The Effects of a 4-Week BAPS Training Program on Measures of Static and Dynamic Balance in The Older Adult Population: A Case Study

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Mandy L. Krause & Kelly A. Ogden
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Approved:

[redacted]

Professor Ann E. Taylor, M.A.
Committee Chair, PTH 669

[redacted]

Laura Zacharewicz, MS, PT
Assistant Professor

[redacted]

Marjane Selleck, MS, PT
Director, Physical Therapy Program

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Kelly and Mandy

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Mandy L. Krause & Kelly A.Ogden

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Abstract

The purpose of this study was to determine if a balance-training program using the BAPS board would improve postural control and balance; therefore, decreasing the risk of falls in the older adult population. A healthy community dwelling 63 year old female was used in this study. After completing a verbal medical history evaluation and a lower quarter screen to rule out any unapparent musculoskeletal or neurolgical deficits, the participant completed a 4-week BAPS board training program. Baseline and post-treatment measurements were performed for static and dynamic balance using the Functional Reach Test, Tinetti Gait and Balance Assessment, and perturbed and unperturbed stance under various conditions. Following training, the participant showed improved balance in all assessments. The results of the study indicate that BAPS board training is a beneficial treatment regime for improving balance.

The Effects of a 4-Week BAPS Training Program on Measures of Static and Dynamic Balance in the Older Adult Population: A Case Study

Startling statistics regarding falls in the elderly has been a growing concern of many health care professionals. Due to the loss of balance function and increased incidence of falls in the elderly, improving postural control/balance (the regulation of the body's position in space for the dual purpose of stability and orientation) is a major concern in rehabilitation and geriatric medicine (Wegener, Kisner, & Nichols, 1997). Falls are the leading cause of death due to an accident or unintentional injury in individuals over the age of 65 (Sattin, 1992). It has been estimated that one-third of the elderly population living in nursing homes, aged 65 and older, experience one or more falls per year (Wegener et al., 1997) 20 to 30 percent of those who fall will suffer moderate to severe injuries causing reduced mobility and independence, and a greater risk of death. Ninety five thousand deaths a year are attributed to falling (Goggin, 1999).

The Medicare cost for a fall victim is large. In 1994, the average cost for a fall injury was fourteen hundred dollars for a person over the age of 65 (Goggin, 1999). The total direct cost of fall injuries in individuals 65 and over was 20.2 billion dollars; therefore, decreasing the risk of falls and increasing postural control is of interest to all those involved (Englander, 1996).

The ability for an individual to carryout physical activities effectively and safely requires coordinated activity between the three balance systems: visual, vestibular, and proprioceptive/somatosensory systems. If one system provides inadequate information or is detrimentally affected by a musculoskeletal injury, head trauma, disease, or aging, it is necessary for the other two systems to compensate for the malfunctioning one and provide accurate information so that sensory organization and dynamic activities can take place. Dynamic activities are activities that cause the center of gravity (COG) to move in response to muscular activity (e.g. walking, running, stair climbing, and other daily activities) (Bernier & Perrin, 1998). Age related morphological changes occur in all sensory systems including those essential for the maintenance of posture (New England Research Institute for Studies on Aging & Sargent College of Heath and Rehabilitation Sciences Boston University [NERISA & SCHRSBU], 1998).

The role of vision in balance control has been frequently examined. "When somatosensory conflict is present, such as a moving platform or a compliant foam surface, balance is significantly decreased with eyes closed compared to eyes open. On a stable surface, closing the eyes should cause only minimal increases in postural sway in normal participants. However, if the somatosensory input is disrupted due to injury, closing the eyes will increase sway significantly" (Bernier & Perrin, 1998, p. 265). Due to the relatively slow visual reflexes in the elderly, the visually guided postural reflexes do not react quickly enough to prevent a fall when balance is lost (Balance Disorder Institute, 1999), and limitations in the visual field may impair orientation and diminish the ability to accurately determine the COG (Balance Disorder Institute, 1999).

The vestibular system, the second system used in balance control, plays a minor role in maintaining balance when visual and somatosensory systems are intact. Its major role is to detect the position and movement of the head in space with respect to gravity and sudden changes in the direction of movement of the head. It is also important for the coordination of eye stability and head position (Bernier & Perrin, 1998).

Proprioception (somatosensation) input, the third system used in balance control, is one of the primary forms of sensory input for postural control (Kinzey, Ingersoll, & Knight, 1997). Proprioception is the cumulative neural input to the central nervous system (CNS) from the mechanoreceptors in the joint capsules, ligaments, muscles, tendons, and skin that contribute to the body's ability to maintain postural stability. When these structures are subjected to mechanical deformation, action potentials are conducted to the CNS where the information can influence muscular response and position sense (Mattacola & Lloyd, 1997). The myotatic stretch reflex is the first mechanism to react during the loss of balance (Bernier & Perrin, 1998). Stretch reflexes may be insufficient and act to destabilize balance; therefore, the other balance systems are required to maintain balance (Bernier and Perrin).

The maintenance of upright postural control is a complex task, requiring an individual's COG to reside over a small base of support (BOS). It requires an intact neuromuscular system, effective motor response, and sufficient muscle strength to sustain an upright posture or to return the COG within the BOS when balance is disturbed (Bernier & Perrin, 1998).

Characteristic patterns of muscle activity called muscle synergies, which are associated with postural control, are referred to as ankle, hip, and stepping strategies. These postural movement strategies are used in both feedback and feedforward (anticipatory) situations in order to maintain equilibrium in a number of circumstances. Studies have shown that normal subjects can shift relatively quickly from one postural movement strategy to another (Shumway-Cook & Woollacott, 1995).

The use of ankle, hip, or a stepping strategies when standing on a firm, flat surface may be different from those used when standing on a narrow beam. An ankle strategy restores the COG to a position of stability through body movement centered primarily about the ankle joint. Activation of the gastronemius muscle produces a plantar flexion torque that slows and then reverses the body's forward motion. Activation of the hamstring and paraspinal muscles maintains the hips and knees in an extended position. The use of ankle strategies requires intact range of motion and strength in the ankles (Shumway-Cook & Woollacott, 1995).

A hip strategy controls motion of the COG by producing large and rapid motion at the hip joints with antiphasic motions at the ankles. Horak and Nashner suggest that the hip strategy is used to restore equilibrium in response to larger, faster perturbations, or if the support surface is compliant or smaller than the feet (e.g. standing on a beam) (Shumway-Cook & Woollacott, 1995). When postural perturbations are strong enough to displace the COG outside the BOS, stepping strategies are elicited as a step or a hop, to bring the support base back into alignment under the COG (Shumway-Cook & Woollacott). Research has indicated that stepping strategies are commonly executed protective responses for balance recovery in the natural environment (Pai, Rodgers, Patton, Cain & Hanke, 1998). "Steps may occur in anticipation of an impending collision or fall, or in reaction to an imposed horizontal movement of the body COG with respect to the actual or anticipated limits of the BOS" (Pia et al., 1998, p.1111). Elderly fall victims may ineffectively initiate and execute steps to prevent loss of balance (Pia et al., 1998). The finding of a study conducted by Pia et al. indicated that the "elderly in general, and older fallers in particular, would initiate steps more frequently and at lower levels of perturbation intensity than younger adults" (Pia et al., 1998, p.1115).

Impaired postural control is the result of inaccurate information about the position of the body's COG, inadequately executed movements to bring the COG to a balanced position, or a combination of both (Balance Disorder Institute, 1999). In the older adult population, imbalance is usually the result of multiple dysfunctions (Balance Disorder Institute, 1999). Studies describe that with aging, the functioning of the vestibular, visual, and proprioceptive sensory systems decrease. Other changes that occur with aging of the motor and sensory systems are decreased muscle strength, muscle atrophy, slowing of peripheral nerve conduction velocity with a decreased rate and magnitude of reflex responses, reduction in the size and number of mitochondria, a loss of both the number and the size of muscle fibers, and reduced sensation (Harrison, Duenkel, Dunlop, & Russell, 1994). In addition, there is also a decrease in the posterior spinal column tract that occurs with aging and is responsible for decreased righting responses (Bottomley & Lewis). These changes contribute to increased postural sway (Harrison et al., 1994), and "as postural control mechanisms deteriorate with age and disease, balance becomes increasingly tenuous resulting in an enhanced susceptibility to falls" (Duncan, Weiner, Chandler, & Sstudenski, 1990, p.192).

After a fall, many patients are immobilized and put on bed rest that may cause further impairment. Experts at the Huffington Center on Aging at Baylor College of Medicine in Houston report that while fractured bones are a concern, it is the immobility caused by the falls that results in the long-term damage to an elderly person. As we age, we naturally begin to lose bone and muscle mass. The loss of bone and muscle mass can be compounded if a person is forced to stay in bed and recover from a fracture; therefore, increasing the risk for additional falls and medical expenses (Huffington Center on Aging, 1997).

Balance can be evaluated with a variety of static balance measures and/or dynamic balance assessments (Mattacola & Lloyd, 1997). Static balance (when the COG is over the BOS when the body is not moving) tests are a common way of assessing balance control. These tests consist of the participant maintaining upright stance under the following conditions: 2-legged stance, 1-legged stance, and tandem stance, with the eyes open and closed, and perturbed or unperturbed (Patla, Frank, & Winter, 1990). All conditions are timed. Timed balance scores have been found to decrease with age, and single-leg balance times have been found to be shorter for fallers than for non-fallers (Cho & Kamen, 1998).

Dynamic balance measures assess the ability to maintain equilibrium in response to either self-motivated or external perturbations. Reaching is a daily activity that constantly introduces a stress on our body. Volitional arm movements are accompanied by stabilizing muscle activity of the legs and trunk for postural control. Evaluation of this activity has shown that the elderly population has decreased efficiency and deferred anticipatory preparation for movement and impaired coordination of postural adjustments for upper extremity movement (Duncan et al., 1990). Static dynamic balance can be measured/evaluated by throwing a physioball or by other throwing activities because it mimics the postural responses that are needed during activities such as reaching overhead or removing a shirt (Kinney, LaPier, Liddle, & Bain, 1997).

A common dynamic balance assessment is the Functional Reach Test (FRT). The FRT is a single item test developed as a quick screen for balance problems in older adults (Niznik, Turner & Worrell, 1993). Duncan et al. (1990) defines the FRT as the "maximal distance one can reach forward beyond arm's length, while maintaining a fixed BOS in the standing position" (p. 192). The internally motivated reach is a feedforward mechanism and reflects the participant's functional capabilities of balance that is typically used in activities of daily living (Niznik et al., 1993). The FRT is a reliable measure that is easily administered and reproducible to assess the high prevalence of falls and instability in older individuals. It is a dynamic measure that is inexpensive, reliable, precise, age-sensitive, easily accessible, it applies current postural control theory, and it has high inter-rater reliability (Duncan et al., 1990). In addition, it is easily performed in homes, nursing homes, and in outpatient clinics (Duncan et al., 1990). A study conducted by Giorgetti, Harris and Jetti (1998) found the "FRT is a clinically feasible outcome measure of balance in non-disabled and disabled older people based on reliability coefficient of 0.73" (Giorgetti, Harris & Jetti, p.282). "Part of the variability observed in the FRT may be in the ability of the participant to choose the appropriate motor strategy for the reaching task" (Giorgetti et al., 1998, p.282). For information on how the FRT is administered see Appendix A.

A second inexpensive and easily performed balance assessment is the "Tinetti Gait and Balance Assessment" (Appendix B). It is a tool used by many health professionals to determine an individual's risk of falling. Scores of the Tinetti assessment are tabulated for both balance and gait, with a maximum score of 28. Participants that score less than 19 are at a high risk of falling, while a score of 19-24 indicates that a participant is at a greater risk of falling but is not a high risk candidate. Many experts find the "Tinetti" assessment particularly helpful because it is a simple and inexpensive tool and a familiar tool to physicians and other health care professionals. A deficient rating indicates the need for therapeutic intervention and upon re-evaluation it may document improvement. Another advantage of using the "Tinetti" assessment is the ability to ascertain whether a fall was attributable to a gait or balance insufficiency (Lewis, 1993).

An additional balance assessment tool is the one-legged stance (OLS) test. OLS is defined as the number of seconds a participant is able to maintain their balance on one foot with their arms crossed over their chest during unperturbed and perturbed conditions. When testing older participants it is recommended that a 30-second time limit be utilized. This time limit allows for a range of various values and increases the sensitivity of the test. Some participants have not identified the proper motor strategy to maintain balance on one leg, which may explain one possible reason for the various responses during the same testing period. Using ankle or knee strategies during one-legged standing may enhance the balance response by increasing proprioceptive feedback when compared to the individual who has minimum movement in those joints. Upper extremity motor strategies are eliminated secondary to the participant folding their arms across their chest (Giorgetti et al., 1998). OLS "is a clinically feasible and practical measure of balance ability in the community-dwelling older population" (Giorgetti et al., 1998, p.280). Research conducted by Giorgetti et al. (1998) found a reliability coefficient of 0.75 for the non-disabled sample and 0.85 for the disabled sample for the OLS test. It is extremely important for physical therapists to use these types of well-known tools because familiarity and acceptance are critical to the functional assessment and documentation process.

Research indicates exercise is an important factor that needs to be incorporated into everyone's lifestyle, young and old. Specific functional exercises that train people at risk for falls are vital (NERISA & SCHRSBU, 1998). Regular physical activity can help the body maintain, repair, and improve itself. In a recent study, men and women (ages 86-96) improved their knee flexibility and tripled their leg muscle strength by exercising with weights. The results of this study were especially encouraging since weak muscles can lead to falls that may secondarily cause hip fractures and many other injuries for older adults. Exercises that are especially helpful in fall prevention include those that provide opportunities to: (a) improve balance skills and flexibility, (b) strengthen quadriceps muscles and hip extensors, (c) improve coordination, and (d) improve overall conditioning. In addition, exercise helps prevent falls by improving blood pressure regulation, strength, flexibility, and sensory input (NERISA & SCHRSBU, 1998).

Research conducted by Santora and Smith (1998) indicates that "exercise that produce stress on major bones has been shown in controlled studies to increase bone mass and total body calcium or to retard the rate of loss in middle-aged and elderly women" (NERISA & SCHRSBU, 1998, p. 22). As stated through the facts above, exercise has been shown to improve strength, coordination, and balance skills that in turn will decrease the risk of falling (NERISA & SCHRSBU, 1998).

The biomechanical ankle platform system (BAPS) is one way in which participants can train/exercise in order to improve balance. The BAPS incorporates an axis of rotation for insertion of a hemispherical attachment. The shape and design of the board is the result of an analysis of the anatomy, kinesiology, and mechanics of motion and function of the ankle. It is essential to maintain proper foot alignment because of the exact calibrated shape and design of the platform (Camp International Limited, 1984).

The BAPS consists of levels 1-5. Each subsequent level increases the percentage of all ranges by an exact proportionate amount. The rotation of the platform around its peripheral edge is a mandatory protocol parameter of the BAPS, except in balance training (Camp International Limited, 1984).

The use of the BAPS board with and without shoes is beneficial. The use of the system without footwear allows for proper exercise without extrinsic compensation and allows for observation of the foot and ankle in various motions. The use of the system with footwear can change the relationships of certain segments of the foot and ankle; therefore rehabilitation, training, and conditioning with footwear is a beneficial part of the program (Camp International Limited, 1984).

The BAPS has been shown to improve lower extremity proprioception, strength and coordination; therefore, with BAPS training, it is possible to increase postural control and balance (Soderberg, Cook, Rider, & Stephenitch, 1991). The use of a BAPS allows safe, controlled, and predictable stress to the lower extremity in its dynamic position of use (Camp International Limited, 1984). In addition, the weight bearing, range of motion (ROM), rotational, speed, and resistive weight-training stresses are all properties that the BAPS allows, which leads to controlled functional progression in rehabilitation (Camp International Limited, 1984). Functional stability incorporates the components of appropriate ROM, strength, proprioception and reaction speed. "The BAPS incorporates all these components gradually and progressively in a closed kinetic chain, preparing the lower extremity for return to dynamic functional activity" (Camp International Limited, 1984, p. 14).

Bernier and Perrin (1998) found that a six week balance and coordination training program increased the control of postural sway, and Kinzey et al. (1997) stated that coordination training aimed at increasing proprioception decreases postural sway and the chance of injury.

The purpose of the study was to determine if a balance-training program using the BAPS board will improve postural control and balance; therefore, decreasing the risk falls in the older adult population. It was hypothesized that balance training with the BAPS board will improve balance in the older adult population.

Method

Participant

A healthy community dwelling sedentary 63-year-old female was used in this study. The participant was a volunteer from Troy, NY. Exclusion criteria for participation included: uncorrected vision or any visual depth perception disorders, injuries to the trunk that interfere with activities of daily living (ADL's), diagnosed vestibular or neurological disorders, alcohol consumption within the last 12 hours, uncontrolled metabolic disorders, history of dizziness or unexplained falls within the last 6 months, medications with known potential side effects on balance, and any lower extremity (LE) pathology such as total joint replacements, diagnosed arthritis, decreased sensation, or unresolved musculoskeletal injuries.

Procedure

The participant signed an informed consent form and completed a verbal medical history evaluation before the start of the study. A lower quarter screen was performed to rule out any unapparent musculoskeletal or neurological deficits.

Static balance was measured by static unperturbed (quiet stance) two-legged stance with feet together and eight inches apart, one-legged stance, and tandem stance. All conditions were measured with eyes open and eyes closed, arms crossed over the chest. The participant stood on a hard and soft (mat) level surface without shoes. The participant was timed (with a maximum of 30 seconds) for each task to determine if she could maintain the position. If any of the following events occurred before 30 seconds had lapsed, the watch was stopped and the time was recorded: 1) during two-legged stance, any displacement of the feet on the floor or use of the arms; 2) during one-legged stance, any use of the arms or the contralateral leg for support such as bracing the nonweight-bearing lower extremity against the weight-bearing extremity, or hopping on the nonweight-bearing extremity; 3) opening the eyes during the eyes-closed activities. In addition, the participant completed perturbed (creating a loss of stability via manual external nudges) two-legged stance with eyes open and closed under the above conditions minus the time element in order to observe elicited ankle, hip, or knee strategies. The participant completed five trials under each condition and all trials were averaged. The participant was able to alternate legs and rest between trials.

Static dynamic balance was measured by throwing an inflated physioball of 65 cm in circumference overhead to a catcher 10 feet away without displacing her feet. The participant completed 5 trials. Data was collected regardless if the ball reached the catcher, and the number of stepping responses was recorded. In addition, the participant completed a FRT using the standard guidelines.

Dynamic balance was measured by the ability of the participant to complete the "Tinetti Balance and Gait Assessment". Balance assessments as previously described were completed before the start of the first treatment and after the last treatment.

The participant trained on a standard BAPS board (66-cm mediolateral and 60 cm anterioposterior) inside the parallel bars with a mirror in front of her in order to minimize flexion of the cervical spine and maintain a consistent posture. In addition, the participant was reminded not to load through her hands on the bars, but that the bars were there in case there was a loss of balance.

The participant completed exercises 1-2 three times a week for the first two weeks, and then she completed exercises 3-4 for the second two weeks:

1. Stand with one foot on the board. Move the front edge forward nearly touching the floor. Then, move the board back, with the rear nearly touching the floor. During exercise, the board should not touch the floor. Continue the movement for 15 seconds. Rest for 10 seconds. Repeat this session 10 times on each foot.
2. Stand with one foot on the board and move the left edge until it nearly touches the floor. Then, move the right until it nearly touches the floor. Continue the movement for 15 seconds. Rest for 10 seconds. Repeat this session 10 times on each foot.

3. Stand with one foot on the board and complete sessions 1-2 with flexed knees. Do movements in session 1-2 for 30 seconds. Rest for 20 seconds. Repeat this session 5 times on each foot.
4. Stand with one foot on the board and move the front edge of the board forward and return to center; move the board to the right and return to center; move the board to the back and return to center; move the board to the left and return to center. Continue the movement for 60 seconds. Rest for 10 seconds. Repeat this exercise 5 times with each foot.

The participant was progressed by increasing the size of the ball under the BAPS board as appropriate.

Results

It should be noted that the participant progressed without difficulty from a level 2 to a level 3 on the third day of training, and continued to use level 3 throughout the remainder of the treatment regime. Following the treatment regiment the participant showed marked improvement in static unperturbed tandem stance with eyes open on a hard surface (pre = 22.2 sec., post = 27 sec.) and on a soft surface (pre = 2.2 sec., post = 15.6 sec.). In addition, the participant displayed a notable improvement with static unperturbed tandem stance with eyes closed on a hard surface (pre = 9.6 sec., post = 13.4 sec.). See Table 1 for a complete report of mean pre and post treatment results. See Figure 1 and Figure 2 for a graph of mean pre and post treatment results.

During baseline perturbed two-legged stance on a soft surface with eyes closed, stepping responses were elicited. Following treatment, no stepping responses were elicited under the above condition, although one-stepping response was elicited with two-legged stance on a soft surface with eyes open.

The FRT indicated that the participant was at a risk for falling (with an average reach length of 9.5 inches) at baseline and after training (with an average reach length of 10.83 inches). It should be noted that although the participant is still at risk for falling, according to the FRT, the participant did improve her reach distance by 1.33 inches following the treatment regime. For a complete list of pre and post-training FRT trial reaches See Table 2. See Figure 3 for pre and post training graphed results of the mean FRT results.

The "Tinetti Gait and Balance Assessment" indicated the participant was at risk for falling, but not a high risk, at baseline with a score of 23/28. Post-treatment assessment indicated that the participant was no longer at a risk for falling with a score of 27/28. See Figure 4 for a graph of pre and post treatment results. The participant reduced her base of support, was steady when nudged, right and left step lengths were equal, and her heels almost touch while walking as compared to pre-training evaluation.

The participant did not show any balance deficits with the overhead throw of the physioball. No stepping strategies were elicited during pre or post-testing.

Discussion

Upon evaluation of the participant, it was evident to the researchers that the participant had impaired balance. Post–treatment, the participant exhibited notable improvement in static unperturbed stance for all conditions. No stepping responses were elicited during perturbed conditions with the exception of a stepping response during two-legged stance on a soft surface with eyes open. As shown by previous research, BAPS training increases proprioception feedback, strength, postural control, and balance; therefore, an improvement in perturbed and unperturbed static stance (Soderberg et. Al, 1991).

An improvement in the FRT was also noted, although the participant was still considered at risk for falling. The participant's reach may have been limited secondary to a high center of gravity; therefore, causing premature loss of balance. Many women in this age group tend to have a higher center of gravity due to a change in the distribution of body mass to the upper body. According to current standards, women 41-69 years of age should be able to reach 13.8 inches in order to be considered at no risk for falls (Duncan et al, 1990).

According to the "Tinetti", the participant was no longer at risk for falls post-treatment. At post-treatment assessment, the participant only lost 1 point out of a possible 28 secondary to using the arms of the chair while sitting down. Had verbal cues been give to the participant, she would have received a perfect score. It should be noted that the participant had no difficulty sitting down in a chair without arms as observed throughout the treatment regime. The "Tinetti" is an extremely important tool for physical therapists because of its familiarity and acceptance in functional assessments. It is a widely accepted tool by health care professionals for determining the probability of a fall (Lewis, 1993).

The participant appeared to have no difficulty with exercises 1 (standing on the BAPS board on one foot while moving the board in an anterior-posterior direction), 2 (standing on the BAPS board on one foot while moving the board in a side to side direction), and 4 (standing on the BAPS board with one foot while moving the board in a circular pattern while returning to the center after each anterior, posterior, left, and right motion). She complained of some difficulty with exercise 3 (completing both exercises 1 and 2 with the participant's knee flexed) which may be explained by weakness in the lower extremities secondary to the sedentary lifestyle of the participant.

In hindsight, this study could have benefited from using a larger, more diverse, older adult population because a larger sample size would enhance the validity of the results. The study would be more relevant if an older adult population was used to determine if BAPS board training is appropriate. The 63-year-old in our study made improvements in balance so it is proposed that a more impaired elderly population may make even greater improvements.

The study could have also benefited from utilizing an ABA format that would have included an additional assessment two or more weeks post-intervention. This format would enable the researchers to determine the long-term effects of the treatment regime.

As hypothesized, BAPS training is an effective method for balance training and decreasing the risk of falls as demonstrated by the current study, although further research needs to be conducted concerning balance in the older adult population. Further research should consider the above suggestions along with the possible inclusion of a control group, a BAPS training group, a BAPS training and exercise group, and/or an exercise group in order to compare their effects and to determine the best method of treatment in balance training in the older adult population.

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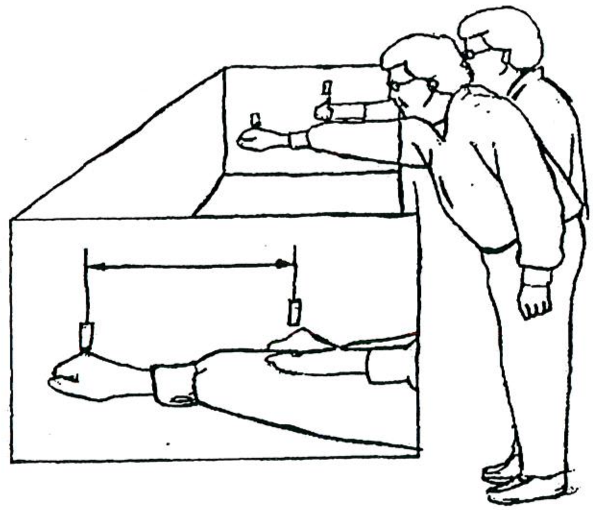
Appendix A



Instructions:

- Attach a yardstick to the wall at the level of the patient's shoulder.
- The patient stands with their shoulder at 0 on the yardstick.
- The patient stands with their feet shoulder length apart, and with their arm flexed to 90 degrees.
- The patient reaches with their hand in a fist.
- Without moving their feet, the patient reaches as far forward as possible, while maintaining their balance.
- The patient receives 3 trials, which are then averaged together.
- The distance reached is compared to age related norms.

Functional Reach Test Norms:

Norms	Men in inches	Women in inches
20 – 40 years	16.7 + 1.9	14.6 + 2.2
41 – 69 years	14.9 + 2.2	13.8 + 2.2
70 – 87 years	13.2 + 1.6	10.5 + 3.5

Duncan, P. W., Weiner, D. K., Chandler, J., & Sstudenski, S. (1990). Functional reach: a new clinical measure of balance. Journal of Gerontology, 45 (6), M192-M197.

Appendix B

Tinetti Gait and Balance Assessment Test

Tinetti Assessment Tool: Balance Tests

Initial Instructions: Participant is seated in a chair. The following maneuvers are tested.

1) **Sitting Balance**

Leans or slides in chair = 0
Steady, safe = 1 _____

2) **Arises**

Unable without help = 0
Able, uses arms to help = 1
Able, without using arms = 2 _____

3) **Attempts to arise**

Unable without help=0
Able, requires > 1 attempt = 1
Able to arise, 1 attempt = 2 _____

4) **Immediate standing balance** (first 5 seconds)

Unsteady (swaggers, moves feet, trunk)= 0
Steady but uses walker or other support = 1
Steady without walker or other support = 2 _____

5) **Standing Balance**

Unsteady = 1
Steady but wide stance (medial heels > 4" apart)
And uses cane or other support = 1
Narrow stance without support = 2 _____

6) **Nudged** (participant at maximum position with feet as close together as possible, examiner pushes lightly on the participants sternum with palm of hand 3 times).

Begins to fall = 0
Staggers, grabs, catches self = 1
Steady = 2 _____

7) **Eyes Closed** (at maximum position #6)

Unsteady = 0
Steady =1 _____

8) **Turning 360 degrees**

Discontinuous steps =0
Continuous steps = 1
Unsteady (grabs, staggers) = 0
Steady = 1 _____

9) **Sitting down**

Unsafe (misjudged distance, falls into chair) = 0
Uses arms or not a smooth motion = 1
Safe smooth motion = 2 _____

Balance Score: _____ / 16

Tinetti Assessment Tool: Gait Tests

Initial Instructions: Participant stands with examiner, walks down the hallway or across the room, first at usual pace, than back to rapid, but safe pace (using the usual walking aids).

10) **Initiation of Gait** (Immediately after told to go)

Any hesitancy or multiple attempts to start = 0
No hesitancy = 1 _____

11) **Step length and Height**

A. Right swing foot

Does not pass left stance foot with step = 0
Passes left stance foot = 1
Right foot does not clear floor completely with step = 0
Right foot completely clears floor = 1 _____

B. Left swing foot

Does not pass right stance foot with step = 0
Passes right stance foot = 1
Left foot does not clear floor completely with step = 0
Left foot completely clears floor = 1 _____

12) **Step Symmetry**

Right and left step length not equal (estimate) = 0
Right and left step appear equal = 1 _____

13) **Step continuity**

Stopping or discontinuous steps = 0
Steps appear continuous = 1 _____

14) **Path** (estimated in relation to floor tiles, 12-inch in diameter; observe excursion of 1 foot over about 10 feet of the course.)

Marked deviation = 0
Mild / moderate deviation or uses walking aid = 1
Straight without walking aid = 2 _____

15) **Trunk**

Marked sway or uses walking aid = 0
No sway but flexion of knees or back or spread arms out while walking = 1
No sway, no flexion, no use of arms, and no use of a walking aid = 2 _____

16) **Walking Stance**

Heels apart = 0
Heels almost touching while walking = 1 _____

Gait Score: ____/12

Balance + Gait Score: ___/28

Score below 19 = high risk of falling
Score 19 – 24 = greater risk of falling but not a high risk

*** Source: The Journal of the American Geriatrics Society**

Table 1

Mean Pre and Post Balance Assessment Results

Testing Condition	Pre-Training (Seconds)		Post -Training (Seconds)	
	Surface		Surface	
	Hard	Soft	Hard	Soft
Static unperturbed two-legged stance, eyes open	30	30	30	30
Static unperturbed two-legged stance, eyes closed	30	30	30	30
Static unperturbed one-legged stance, eyes open	3.4	1.8	5.4	3.4
Static unperturbed one-legged stance, eyes closed	2	2.2	3.4	2.6
Static unperturbed tandem stance, eyes open	22.2	2.2	27	15.6
Static unperturbed tandem stance, eyes closed	9.6	2	13.4	3.4

Table 2

Pre and Post Training Functional Test Results

Trial #	Pre-Training (Inches)	Post-Training (Inches)
1	8	10
2	10.5	11
3	10	11.5
Average	9.5	10.83

Figure Caption Page

Figure 1: Mean Pre and Post Balance Assessments on a Soft Surface

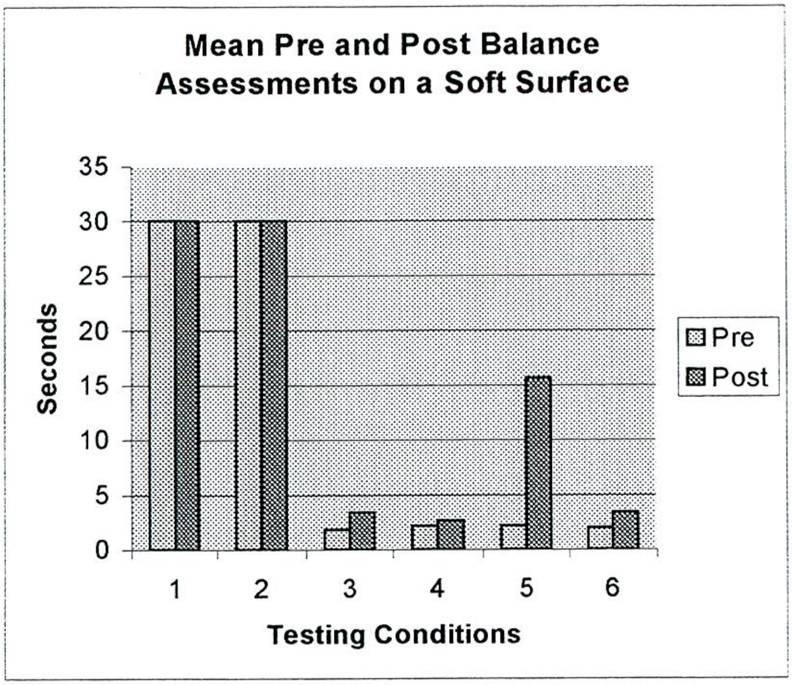
1= Static unperturbed two-legged stance, eyes open, 2= Static unperturbed two-legged stance with eyes closed, 3= Static unperturbed one-legged stance, eyes open, 4= Static unperturbed one-legged stance, eyes closed, 5= Static unperturbed tandem stance, eyes open, 6= Static unperturbed tandem stance eyes closed.

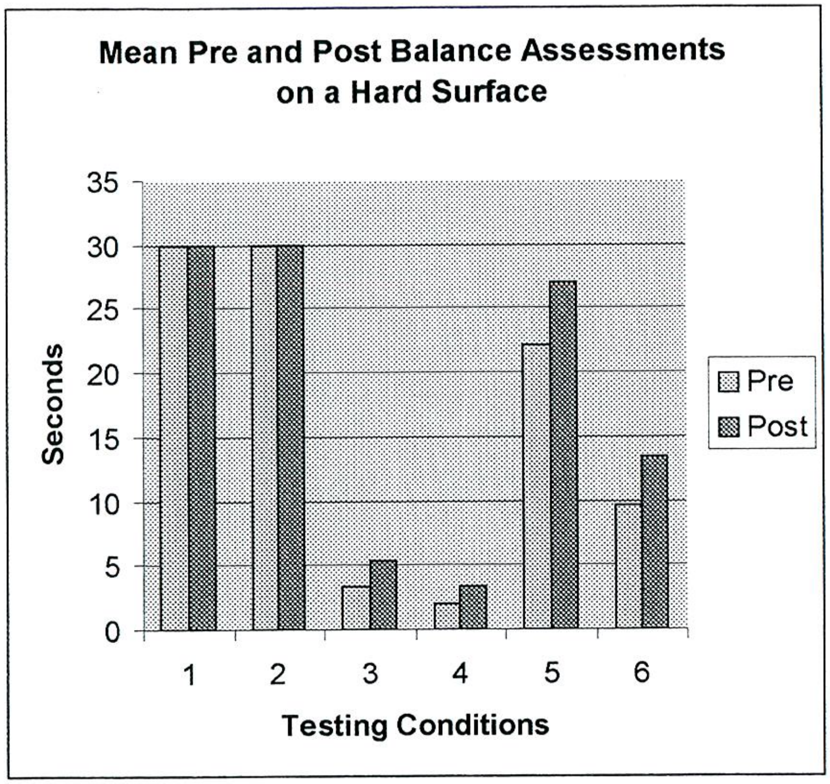
Figure 2: Mean Pre and Post Balance Assessments on a Hard Surface

1= Static unperturbed two-legged stance, eyes open, 2= Static unperturbed two-legged stance with eyes closed, 3= Static unperturbed one-legged stance, eyes open, 4= Static unperturbed one-legged stance, eyes closed, 5= Static unperturbed tandem stance, eyes open, 6= Static unperturbed tandem stance eyes closed.

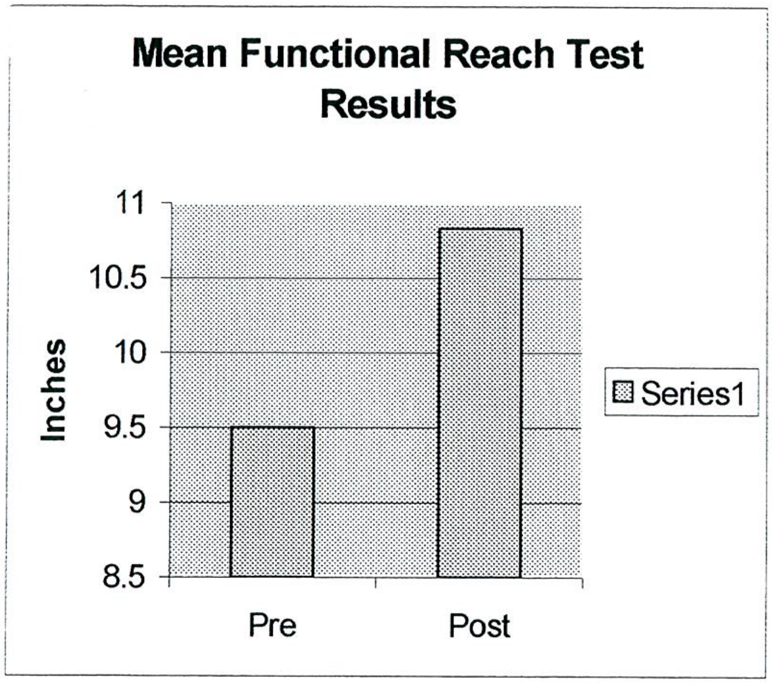
Figure 3: Mean Functional Reach Test Results

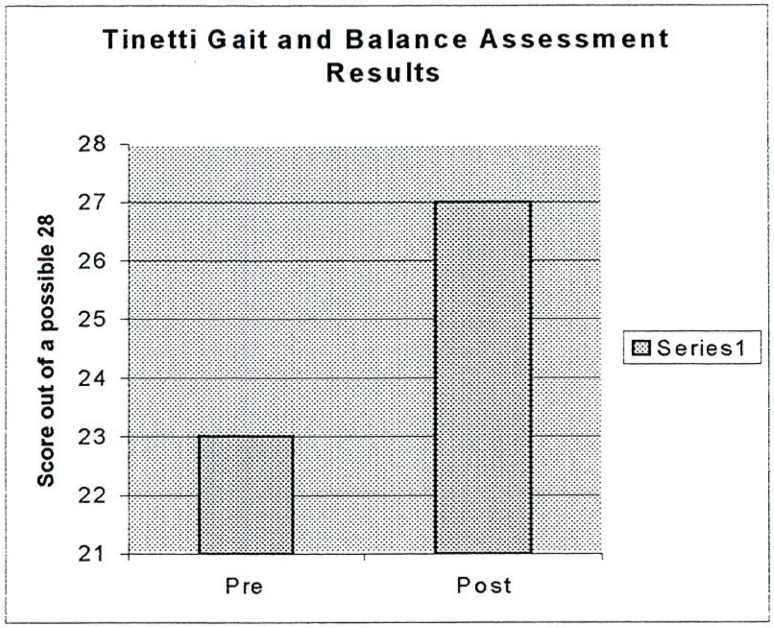
Figure 4: Tinetti Gait and Balance Assessment Results


Mean Pre and Post Balance
Assessments on a Soft Surface
Seconds
35
30
25
20
15
10
5
0
1
2
3
4
5
6
Testing Conditions
Pre
Post



Mean Pre and Post Balance Assessments
on a Hard Surface
Seconds
35
30
25
20
15
10
5
0
1
2
3
4
5
6
Testing Conditions
Pre
Post


Mean Functional Reach Test
Results
Inches
11
10.5
10
9.5
9
8.5
Pre
Post
Series1


Tinetti Gait and Balance Assessment Results
Score out of a possible 28
28
27
26
25
24
23
22
21
Pre
Post
Series1

January 14, 2000

Kelly Ogden
12 Colehammer Avenue
Troy, New York 12180

Dear Kelly:

RE: IRB PPROPOSAL #121-99

The Institutional Review Board has reviewed your application, and with the additional information you provided, has approved your project. Good luck with your research.

There are a few minor changes that need to be made to your cover letter and informed consent form. Please see the attached.

The Sage IRB Committee has approved your project for one year from the date of this letter. Should your research extend beyond one year, you must reapply to the Institutional Review Board.

I hope that you will consider sharing the results of your work at the Sage Graduate School Research Symposium on April 29, 2000. Let me know if you have any questions or need further information

Sincerely,

Connell G. Frazer, Ed.D
Dean, Sage Graduate School

CGF/ew

Cc: L. Zacharewicz

IRB3'99/ogden.jan14'00