# The Effectiveness of Swiss Ball training on Balance in older adults.

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## Abstract

*Background:* Falling is a common cause of injury in the older adult population. This has serious implications to individual and community health care and expense. Poor or impaired balance is one of the most common risk factors for falling. Exercise has been shown to increase balance in older adults. Few studies have investigated the role of Swiss balls in improving balance. The aim of this study was to investigate the effects of Swiss ball training on balance in people over 65 years of age.

*Methods:* 15 volunteers over the age of 65 were recruited from a fitness centre in Melbourne and were randomly assigned to exercise or control groups. Participants in the exercise group performed 10 exercises using a Swiss ball over a 6 week period. Participants in the control group did no Swiss ball exercises. Both groups continued with their usual daily activities. Pre and post tests of balance were performed using the Berg Balance Scale (BBS), postural sway (PS), Timed one leg standing (TOLS) and functional reach (FR) tests.

*Findings:* Results were analysed using independent samples t-tests, Cohen's d and Bonferroni's adjustment. Improvements were noted in all the tests however none were significant. Medium to high effect size in some tests suggest larger sample size may reveal more significant results.

*Interpretation:* Findings of this study show that a training program involving exercises on a Swiss ball in the prone, supine and seated positions may lead to improved balance. This indicates that Swiss balls could be an important tool in improving balance and may help reduce the risk of falling in older female adults.

## Introduction

Falling is a common cause of injury in the older adult population. While falls are not an inevitable result of ageing, they do pose a serious concern to many older people and to the health system. In Australia in 1998, fall related injuries resulted in 45,069 episodes of in-patient hospital care and 1,014 recorded deaths (Cripps & Carman, 2001). Approximately 45% of adults over 65 years of age will experience at least one fall per year with 10 per cent having multiple falls, and over 30 per cent experiencing injuries requiring medical attention (Gryfe et al., 1977; Powell et al., Shumway-Cook A et al., 1997a; Stelmach & Worringham, 1985). The rate of falls and associated injuries is even higher for older people in residential care facilities and hospital settings (Hill et al., 2004). Falls are costly to both the individual and the community in terms of health, daily function, quality of life and health department expenses. Management of injurious falls in Australia in 2001 was estimated to cost $AUD 498.2 million (Hill et al., 2004). According to the Australian Bureau of Statistics, the proportion of the Australian population over the age of 65 years will increase from approximately 13% in 2002 to about 20% in 2021 (Australian Bureau of Statistics, 2003). This could have serious implications to the community in terms of morbidity and mortality and overall costs of falling. It is estimated that by the year 2051, the total health cost attributable to fall related injury will increase to $AUD 1375 million per annum (Moller, 2002).

Many risk factors have been identified with falling including muscle weakness, gait problems, visual and cognitive impairment, depression, functional decline, certain medications and poor or impaired balance (Rubenstein & Josephson, 2002). Notably, poor or impaired balance is one of the most common risk factors for falling amongst the elderly population (Rogers et al., 2001) with approximately 10-25% of falls being associated with poor balance and gait abnormalities (Shumway-Cook et al., 1997b).

Balance is the ability to maintain the body's position over its base of support. (Rogers et al., 2001). It involves the integration of several systems; visual, proprioceptive and vestibular. The muscular system also plays a role in balance as all body movements are effected by skeletal muscles (Magee, 1997). Balance involves static and dynamic components and poor or impaired balance has been shown to be an important predictor of falls within the elderly population (Berg et al., 1992a). A number of balance measures have been developed that have enabled particular components of balance to be measured. One such component is the centre of gravity (COG).

The COG of the body continually moves and postural sway is the body's effort to maintain balance, with increased sway indicating poorer balance (Rogers et al., 2001). It can be measured using force platform technology which measures movement of the centre of pressure (COP) of the vertical force vector in the horizontal plane (Rogers et al., 2001; Winter, 1995). Distance and velocity of postural sway increases with age and these increases are even greater when visual cues are removed and base of support (BOS) is reduced (Hasan et al., 1990; Slobolunov et al., 1998). The identification of factors associated with poor balance is important as balance has been shown to have the potential to be influenced by intervention such as exercise (Shumway-Cook et al., 1997a; Tinetti et al., 1994).

Regular exercise provides a range of health benefits in older adults and is associated with decreased mortality and age related morbidity (Nied & Franklin, 2002).

Gillespie et al., (2001) reviewed studies that looked at the effects of interventions for preventing falls in elderly people and determined that one of the interventions likely to be beneficial in this area was a program of muscle strengthening and balance retraining.

The majority of research has focused on individualised exercise programmes, that is programmes designed according to the individuals needs (Campbell et al., 1997; Shumway-Cook et al., 1997b; Wolf et al., 2001). Shumway-Cook et al (1997b) tested the effects of multidimensional exercises on balance, mobility and falls risk in community dwelling older adults. The authors reported that an individualised exercise program improved balance and functional ability thereby decreasing the fall risk in older adults living in the community. However, there was no randomisation of participants to exercise groups and there was no blinding in the assessment of the outcomes.

In another study investigating individualised programs, Campbell et al., (1997) assessed the effectiveness of a home exercise program of strength and balance in reducing falls in elderly women. The study was randomised and well defined and the investigators were blinded to which group the participants belonged to. At six month reassessment, the exercise group showed a significant improvement in balance measures. The authors concluded that an individualised program of strength and balance retraining exercises could improve physical function and reduce falls and fall related injuries in women over 80 years of age (Campbell et al., 1997).

Similarly, Wolf et al., (2001) conducted a study investigating the effects of a short individualised exercise program on balance dysfunction in the elderly (n=94). The authors used a single-blind, randomised, repeated-measures experimental design consisting of an experimental and control group. The experimental group performed an individualised balance training programme whilst the control group did not participate in any exercise programme. The experimental group improved significantly more in overall balance as measured by the Berg Balance Scale (BBS) and Dynamic Gait Index (DGI) than those in the control group.

The research clearly establishes the value of using an individualised exercise program in improving overall balance. Alternatively other studies have suggested that a programme consisting of a standard set of exercises in which all participants perform the same exercises, may also be beneficial in improving balance in the elderly. This type of standard programme may be conducive to performing exercises in a group setting thereby improving safety and maintaining a social atmosphere (Rogers et al., 2001). However only a small number of studies have investigated the efficacy of such programmes.

Rogers et al., (2001) used a standard exercise programme to measure change in balance in adults aged 61 to 77 years of age (n=12). Over 10 weeks participants performed stretching, strengthening and balance exercises. Balance exercises were performed on air-filled exercise balls in prone, supine and seated positions. The authors reported that several postural sway composite scores improved; medial – lateral amplitude and speed of sway ( 9% ) and mean and maximum instantaneous speed ( 13% ). However, antero – posterior amplitude and speed of sway did not change. The authors also reported that functional reach increased significantly after training. The authors concluded that exercising on the non-stable support surface of the exercise ball improves balance in older adults. However limitations of this study were the lack of control grouping and small sample size.

In a later study, Day et al., (2002) also investigated the effectiveness of a standard exercise programme in preventing falls amongst older people (n=1090). Participants were randomly assigned to a control group or one of seven experimental groups. Experimental groups were subjected to different combinations of the three interventions; group based exercise, home hazard management and vision improvement. Strengths of the study were group selection criteria and blinding of assessors. Balance measures improved significantly among the group based exercise participants and the authors concluded that group based exercise was the most potent single intervention tested, and the reduction in falls among this group was associated with improved balance.

Standardised exercise programs can therefore also be seen to be beneficial in improving balance in elderly adults. Balance can be tested in a number of different ways.

The Berg Balance Scale (BBS) is a test involving 14 items in order of increasing difficulty (see appendix 1). Each item is measured on a 5-point ordinal scale (0 = unable to complete the task, to 4 = can complete the task independently). The BBS has displayed excellent intra-rater and inter-rater reliability (r=0.91) (Berg et al., 1992b). It has also shown concurrent validity by strong correlations with other tests of balance such as the Tinetti

Mobility Index (TMI) (r=0.91) (Tinetti et al., 1986). A study by Lajoie & Gallagher, (2004) reported that the BBS along with reaction time and the Activities-specific Balance Confidence scale (ABC) contributed significantly to the prediction of falls with 89% sensitivity and 96% specificity.

The Timed One Leg Standing (TOLS) test is another test that has shown strong inter-rater reliability (Giorgetti et al., 1998; Potvin et al., 1980). Participants attempt to stand on one leg with their arms crossed in front of their chest. They are timed for how long they can balance on one leg without dropping the opposite foot to the ground or without moving their arms away from their chest (Giorgetti et al., 1998). The authors tested disabled and non-disabled older adults comparing results between the examiners. Reliability co-efficient for the TOLS test was 0.85 for the disabled sample and 0.75 for the non-disabled sample. Potvin et al. (1980) examined test-retest reliability of the TOLS test in normal, healthy men. Reliability was 0.78 as measured by a Pearson product moment correlation co-efficient (Potvin et al., 1980). However, only 25% of participants (15 out of 61) were aged 65 years of age or older. A study conducted in Japan (n = 34), evaluated specific effects of balance and gait exercises among frail elderly individuals (Hiroyuki et al., 2003). The authors reported a significant increase in TOLS in the balance exercise group and concluded overall that balance exercises led to improvements in static balance while gait exercises led to improvements in dynamic balance

Postural sway is another popular test of balance. It is measured by a force platform (Winter, 1995) and has been shown to have a significant correlation ($P<0.001$) with other functional tests of balance (Ekdahl et al., 1989).

Functional reach is the distance a person can reach past their arm's length whilst maintaining balance. High inter-rater and test-retest reliability has been reported in the functional reach test (0.98 & 0.92 respectively) (Duncan et al., 1990). Functional reach has been correlated with other tests of dynamic balance such as the Step up test and with maximal Centre of Pressure (COP) excursion ($r = 0.71$) (Duncan et al., 1990; Tinetti et al., 1986).

In summary, the research demonstrates that balance can be improved by exercise intervention. Many forms of exercises have been used to test this theory and one of these involves the use of a Swiss ball. There is limited research into using Swiss ball exercises to improve balance, but preliminary findings have been encouraging. However further research is required to expand these findings. Two broad approaches to exercise programming (individualised and standardised) have been investigated. Whilst both programmes have been shown to be effective in improving balance, standardised programmes have the benefit of being conducive to being performed in a group setting thus improving safety and maintaining a social atmosphere.

The aim of this study was to investigate the effects of Swiss ball training on balance in people over 65 years of age using a standardised exercise programme.

## Method

Fifteen female volunteers of average height (M=162.6cm, SD=7.0) and weight (M = 69.4 kg, SD=15.85) and aged over 65 years (M=69.3, SD=3.6), were recruited from the Knox Leisureworks YMCA gymnasium in Melbourne. Exclusion criteria were as follows; 1. Subjects with a history of low back pain within the last 8 weeks. 2. Subjects with a diagnosed spinal condition. 3. Subjects being treated for any condition that may affect balance. During the study period, three participants withdrew due to unavailability or medical conditions. Therefore twelve (N=12) participants completed the study.

All procedures were approved by the Victoria University Human Research Ethics Committee and all participants signed an informed consent form prior to the commencement of the study. All participants were given a verbal and written explanation of the testing and exercise procedures before baseline measures were taken.

Testing procedures

At the pre-testing session, each participant completed the following tests of balance;

Timed one leg standing; each participant stood on one leg in bare feet with their arms crossed in front of their chest. They were timed (with digital stopwatch) for how long they could balance on one leg without dropping the opposite foot to the ground or without moving their arms away from their chest. Both legs were tested individually.

Functional reach; each participant stood in bare feet, feet shoulder width apart and arms outstretched and together. They then reached forward, keeping their heels on the ground and their back straight, until they lost their balance and had to step forward. Functional reach was determined by the distance the hands travelled from the starting position to the point of losing balance. This was measured using a tape measure placed horizontally on the parallel wall.

Postural sway; is commonly measured using a force platform (Winter, 1995) but for the current study a new method was employed using a Pliance® pressure mat. This mat has been shown to be as reliable as a force platform, but is totally portable, thus allowing it to be used in the field (McLaughlin, 2004). Each participant was tested in two stances;
1) Bilateral stance, eyes open for 10 seconds. 2) Bilateral stance, eyes closed for 10 seconds. Each test was performed in bare feet and the centre of pressure range in both the antero-posterior and medio-lateral directions were calculated.

Berg Balance Scale; The BBS is a test involving 14 items in order of increasing difficulty (see appendix 1). Each item is measured on a 5-point ordinal scale ranging from 0 = unable to complete the task, to 4 = can complete the task independently. Each participant performed each of the items in order and was scored by the examiner according to how well they perform the task.

At the conclusion of the testing session, each participant was randomly assigned to an exercise group or a control group. The exercise group were taken through a demonstration and practical session of the Swiss Ball exercises that they were to do over the next six weeks. The participants were free to continue their normal activity routine and were asked to only perform the Swiss Ball exercises demonstrated to them and not any other Swiss Ball exercises. Each participant was given a photocopy of the exercises in the order they were to be performed. The exercise group was monitored by the instructor meeting with the group every two weeks and phoning the participants every alternate week to make sure they were doing the exercises correctly and to answer any questions or problems. The control group were free to continue with their normal activity routine, but were asked not to perform any Swiss Ball exercises for the next six weeks. Participants in the control group were monitored by phone every two weeks to answer any questions or problems.

At the end of the six week period, participants were re-tested on the same four balance tests used in the pre-test session with the examiners blinded to study groups. The participants were again given a verbal and written explanation of the tests before they commenced.

A total of eight measures of balance were used in the current study:

1. Timed One leg standing test right and left (TOLSR and TOLSL); 2. Functional reach test (FR); 3. Postural sway test (PS). Postural sway was assessed in four ways- eyes open and eyes closed in both medio–lateral (EOX and ECX) and antero–posterior (EOY and ECY) directions; 4. Berg Balance Scale (BBS)

<u>The exercises</u>

Ten exercises were demonstrated to the participants by a qualified professional instructor. The exercises were taken from the book "Effective Swiss Ball Training – Volume 1: Functional Swiss Ball Training" (Hermann, 2001) and involved the participants using a Swiss Ball (AOK health) in seated, prone and supine positions. The exercises took approximately 15 minutes to complete and participants were asked to perform the exercises three (3) times per week for six (6) weeks.

## Statistical analysis

Age, height and weight data were determined and Independent samples t-tests, Bonferroni's adjustment and Cohen's d were performed on the difference scores between groups for each parameter. All statistical analysis was carried out using SPSS version 11.5.1 for windows.

## Results

Differences between pre and post-test scores were recorded for control and exercise groups and are shown in table 1 below (calculated as pre minus post). For the postural sway scores (labelled * in table 1), a negative change signifies decreased sway and therefore increased balance. As shown in table 1, there was an overall increase in balance for most tests with both groups showing varying improvements in balance. However the TOLSR and TOLSL show conflicting results in balance for both groups. Standard deviation data for these two tests was particularly high.

Independent samples t-tests, and Cohen's d were performed on the difference scores between groups for each parameter (table 2 below). Bonferroni's adjustment was then calculated at 0.006.

The only test that scored a close to significant result was the antero-posterior sway measure with eyes closed (ECY) ($p = 0.01$). The results suggest that while both groups improved on this particular score from pre to post, the experimental group achieved a greater level of improvement when compared to the control group.

Whilst no other test recorded a significant result for pre to post change, a number of parameters (BBS and TOLS) recorded medium to high effect size values. This would suggest that future studies using similar parameters to the present study should choose a larger sample size in order to enhance the possibility of achieving significant results.

Table 1: Balance tests used with mean difference between pre and post test.

| Balance tests | Group | Mean change | SD |
|---|---|---|---|
| BBS | Control | 7.67 | 2.07 |
| | Exercise | 10.83 | 4.49 |
| EOX *(cm) | Control | -0.71 | 1.38 |
| | Exercise | -0.45 | 1.09 |
| EOY *(cm) | Control | -0.44 | 1.09 |
| | Exercise | -0.14 | 0.75 |
| ECX *(cm) | Control | -0.62 | 0.84 |
| | Exercise | -0.73 | 0.87 |
| ECY *(cm) | Control | -0.15 | 0.37 |
| | Exercise | -0.44 | 0.28 |
| FR (cm) | Control | 2.17 | 2.4 |
| | Exercise | 2.67 | 1.5 |
| TOLSR (sec) | Control | -11.77 | 16.36 |
| | Exercise | 3.52 | 17.15 |
| TOLSL (sec) | Control | 6.4 | 16.54 |
| | Exercise | -2.65 | 6.6 |

**Table 2: Independent t-test and effect size results for change scores**

| Balance test | T | p | d |
|---|---|---|---|
| BBS | -1.569 | 0.15 | -0.85 |
| EOX | -0.363 | 0.72 | -0.22 |
| EOY | -0.552 | 0.59 | -0.33 |
| ECX | -0.237 | 0.82 | 0.14 |
| ECY | 3.107 | 0.01 | 1.34 |
| FR | -0.432 | 0.68 | -0.26 |
| OLSR | -1.579 | 0.15 | -0.86 |
| OLSL | 1.246 | 0.24 | 0.70 |

* Bonferroni's adjustment = 0.006

## Discussion

After calculating Bonferroni's adjustment at 0.006, data from the present study indicate no significant improvements in balance. The only condition that was close to this value was in the exercise group with the eyes closed in the antero-posterior direction (ECY) ($p = 0.01$). With small sample sizes in each group ($n = 6$), effect size data is most relevant. For the ECY condition a high effect size gives strength to the result for the test ($d = 1.34$). This data indicates that Swiss ball exercises may help to reduce postural sway in the antero-posterior direction with eyes closed. Postural sway also decreased post exercise in the medio–lateral direction in the exercise group but this result was not significantly different from the control group change ($p = 0.82$). The above findings differ from those of Rogers et al. (2001), who reported that several postural sway composite scores improved including medio–lateral amplitude (by 9%) as a result of training, involving stretching and strengthening exercises as well as exercises on air-filled exercise balls. However, antero–posterior amplitude and speed of sway did not change. The exercises performed in the Rogers et al. study were similar to the current study ie exercises were performed in prone, supine and seated positions. The participants also performed stretching and strengthening exercises which may have assisted in their improvements in postural sway.

It has been reported that postural sway increases with age and that this increase is even greater when visual cues are removed even following an exercise program (Hasan et al., 1990; Lichtenstein et al., 1989; Slobolunov et al., 1998). The findings from these studies differ from those in the current study in which there was an improvement in antero-posterior sway with the eyes closed. The differences could be attributed to the Swiss ball exercises in the current study being designed to improve overall balance and core stability (Hermann, 2001) and the aforementioned studies using general balance exercises not involving Swiss balls.

BBS scores in the current study improved for both exercise and control groups (exercise > control) although this change was not significant (p = 0.15). This differs from the findings by Wolf et al. (2001) who reported that subjects in the exercise group improved significantly more on the BBS than those in the control group following a four to six week balance training program. These differences may be attributed to different exercise conditions in each study. In the study by Wolf et al (2001), each participant was given an individualised programme developed by a physical therapist. In the current study, all participants were given a standard programme so each participant received the same intervention.

Functional reach improved for both groups in the current study but again not to significant levels. This may be due to choice of exercises focusing on overall balance and stability and not specifically targeting forward reaching. Rogers et al. (2001) reported that functional reach increased significantly after a training program involving exercises on air-filled exercise balls similar to the current study. However, the intervention in the study by Rogers et al. also included stretching and strengthening exercises using hand weights. This differs from the current study in which the intervention involved only exercises on Swiss balls. Therefore the improvement in functional reach seen in the Rogers et al study could possibly have been due to other facets of the intervention such as stretching or hand weight strengthening.

TOLS scores show conflicting results with the exercise group improving on the right leg and the control group improving on the left leg, however results were not significant. Participants had as much time as necessary between testing of each leg to rest and catch their breath which may have contributed to the second leg tested achieving a better result. Right or left leg dominance may also have been a factor. These results may also be explained by the choice of exercise with no specific exercises focusing on improving one legged balance. Hiroyuki et al (2003) reported a significant increase in TOLS scores in participants in the balance exercise group. In this study, participants in the balance exercise group performed exercises prescribed by a physiotherapist. Exercises were more specific to one leg balancing including forward reaching, standing on one leg, tandem standing and balance board work which may have contributed to the improvement in the TOLS scores.

Poor or impaired balance is one of the most common risk factors for falling (Rogers et al., 2001). It has also been shown that balance is an important predictor of falls within the elderly population (Berg et al., 1992a). Therefore improved balance may lead to a reduction in the mortality and morbidity of falls amongst elderly women. Implications of the current study show that a training program involving exercises on a Swiss ball in the prone, supine and seated positions may help improve balance.

A number of limitations were identified in this study. Firstly, the small sample size (N = 12) may not have been representative of the general population of women aged over 65 years. Secondly non compliance with the exercise regime was reported. Specifically some participants in the exercise group were observed to be performing more, and different, exercises to those specifically prescribed by the examiners. Another of the group only performed the exercises when there was somebody around to assist due to fear of falling. In addition some participants in the control group had been practicing one leg standing to improve their score. In future studies, it would be advisable to ensure a more structured process to improve compliance such as logging progress and having it checked regularly (Day et al., 2002) or by having the participants monitored more closely whilst doing the exercises eg have an instructor run planned exercise sessions.

The intervention period may have been too short at six weeks. Although neuromuscular changes do occur within six weeks (Ploutz et al., 1994) it may not have been long enough for other changes such as strength or morphological changes to occur. The results from the current study do show some improvements in balance, however not statistically significant. Other studies have shown more significant results with longer intervention periods ranging from 10 weeks to one year (Rogers et al., 2001; Campbell et al., 1997).

Although the study was advertised in many areas in the Shire of Knox, such as local health clubs, RSL clubs, bowling clubs and bingo halls, the participants all had some involvement with the Knox Leisureworks YMCA gymnasium either with the gym or with other classes such as aqua aerobics. This may suggest a biased sample not reflective of the general community.

## **Conclusion**

Findings from the current study indicate that exercising in various positions such as prone, supine and seated, on a Swiss ball may increase some aspects of balance, specifically forward – backward sway with eyes closed. Further research is warranted in this area, with larger sample sizes and a longer, more rigorously structured exercise program. This may demonstrate more clearly how specific exercises can effect the balance of women over 65 years of age.

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