an exercise-based falls prevention program. *Age and Aging* **30**, 77-83.
- Harada, N., Chiu, V., Fowler, E., Lee, M. and Reuben, D. (1995) Physical therapy to improve functioning of older people in residential care facilities. *Physical Therapy* **75**, 830-838.
- Hauer, K., Rost, B., Rutschle, K., Opitz, H., Specht, N., Bartsch, P., Oster, P. and Schlieff, G. (2001) Exercise training for rehabilitation and secondary prevention of falls in geriatric patients with a history of injurious falls. *Journal of the American Geriatric Society* **49**, 10-20.
- Hobeika, C. (1999) Equilibrium and balance in the elderly. *Ear Nose and Throat Journal* **78**, 556-565.
- Judge, J. (2003) Balance training to maintain mobility and prevent disability. *American Journal of Preventative Medicine* **25**(3 Suppl 2), 150-156.
- Judge, J., King, M., Whipple, R., Clive, J. and Wolfson, L. (1995) Dynamic balance in older persons: effects of reduced visual and proprioceptive input. *Journal of Gerontology Series A* **50**, M263-270.
- Karlsson, M. (2002) Is exercise of value in the prevention of fragility fractures in men? *Scandinavian Journal of Medicine, Science, and Sports* **12**(4), 197-210.
- LaStayo, P., Ewy, G., Pierotti, D., Johns, R. and Lindstedt, S. (2003) The positive effects of negative work: increased muscle strength and decreased fall risk in a frail elderly population. *Journal of Gerontology Series A* **58**, M419-424.
- Liu-Ambrose, T., Khan, K., Eng, J., Janssen, P., Lord, S. and McKay, H. (2004) Resistance and agility training reduce fall risk in women aged 75 to 85 with low bone mass: a 6-month randomized, controlled trial. *Journal of the American Geriatric Society* **52**, 657-665.
- Lord, S., Castell, S., Corcoran, J., Dayhew, J., Matters, B., Shan, A. and Williams, P. (2003) The effect of group exercise on physical functioning and falls in frail older people living in retirement villages: a randomized, controlled trial. *Journal of the American Geriatric Society* **51**, 1685-1692.
- Luchies, C., Wallace, D., Pazdur, R., Young, S. and DeYoung, A. (1999) Effects of age on balance assessment using voluntary and involuntary step tasks. *Journal of Gerontology Series A* **54**, M140-144.
- Malbut, K., Dinan, S. and Young, A. (2002) Aerobic training in the 'oldest old': the effect of 24 weeks of training. *Age and Ageing* **31**, 255-260.
- McMurdo, M. and Harper, J. (2003) Falls, bones and the primary care team. *European Journal of General Practice* **9**, 10-12.
- Mecagni, C., Smith, J., Roberts, K. and O'Sullivan, S. (2000) Balance and ankle range of motion in community-dwelling women aged 64 to 87 years: a correlation study. *Physical Therapy* **80**, 1004-1011.
- Nelson, M., Layne, J., Bernstein, M., Nuernberger, A., Castaneda, C., Kaliton, D., Hausdorff, J., Judge, J., Buchner, D., Roubenoff, R. and Singh, M. (2004)

The effects of multidimensional home-based exercise on functional performance in elderly people. *Journal of Gerontology Series A* **59**, 154-160.

- Nitz, J. and Choy, N. (2004) The efficacy of a specific balance-strategy training program for preventing falls among older people: a pilot randomized controlled trial. *Age and Ageing* **33**, 52-58.
- Rogers, M., Fernandez, J. and Bohlken, R. (2001) Training to reduce postural sway and increase functional reach in the elderly. *Journal of Occupational Rehabilitation* **11**, 291-298.
- Sakari-Rantala, R., Era, P., Rantanen, T. and Heikkinen, E. (1998) Associations of sensory-motor functions with poor mobility in 75- and 80-year-old people. *Scandinavian Journal of Rehabilitative Medicine* **30**, 121-127.
- Schlicht, J. (2002) Stability balls: an injury risk for older adults? *ACSM'S Health and Fitness Journal* **6(4)**, 14-17.
- Shaw, J. and Snow, C. (1998) Weighted vest exercise improves indices of fall risk in older women. *Journal of Gerontology Series A* **17**, M53-58.
- Shigematsu, R., Chang, M., Yabushita, N., Sakai, T., Nakagaichi, M., Nho, H. and Tanaka, K. (2002) Dance-based aerobic exercise may improve indices of falling risk in older women. *Age and Ageing* **31**, 261-266.
- Steadman, J., Donaldson, N. and Kalra, L. (2003) A randomized controlled trial of an enhanced balance training program to improve mobility and reduce falls in elderly patients. *Journal of the American Geriatric Society* **51**, 847-852.
- Stevens, J. and Olson, S. (2000). Reducing falls and resulting hip fractures among older women. *Home Care Providers* **5(4)**, 134-139; quiz 140-131.
- Urbscheit, N. and Wiegand, M. (2002) Effect of two exercise programs on balance scores in elderly ambulatory people. *Physical and Occupational Therapy Geriatrics* **19(4)**, 49-58.
- Woollacott, M. (2000) Systems contributing to balance disorders in older adults. *Journal of Gerontology Series A*, **55**, M424-428.
- Wu, G. (2002) Evaluation of the effectiveness of Tai Chi for improving balance and preventing falls in the older population--a review. *Journal of the American Geriatrics Society* **50**, 746-754.

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## KEY POINTS

- Exercise training can improve balance
- Need to consider both static and dynamic aspects of balance individually
- Improved balance can reduce the risk of falls