IMPROVING BALANCE BY EDUCATION, WALKING AND THE WII™

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Abstract

Purpose: To determine whether balance education, walking and Wii™ bowling improve balance and reduce the risk of falls in older adults.

Background/Significance: Fall related injuries are the leading cause of death due to injuries in Americans over age 65. Falls are linked to impaired balance and impaired gait.

Subjects: Ten participants, sixty-five years and older who were at a risk for falls or who have fallen, were recruited from a senior center and retirement community.

Methods and Materials: Each session consisted of 20 minutes of walking, 20 minutes of balance education and 20 minutes of Wii™ bowling twice a week for eight weeks. Pretest, posttest and a follow-up consisted of the Berg Balance Scale, the Timed “Up & Go”, and the Activities-specific Balance Confidence Scale as well as verbal report if the subject had fallen.

Analyses: The Wilcoxon signed-rank test was used to examine statistical significance. Minimal detectable change or smallest detectable difference scores were used to examine clinical significance.

Results: The results were statistically significant for The Berg Balance Scale and the Timed "Up & Go" from pre-test to post-test, which were maintained at follow-up. Clinical significance was seen for the Berg Balance Scale but not for the Timed “Up & Go” or the Activities-Specific Balance Confidence Scale. There were no reported falls at follow-up.

Conclusions: A multi-factorial balance program including walking, education, and Wii™ bowling may be an effective intervention to improve balance and decrease fall risk for older adults.

Funding Source: Sage Internal Grant

Key Words: Wii™, falls, older adults
Introduction:

Falls are the leading cause of a death related injury in adults over 65 years of age.\textsuperscript{1} Each year 30-40\% of adults over 65 years old fall at least once per year.\textsuperscript{1} Falls result in fractures, activity avoidance, health decline, disability, fear of falling and hospitalization.\textsuperscript{2} Of those who fall, 20-30\% suffer moderate to severe injuries such as hip fractures, head trauma and lacerations. These injuries decrease function and increase the risk of death.\textsuperscript{1} Injuries from falls can lead to sedentary behavior, fear of falling, lower quality of life and impaired function.\textsuperscript{3}

Adults 65 years and older can be identified if they are at risk for falls. A previous fall, and age are the two most common risk factors for falls.\textsuperscript{4} Other risk factors for falls in older adults include limited mobility, impaired cognition, visual deficits, muscle weakness, impaired balance and gait deficits.\textsuperscript{5} It has been shown that older adults who are taking four or more medications have a significantly increased fall risk.\textsuperscript{5} The greater the number of risk factors an individual has the higher the likelihood of a fall. Tools that are commonly used to identify fall risk include the timed “Up-and-Go” test (TUG), the Functional Reach Test, the Performance Oriented Mobility Assessment, and the Berg Balance Scale (BBS).\textsuperscript{4}

Several studies have suggested prevention programs as a possible way of reducing fall risk in older adults. Multi-factorial fall prevention programs have been noted as the most effective fall prevention strategies for this population. The first and most important step in a fall prevention program is the identification of those who are at risk for a fall.\textsuperscript{6} These programs are aimed at identifying individual risk factors along with exercise, balance training and educational programs. Studies containing multi-factorial components have been shown to decrease the fall risk for individuals in their homes as well as community
Exercise programs that include walking and balance training are important fall prevention strategies for older adults. A meta-analysis of ten studies assessing older adults at risk for falls showed that both exercise and a multi-factorial intervention program were successful in decreasing falls. The multi-factorial intervention however, was 5 times more effective than exercise alone. Clemson et al. conducted a study looking at the effectiveness of a multifaceted community-based program in reducing falls in at-risk older adults. The program consisted of increasing lower extremity strength and balance, improving safety in the home and community, encouraging regular visual screenings and medication reviews. The intervention group showed a 31% reduction in falls, concluding that a multifaceted program is effective for community dwelling older adults. The impact of falls on patients and the healthcare system is large. It has been shown that decreasing the incidence of falls increases socialization and functioning in older adults who have previously fallen or have a fear of falling.

Many fall prevention programs contain an educational component. Education and environmental modifications show little evidence alone but are recommended as part of a comprehensive fall prevention program to reduce the risk of falls in older adults. The educational portion of fall prevention programs contains topics such as home safety, fall risk and prevention, appropriate footwear, medication usage, and gait. Other potential topics include nutrition, exercise adherence, proper use of assistive devices and fear of falling. A trusting relationship between a health care provider and an older adult is necessary for education to be effective. This is especially true when discussing environmental modifications because this topic may threaten one’s identity and self-esteem.
Environmental modifications are an important aspect of a fall prevention program because environmental hazards may increase the risk for falls in older adults. Environmental modifications are best targeted at older adults with a history of a fall and limited mobility. Stevens et al. evaluated the effect of an intervention in reducing fall hazards in the home of older adults. All homes had at least one fall hazard, with floor rugs and mats being the most prevalent. The results showed a significant reduction in the mean number of hazards per home. Environmental modifications aim to identify and eliminate the environmental hazards while increasing the safety features. Modifications include non-slip bath mats, increased lighting, raised toilet seats and grab bars in the bathtub and shower.

Involving older adults in their plan of care and understanding their thoughts on fall risk and fear of falling can provide a foundation for education. Older adults may not understand the reason for their fall and this contributes to their fear of falling. The percentage of older adults who acknowledge a fear of falling ranges from 40%-73% in those who had experienced a fall and 20%-46% of those who had not experienced a fall. A study by Arfken et al. found that the participants who reported being very fearful of falling were most likely to have a lower quality of life. Of those participants who were very fearful, 25% had scores on the Geriatric Depression Scale suggesting a diagnosis of depression. Friedman et al. suggest that fear of falling is not merely an acute outcome of a fall. It is likely a combination of being at risk for a fall and the negative consequences associated with experiencing a fall. If a fear of falling develops and results in limited activity, it is likely to persist whether the individual has experienced a fall or not. Older adults who limit activities secondary to a fear of falling are at a high risk for falling. Falls have negative connotations for older adults including risk to their personal and social identities. This negative perception
of falling contributes to a reluctance to admit to a fear of falling and the need to seek out fall
preventing modifications.\textsuperscript{21}

The ability to maintain balance while walking is a fundamental skill that is often
compromised in older adults.\textsuperscript{22} Shkuratova et al. conducted a study to determine the effects
of aging on balance control during walking.\textsuperscript{22} The results showed that when balance was
challenged by changing walking speed from preferred to fast walking, older adults did not
increase their stride length or speed to the same extent as young adults. It was concluded that
this was a strategy to maintain balance and older adults often opt to be more cautious.
Walking has been incorporated into many fall prevention programs. Walking is popular,
suitable for older adults and readily accessible.\textsuperscript{23} Studies have shown that walking has many
health benefits such as reducing the risk of developing cardiovascular disease, slowing
cognitive decline, and decreasing anxiety.\textsuperscript{24,25} A walking program can reduce the risk of falls
by increasing lower extremity strength, endurance and improving ambulatory function.\textsuperscript{23}
Marsh et al. conducted a study to determine whether treadmill walking was comparable to
overground walking for the parameters of gait characteristics, effects on physical function
and level of enjoyment.\textsuperscript{26} The study concluded that treadmill walking resulted in a slower
walking velocity, less positive attitude toward the program and was shown to be less
enjoyable than the over ground walking. The results suggest older adults may adhere better to
an over ground walking program than a treadmill walking program.

Recently, the Nintendo Wii \textsuperscript{TM} has gained popularity with healthcare professionals as
a rehabilitation tool. When used in conjunction with typical physical therapy interventions
the Nintendo Wii \textsuperscript{TM} has been shown to improve balance. Clark et al. conducted a study
looking at the effects of Wii \textsuperscript{TM} bowling on the balance of an 89 year old female.\textsuperscript{27} After 6
one hour intervention sessions, the patient demonstrated improvements in the Berg Balance Scale (BBS) score, the Timed Up and Go (TUG) and the Activities-Specific Balance Scale (ABC). A study conducted by Agmon et al. looked at the Nintendo Wii Fit™ as a means to improve balance among older adults with balance impairments. At the conclusion of the three month training program participants showed improvements in the BBS score and increased gait velocity. The study suggests that the Wii Fit™ is safe and practical for older adults. Williams et al. saw improvements in the BBS at 4 weeks in the Wii Fit™ intervention group when looking at the feasibility of the Wii Fit™ with community dwelling older adults. Daniels conducted a study in which a control group, chair exercise group and a Wii Fit™ group were compared based on physical performance outcomes. Both the chair exercise group and the Wii Fit™ group showed improvements on several measures of a senior fitness test. In addition, the Wii Fit™ group showed improvements on their reported balance confidence and caloric expenditure.

A study by Bateni in 2012 was the first of its kind to compare balance changes due to a program of Wii Fit™ and physical therapy interventions combined, Wii Fit™ alone, and physical therapy interventions alone. The physical therapy intervention group and the Wii Fit™ physical therapy combination group showed greater improvements in the BBS scores than the Wii Fit™ group alone. The results suggest that an intervention program consisting of Wii Fit™ training along with physical therapy training improves balance greater than Wii Fit™ training alone. In addition to improvements in balance, the Wii Fit™ has been shown to provide more enjoyment than traditional balance programs. A recent case report studied the use of the Wii™ and an adaptive snowboard to determine if it would improve a subject’s dynamic balance. The authors saw improvement in every outcome measure including gait
velocity, left/right stride length, the Sensory Organization Test for condition 3, the Four Square Step Test, and the Star Balance Excursion Test. It was concluded that a virtual reality snowboard can be used to gain improvements in balance and gait, while being enjoyable.

Brumels et al. compared a traditional balance program with a video game based balance program. The video game based balance program not only significantly reduced anterior and posterior sway but resulted in higher scores for patient engagement and enjoyment. A study by Rosenberg et al. examined the effects of a Wii™ sports intervention on older adults with depression. The results suggest that game play with peers in a group setting may have beneficial effects on depression symptoms, cognitive performance and quality of life. The Wii™ has been shown to positively affect well-being, mood, quality of life and social connections. Other studies have concluded that the Wii™ is a beneficial tool for use in the rehabilitation of patients with cerebral palsy and patients recovering from a stroke. One case report used a Wii™ sports training program to train a patient with cerebral palsy over 11 sessions. Improvements in postural control, functional mobility and visual-perceptual processing were measured after the training. It has been shown that overall the Nintendo Wii™ is a beneficial tool to be included in a fall prevention program. Hurkman et al. determined that it was efficient for patients with chronic stroke to play the Wii™ at a moderate intensity in order to maintain and improve health.

Studies looking at the Wii™ and its contribution to a fall prevention program in older adults have found clinically significant improvements on the BBS and improvements in quality of life. Among intervention programs that aim to reduce falls, a multifactorial program is found to be the most effective. Multifactorial interventions target the risk factors for falls. Common components of a multifactorial program often include exercise, education,
environmental modifications, medical management and medication adjustments. The aim of this study was to determine whether balance education, walking and Wii™ bowling improve balance and reduce the risk of falls in older adults.

**Methodology**

**Research Design**

The research question was whether using Nintendo Wii™ Bowling, performing a walking program and fall prevention education impacts the balance, fall risk, and balance confidence of a group of older adults as measured by the BBS, TUG and ABC. We hypothesized that after an 8 week program of walking, education and Wii™ Bowling that the TUG, BBS and ABC scale scores would show improvement for our 10 participants. This was a quasi-experimental, pretest–posttest design. The intervention phase consisted of each subject participating in 20 minutes of walking, patient education, and Wii™ Bowling, for two separate one hour sessions per week over an 8 consecutive week period. Follow-up was conducted either 12 weeks or 18 weeks after the conclusion of the 8 week study. Participants and researchers were not blinded in this study. The study was approved by the Sage College’s Institutional Review Board in Troy, NY.

**Participants**

Participants consisted of a sample of convenience of the older adult population residing at a senior apartment complex and those who frequented a senior center, both located in Troy New York. To recruit participants for this study, we obtained a convenience sample from the facility via verbal communication, postings and promotional flyers. The procedures were explained to all subjects and an informed consent form was signed prior to
the start of the study. Subjects were free to withdraw from the study at any time by simply notifying a researcher.

**Inclusion Criteria**

Individuals qualified for this study if they were 65 years of age or older and at risk for falls according to the BBS. People were considered at risk for falls if they had scores less than 50/56. Participants also had to be able to walk 20 feet independently without an assistive device. Exclusion criteria for this study included having a resting blood pressure reading over 160/100 mmHg and if subjects required physical assistance for standing and walking. Individuals were also excluded if they had unstable health, decreased mobility, or an inability to attend intervention sessions on a consistent basis. Please refer to table 1 for detailed participant demographic information.

**Outcome Measures**

The BBS, TUG, and ABC scale measures were given prior to the intervention to establish baseline data, then given post intervention and at follow-up either at 12 or 18 weeks to determine changes made during the interventions. The participants were first given the BBS to determine if they met the inclusion criteria of our study (BBS score <50/56). If the inclusion criterion was met they were then given the TUG and ABC scale measures.

The BBS is the gold standard for measuring balance. The scale consists of 14 activities that receive a score between 0-4 based on the participant’s ability to complete the task. A score of 0 indicates that the person is unable to perform the activity, while a score of 4 indicates that the person performs the activity independently. To calculate a total score, all 14 items are added together for a possible maximum 56 points. A score of 45 or greater has been shown to be a good indicator for identifying people who are not at risk for falls, though
conversely, those with scores below 45 are not necessarily at an increased risk for falls.\textsuperscript{39} Additionally, for participants whose score was between 46-54, there is a 6\% decrease in fall risk for each 1 point gain in BBS score.\textsuperscript{40}

Participants in our study were not allowed to use an assistive device during this assessment. Examples of activities performed on the BBS include transfers between chairs, static standing balance activities such as standing on one foot or standing with eyes closed, and dynamic standing balance such as turning 360 degrees within 5 seconds. Mackintosh et al. indicated that there were high validity and reliability ratings of the BBS in older adult populations.\textsuperscript{41} The test-retest reliability for the BBS is .98, the concurrent validity value is .76, the sensitivity value is 64\% and the specificity value is 90\%.\textsuperscript{41,42} The Minimal Detectable Change (MDC) for the BBS is 5 points.\textsuperscript{38}

An additional measure of balance is the TUG, which measures active performance of walking, transitioning such as sit/stand and turning.\textsuperscript{43} The researcher uses a stopwatch to time how long it takes the participant to rise from a chair, walk 3 meters, turn around, walk back to the chair and sit back down. The 3 meter position is marked with a piece of visible tape on the floor and participant is asked to walk to that point and return to the chair as quickly and safely as they can. Participants were not allowed to use an assistive device for this test. A TUG time of greater than or equal to 14 seconds, regardless of age, places an individual at a possible risk for falls. This test has an intratester and intertester reliability of .99, and a construct validity value of .76.\textsuperscript{42} Posiadlo et al. also describe the TUG as having content validity, concurrent validity and is acceptable for use as a screening or descriptive tool.\textsuperscript{43} The TUG also has a sensitivity and specificity of 87\% when identifying fall risk in community dwelling older adults.\textsuperscript{13} The SDD (smallest detectable difference) for the TUG is
1.63s as shown in a population of Parkinson’s patients with mild to moderate severity of disease.\textsuperscript{44}

Our third measure, the ABC Scale, has 16 self-reported items. The participant rates their confidence in performing various home and community activities using a scale of 0-100. A score of 0 is equal to the participant having no confidence that they can safely do the activity without falling and a score of 100 means that they are completely confident that they can safely perform the activity. The total score is the average of the 16 individual scores. The test retest reliability value for the ABC scale is .92.\textsuperscript{45} The ABC also has a high correlation to TUG scores which indicates that there is a relationship between functional mobility and the confidence of the individual.\textsuperscript{46} The MDC value for the ABC is 18\%.\textsuperscript{40}

**Intervention**

The program consisted of an 8 week balance program conducted at both the senior apartment complex and the senior center. The program was performed twice a week and included education, Nintendo Wii\textsuperscript{TM} bowling and a walking program, each performed for 20 minutes.

The educational component included a presentation and discussion on the causes of falls and identifying solutions to reduce fall risk throughout the 8 week program. Topics that were discussed included balance safety in the home, community, and environment. Proper footwear was discussed as was awareness of medication side effects that could possibly affect balance. Diet and nutrition and the importance of proper hydration were also discussed, food and beverage examples and samples were provided during these sessions. All participants were given a night light, a reacher and gift cards to a local grocery store.
The balance intervention engaged participants in Wii™ bowling that simulated the TUG test as described by Clark. The participants stood up from a chair, walked 3 meters, bowled, turned and walked back to the chair and sat down. The subjects repeated this sequence every time they bowled. Subjects were potentially at risk for falling during the balance testing and balance interventions and therefore were guarded by a physical therapy student supervised by a physical therapist. Participants were not allowed to use an assistive device for the bowling intervention.

The walking program was performed on an even surface at the subject’s own pace. The subjects walked throughout the main apartment buildings hallways at the senior residence or around the ballroom located in the senior center with 100 foot increments measured out. Each time that the subject walked 100 feet a lap was recorded. Researchers walked along with the participants for safety as well as motivation. Participants were able to take breaks when needed and were allowed to use an assistive device during this portion of the intervention.

Participants were screened again at the end of the 8 weeks using the same 3 outcome measures to see if improvements were made. Follow-up assessments were performed at 12 weeks following the end of the intervention at the senior apartment complex and 18 weeks at the senior center, using the same 3 outcome measures to assess for carryover.

**Data Analysis**

In order to examine changes in balance and balance confidence in our elderly participants we compared their scores from pretest to posttest, posttest to follow-up, and pretest to follow-up. We used Version 19 of SPSS to analyze the data and the Wilcoxon signed-rank test to determine statistical significance. We chose this test because of the small
number of participants (n=10). Results were also compared to established Minimal Detectable Change (MDC) scores for the BBS: 5 points and ABC: 18% as well as the Smallest Detectable Difference (SDD) for the TUG: 1.63 seconds to determine clinical significance.

**Results**

Ten participants, six females and four males, with an average age of 84 years (79-92 years), were recruited from a senior center (3 participants) and retirement community (7 participants) in Troy, NY. Follow-up testing was performed on the first three participants 18 weeks after completing the study using the same three outcome measures to assess carryover. Of the 3 participants, the 3rd participant was unable to attend the follow-up session due to a recent hospitalization. Follow-up testing was performed on the remaining 7 participants from the retirement community 12 weeks after finishing the study. Participant 9 and 10 did not attend the follow-up. Data from all 10 participants were included in the study and the data was analyzed as a group to determine statistical and clinical significance when comparing pretest to posttest, posttest to follow up, and pretest to follow-up.

**Walking**

During the walking portion of our study, a 100 foot circle course was measured out for the first three participants at the Senior Center. The participants were instructed to walk around the course as many times as they could in 20 minutes, taking breaks when needed. The number of laps each participant completed along with the number of rest breaks were recorded during each session. All three participants improved their walking distance from the first day of the intervention to the last day of the intervention. Participant 1 improved from 24 laps to 39 laps. Participant 1 also required 2 rest breaks during the first day
and none during the final day. Participant 2 increased from 22 laps to 28 laps. Participant 3 improved from 8 laps to 16 laps. Participant 3 improved from requiring 3 rest breaks during the first day to only requiring one rest break on the last day.

At the retirement community, a 100 foot course was measured out in a hallway. Unlike the previous group, the participants did not appear to make improvements on the number of laps completed when comparing the first day of the intervention to the last day of the intervention. Participant 4 and 10 had both been walking regularly prior to the study and they both maintained a steady number of laps throughout the study. Participant 5 missed the last five sessions due to illness; therefore it was difficult to assess any improvement. Participant 6 needed to learn to pace himself and take rests when needed. Participant 6 pushed himself to walk 8 laps during the first session but he let us know that it was too much for him stating that he “slept the rest of the day”. During the remaining sessions he was encouraged to take rests when needed and by the last session he was observed to have decreased shortness of breath while walking. By the end of the study he was able to walk 8 laps without feeling exhausted afterwards. Participant 7 improved during the walking initially requiring 6 rest breaks to complete 3 laps to only needing 4 rest breaks to complete 3 laps. Participant 9 improved from 6 laps to 8 laps during the study.

**Berg Balance Scale**

The results of all ten participants as a group were statistically significant on the BBS from pretest to posttest (p=.006) and pretest to follow-up (p=0.022). Subjects also maintained this improvement from posttest to follow up (p=0.500). The MDC value for the BBS is 5 points. All ten participants as a group also showed clinical significance from pretest to posttest. At pretest the group had a mean score of 41.9/56 and at posttest the mean was
48.2/56 (Figure 1) which is above the cut-off score of 45/56. All participants maintained this clinical significance from pretest to follow-up with a mean of 48.3/56. Shumway-Cook et al stated a 1-point increase in the BBS indicates a 6% decrease in fall risk for individuals with BBS scores between 46/56 and 54/56. As a group, the participants decreased their fall risk by an average of 37.8%.

**Timed Up and Go**

All ten participants as a group made a statistically significant change on the TUG from pretest to posttest (p=0.037) and from pretest to follow up (p=0.032). The subjects maintained this improvement from posttest to follow up (p=0.088). The SDD value for the TUG is a difference of 1.63 seconds. As a group all ten participants decreased the time it took them to complete the TUG with improvement averaging 3.32 seconds. From pretest to follow-up the participants improved on the TUG by an average of 2.65 seconds. The participants had an increase in time at follow-up compared to posttest, but according to the SDD value this was not considered a significant decline. (Figure 2).

Individually, eight out of the ten participants improved their TUG from pre-test to post-test. Five out of the ten participants maintained an improved score from pre-test to follow-up. Of the five that did not maintain improvements, three of them did not attend the follow-up testing.

**Activities-specific Balance Confidence Scale**

All ten participants as a group increased their ABC score but it was not found to be statistically significant from pre-test to post-test (p=0.256) pre-test to follow-up (p=0.368), or post-test to follow up (p= 0.087). The participants improved their score by an average of 2.7% from pre-test to post-test. Although not at the level of the post-test, the average scores
at follow-up were increased by 0.26% from pre-test. The change from pre-test to post-test
and pre-test to follow-up was not a clinically significant change according to the MDC value
which is 18%.45 (Figure 3)

Falls

At follow-up eight of the 10 participants were tested, each of them reported no falls
since completing the 8 week intervention. The 3 participants who had fallen within the 6
months prior to the study had an average initial score of 39 on the BBS which was 4 points
lower than the non-fallers group, which would be expected. At follow-up the falls group had
an average BBS score of 49.33 which was 1.8 points higher than the non-fallers group. All
members of the falls group met the BBS MDC value of 5 at follow-up. Refer to Table 2 for a
compilation of our results.

Discussion

The balance improvements seen in this study can be contributed to the multi-factorial
interventions used. Fall prevention programs containing multi-factorial components have
been shown to decrease fall risk for older adults, both in the home and in the
community.6,7,8,9,10 A multi-factorial intervention program was shown to be 5 times more
effective in reducing fall risk than exercise alone.8 This study included WiiTM bowling,
walking and education. The results are consistent with previous studies in that a fall
prevention program with multi-factorial components is effective in reducing the risk of falls.
This study provides a simple, practical and cost-effective intervention for health care
practitioners to use with older adults to decrease fall risk. It is a fun and motivating way to
improve balance and can be done in any community or clinical setting.
Clemson et al. showed that an intervention that included group education regarding fall prevention strategies and home safety, called the Stepping On Program, was associated with a significant reduction in the rate of falls among participants. They discussed home safety strategies, coping behaviors as well as safety strategies in the community. Each session also gave the participants an opportunity to reflect on how their learning from this program was helping them.

The educational component of our study included many of the same educational topics as Clemson’s study. Participants had an opportunity to sit as a small group for 20 minutes at each session to discuss strategies to lessen fall risk. Our topics of discussion included dietary habits, nutrition and medication interactions, home environmental hazards and safety, lighting, footwear, hydration and exercise. Topics were chosen that could be discussed in the context of falls prevention.

York et al., showed that frailer adults participating in a multifactorial program that includes a form of exercise and an educational program 2 or more times per week for 8 weeks or more can improve strength and balance. Similarly, our study included 2 parts to our exercise and educational components each week. At the first session of the week a new wellness or fall risk prevention topic was introduced and discussed. At the second session of the week the participants had an opportunity to review the topic and discuss how they were adopting the information into their personal life and environment. This gave them a chance to share their successes and hear how other participants were making changes as well.

Incorporating an educational component in a falls prevention program helps the participants become more aware of the risk factors that affect elderly populations. It also may
increase their motivation to make lifestyle changes and become more active which could decrease their risk of falls.

In any study there are external factors that can affect the outcome measures. Our study had a large social aspect to it that could have contributed to increased scores on the balance testing. Each session began with a group discussion about fall prevention strategies and home safety where subjects were encouraged to share information about themselves and with each other. Subjects were grouped together to play Wii™ bowling and were partnered with a researcher while performing the walking component of the study. During the Wii™ bowling, other participants and the researchers provided the participants with encouragement and positive reinforcement. While walking, the researcher engaged each participant in conversation.

Adherence to the 8 week program was important in determining the effect of our intervention on balance. Supervised group exercise programs that involve social integration and group fun have been shown to increase exercise adherence in elderly adults. In a study by Stathi et al., adults aged 70 and older participated in a 12 month program that consisted of facility based exercise sessions and home-based exercise sessions each week. There was a higher compliance to the facility based sessions than there was to the home-based sessions and the majority of the participants favored the facility-based group sessions. In a study by Coghill and Cooper the largest de-motivator identified for adherence to a sustained walking program was a lack of external support including support of family, professional support, and walking with a partner. A study by Kirk at al. found that social support and one on one exercise consultation was shown to be more effective in stimulating exercise in participants than a program that only offers an information leaflet on exercise. A
study by Glass et al. found that social and productive activities were just as important in lowering the risk of mortality as physical activity. These social activities included playing cards, games, and participating in social groups and unpaid community work. Enhanced social activities may compliment exercise programs and help to increase the quality and length of life.

Walking has been incorporated into many fall prevention programs because it is readily accessible, suitable for older adults and has many health benefits. The walking program was performed on an even surface at the subject’s own pace. A walking program can reduce the risk of falls by increasing lower extremity strength, endurance and improving ambulatory function. The walking component of our study allowed for 20 minutes in which the participants could walk at a speed of their choosing with rest periods as needed. As a group their walking distances did not change significantly over time, but there were variations in the distances walked and the number of breaks taken at each session over the course of the study. One participant showed an improvement in walking distance when she used a wheeled walker to assist her. Participants received encouragement from a partner (one of the researchers) who walked with them to ensure safety, as well as from the other participants passing them in the hall, which may have contributed to a longer ambulating distance than they would have achieved if they had walked alone.

Even though walking is incorporated in many fall prevention programs the literature has conflicting information about walking programs being included in a multifactorial study such as ours. Tiedemann et al. suggested that a walking program reduces the effectiveness of other interventions in improving balance. It is possible that the walking program itself is not detrimental to the other interventions but that it simply takes away from time that could
have been spent with a strengthening or balance intervention.\textsuperscript{55} However, in a 9-week study which created and followed a ‘walking club’ for residents of an assisted living facility, participants aged 62-99, were found to have improvements in all outcome measures such as mobility, functional reach and activities of daily living. Participants walked a distance of their choosing and participated as often as they felt comfortable.\textsuperscript{56} Even though their study only included walking, it demonstrated improvements in outcome measures that could affect balance and strength.

All ten participants as a group had statistically significant changes on the BBS from pretest to posttest and pretest to follow-up (Figure 1). This was consistent with the results found by Clark et al., Agmon et al. and Williams et al. that used the Nintendo Wii\textsuperscript{TM} to increase balance scores on the BBS.\textsuperscript{27,28,29} In these three studies the participants improved their BBS score following an intervention program that included the use of a Nintendo Wii\textsuperscript{TM}.\textsuperscript{27,28,29} The results of the study were also consistent with the findings by Bateni et al.\textsuperscript{31} This study looked at balance changes due to a program of Wii Fit\textsuperscript{TM}, physical therapy interventions and the combination of Wii Fit\textsuperscript{TM} with physical therapy interventions alone. The physical therapy intervention group and the Wii Fit\textsuperscript{TM} physical therapy combination group showed greater improvements in the BBS scores than the Wii Fit\textsuperscript{TM} group alone.\textsuperscript{31} According to Shumway-Cook participants whose scores were between 46-54 on the BBS had a 6\% decrease in fall risk for each 1 point gain in BBS score.\textsuperscript{40} As a group the participants in our study decreased their fall risk by an average of 37.8\%.

All ten participants as a group made a statistically significant change on the TUG from pretest to posttest and from pretest to follow up. Subjects maintained this improvement from posttest to follow up (Figure 2). These improvements were consistent with the study by
Clark et al that looked at the effects of Wii™ bowling on the balance of an 89 year old female. After 6 one hour intervention sessions, the patient demonstrated improvements on the TUG. As a group, the mean time to complete the TUG was 14.63 seconds. At posttest, the mean time to complete the TUG decreased to 11.32 seconds and at follow-up the TUG time remained lower than the pretest score with a mean of 11.99 seconds. A TUG time of greater than or equal to 14 seconds, regardless of age, places an individual at a possible risk for falls. This indicates that as a group the participants were at a risk for falls prior to the study. At posttest the participants were no longer at a risk for falls and they maintained this improvement at follow-up.

All ten participants as a group were not found to have a statistically significant change on their ABC scale score from pretest to posttest, pretest to follow up, or posttest to follow up (Figure 3). However, five out of the ten participants improved their ABC scale score from pretest to posttest. The ABC scale is a subjective measure which may indicate why the results were not clinically significant. This may not fully represent balance improvements that were gained from performing these interventions because the participants’ perception may be different than their actual balance deficit. Another reason for the lack of a statistically significant change in the ABC scale is the presence of a ceiling effect. Many of the participants’ initial scores were near the maximum possible for the test, and above the fall risk cut-off score. Older adults with balance dysfunction will have a cut off score of 85% or less. A cut off score of 67% or less indicates older adults that are at risk for falls. Eight out of the ten participants had an initial ABC scale score above 67% and three of the ten had an initial ABC score above 85%.
The Wii™ bowling intervention was designed to match the parameters of the TUG. This intervention was chosen so that the participants would be able to practice challenging balance transitions using bowling sequences which consisted of repetitive sit to stand transfers, ambulating to an intended target, swinging an upper extremity of choice, pivoting 180°, ambulating back to the starting position and returning to sitting. The improvements seen in balance can be attributed to this unique bowling sequence.

Each component of the bowling sequence translates into daily life. The sit to stand transfer challenges balance and strengthens the legs. This component carries over to getting up from the dining room table or getting in and out of a car. Ambulation to and from an intended target occurs throughout the day. Examples include walking to the sink, answering the doorbell and walking to get the mail. Various intrinsic and extrinsic factors can challenge our balance during ambulation to and from a target. Intrinsic factors include decreased strength, visual impairments and gait disturbances. Extrinsic factors include surface type, visual and auditory distractions. The majority of participants chose to swing the Wii™ remote during bowling with their dominant upper extremity. This dynamic upper extremity activity challenged static lower extremity balance. Many daily activities require us to move our upper extremities while our lower extremities are planted. These activities include washing the dishes, brushing our teeth and combing our hair. The last component of the sequence was the 180 degree pivot. This dynamic activity challenges balance and incorporates a weight shift, head and trunk rotation, and changing the body’s orientation in space. During the day we use this pivoting motion in response to someone calling our name, if we forgot something on our way out the door and when changing our intended target during ambulation. It was important to include the previous components into our balance
program so that any improvements noted in balance would carry over into the daily lives of our participants.59

The Wii™ bowling activity was fun, challenging and motivating for our participants. This is consistent with previous studies showing that the Wii™ can positively affect mood, well-being, quality of life and social connections.33,34,35 The balance improvements seen in this study support the use of a Wii™ intervention for older adults with balance deficits. Our results are consistent with the results of Agmon et al., Clark et al. and Williams et al.27,28,29

The strengths of this study include the use of specific proven outcome measures, a high attendance rate, the use of specific and detailed protocols for the application of the Wii and walking measures. All researchers were trained on the use and performance of the tests and outcome measures, specific inclusion and exclusion criteria were used, pretest, posttest and follow up data was collected and combined with a previous study, and the program included educational material applicable to everyday life.

Limitations of this study include a small sample size, participants were from two locations in the same city, and some participant attrition occurred. We also did not include a control group, there was no blinding of participants or researchers, and there was no randomization. Other limitations included group homogeneity; participants were all Caucasian with a disproportionate male to female ratio (F>M), medications and participant health conditions (except vitals) were not taken into account when including or excluding participants, participation in outside therapies and/or exercise programs or any other therapeutic interventions were not taken into account and not all eligible residents chose to participate in the study. Also a training/familiarization and/or practice period was not provided to allow participants to become equally familiar with use of the Wii equipment.
Finally, during sampling the inclusion criteria was broadened to allow for a greater number of possible participants.

In a review of exercise and falls prevention, it was determined that a successful fall prevention program needs to contain exercises that challenge balance. Wii\textsuperscript{TM} bowling provided balance challenges in the form of standing from sitting, ambulating, and controlled arm swing while standing. However, the review went on to discuss the need to progressively challenge the participant in order to have maximum benefit for fall reduction. In our study the level of challenge stayed constant and progressed only as participant speed of completing each ‘bowl’ increased giving them more repetitions within the 20 minute time. Perhaps a future study could incorporate increased levels of difficulty, or use a different Wii\textsuperscript{TM} sports program that would progressively challenge the participants.

We did not use a specific outcome measure or method to track the effectiveness of our educational component. Future studies should be designed to determine the best educational components and strategies that effectively reduce risk for falls.

Our study had a small number of participants (n=10) with no control group. A larger study with randomized groups from differing locations would improve the value of all outcome measures. Additionally, a future study would be even more effective if there were multiple groups to compare the effects of Wii\textsuperscript{TM} bowling as the sole intervention.

**Conclusion**

The results of this study favor the probability that this intervention may produce improvement in balance and reduce the risk of falls in the elderly. Although further research is needed, our participants appeared to have reduced fall risk, based on post-intervention improvement of balance scores. This indicates that a program including education, walking
and the Wii\textsuperscript{TM} may be a beneficial and cost-effective intervention for improving balance in older adults.
References


Table 1: 
Initial Participant Demographics

<table>
<thead>
<tr>
<th>Participants</th>
<th>Average Age/Range</th>
<th>Gender M/F</th>
<th>Assistive Device</th>
<th>Falls within 6 months</th>
<th>Average Initial Scores</th>
</tr>
</thead>
<tbody>
<tr>
<td>N=10, 3 from SC, 7 from SR</td>
<td>83.7 y, 79-92 y</td>
<td>4/6</td>
<td>3/10 (2) st cane, (1) rollator walker</td>
<td>3/10 fallers</td>
<td>Berg 41.9/56, TUG 14.64 s, ABC 75.87%</td>
</tr>
</tbody>
</table>

SC= Senior Center, SR= Senior Residence
### Table 2
Statistical and Clinical Significance of Outcome Measures

<table>
<thead>
<tr>
<th></th>
<th>P-value</th>
<th>Statistically Significant</th>
<th>Clinically Significant</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>BERG Balance Scale (BERG)</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Pre-test to Post-test</td>
<td>p =0.006</td>
<td>YES</td>
<td>YES</td>
</tr>
<tr>
<td>Pre-test to Follow-up</td>
<td>p =0.022</td>
<td>YES</td>
<td>YES</td>
</tr>
<tr>
<td>Post-test to Follow-up</td>
<td>p =0.500</td>
<td>NO</td>
<td>NO</td>
</tr>
<tr>
<td><strong>Timed Up and Go (TUG)</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Pre-test to Post-test</td>
<td>p =0.037</td>
<td>YES</td>
<td>YES</td>
</tr>
<tr>
<td>Pre-test to Follow-up</td>
<td>p =0.032</td>
<td>YES</td>
<td>YES</td>
</tr>
<tr>
<td>Post-test to Follow-up</td>
<td>p =0.088</td>
<td>NO</td>
<td>NO</td>
</tr>
<tr>
<td><strong>Activities-specific Balance Confidence Scale (ABC)</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Pre-test to Post-test</td>
<td>p =0.256</td>
<td>NO</td>
<td>NO</td>
</tr>
<tr>
<td>Pre-test to Follow-up</td>
<td>p =0.368</td>
<td>NO</td>
<td>NO</td>
</tr>
<tr>
<td>Post-test to Follow-up</td>
<td>p = 0.087</td>
<td>NO</td>
<td>NO</td>
</tr>
</tbody>
</table>
Figure 1: Seven of the ten participants had a clinically significant improvement on their BBS score greater than the MDC of 5 points. At follow-up, five still met the MDC value. Three participants were not available for the follow-up score.
Figure 2: Five of the ten participants showed a clinically significant change greater than the SDD value of 1.63 seconds. At follow-up, only one participant still had a clinically significant score. Three participants were not available for follow-up.
Figure 3: None of the participants showed a clinically significant change on their ABC score. MDC = 18%.