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Clinical Use of the Nintendo WII for Balance Rehabilitation: a Case Report

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CLINICAL USE OF THE NINTENDO WII FOR BALANCE REHABILITATION: A CASE REPORT

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Abstract

Background and Purpose: Falls in the elderly population may be due to a number of factors and may pose long-term detrimental effects or contribute to mortality. The purpose of this case report is to describe the non-traditional clinical use of the Nintendo Wii for balance rehabilitation in conjunction with traditional balance interventions for an elderly male patient in order to decrease his risk for falls.

Case Description: The patient was an 83-year-old male with a medical diagnosis of cerebral vascular insult, Alzheimer's disease and a closed head injury due to a fall secondary to a seizure. His balance was assessed post-hospitalization at a transitional care unit (TCU) and was categorized as high risk for falls.

Intervention: The Nintendo Wii was used in conjunction with traditional physical therapy interventions including: therapeutic activity, functional mobility and therapeutic exercise. Three Wii games were chosen to improve the patient's static and dynamic standing balance. These games included the Balance Bubble and Tilt Table games on the Wii Balance Board and golf. Golf was performed in a variety of standing postures (i.e. tandem).

Outcomes: Following a total of 42 physical therapy treatment sessions over four weeks, 11 of which included using the Nintendo Wii, the patient's Berg Balance Score (BBS) improved from 32 to 49 out of 56. The patient's Tinetti Balance Assessment (POMA) score improved from 16 to 24 out of 28, which demonstrates a decrease risk of falls. Upon discharge, the patient was able to return home and complete all activities of daily living (ADL) with supervision from his wife.

Discussion: Despite the patient scoring in the "unbalanced" and "amateur" categories for the Nintendo Wii Tilt Table and Balance Bubble games, his balance scores as measured by BBS and POMA showed significant improvement over the four weeks. Further research is needed for the clinical use of the Nintendo Wii as a valid and reliable balance intervention in populations with high risk of falls.

RESEARCH ADVISOR FINAL APPROVAL FORM

The undersigned certify that they have read, and recommended approval of the research project entitled…

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A CASE REPORT

submitted by
Jasey L. Olsen

in partial fulfillment of the requirements for the Doctor of Physical Therapy Program

Advisor Debra Sellheim Date 4/26/11

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Introduction

Falls are the leading cause of death from injury, a statistic that increases with advancing age.[1] Approximately two-thirds of all injury-related deaths of people over the age of 85 are due to falls. It has been estimated that 30% of community-dwelling elders over the age of 65 and 40% of community-dwelling elders older than 80 years, fall each year. However, these statistics may be underestimated as most falls do not result in serious injuries and many go unreported.[2,3] Risk factors for falls are classified as either intrinsic or extrinsic. Intrinsic factors include sedative use and cognitive impairment. Extrinsic factors include a slippery surface, loose rugs, poor lighting and obstacles. The risk for falls increases as the intrinsic and extrinsic factors accumulate. Regardless of risk factors, age-related changes include a decline in the visual, somatosensory and vestibular systems, which increases the risk of falls.[4]

Alzheimer's Disease (AD) is the most common form of nonreversible dementia in the United States, affecting 20% of persons over the age of 80 years of age and over 95% of persons over the age of 95. AD is a progressive form of dementia, characterized by a gradual decline in memory, language, visuospatial skills, personality and cognition. There is no single identifiable cause; however, AD may be due to a genetic predisposition, advanced age or an accumulation of insoluble fibrous material known as amyloid protein. Amyloid proteins trigger an inflammatory response which causes an increase in free radicals that damage the nervous system.[4] Typical neuromusculoskeletal problems associated with AD include: generalized weakness, increased rigid movements, decreased postural reflexes and restlessness. In addition, falls also occur in approximately 30% of persons with AD, which may be due to a lack of proprioception.[4]

One other important cause of falls are seizures. A seizure is defined as, an uncontrollable firing of cerebral neurons.[1] Seizures occurring in the general population often have an unknown etiology whereas seizures in the elderly often occur due to a previous central nervous system injury such as a stroke or trauma.[5,6] When comparing elderly individuals who sustained a closed head injury secondary to a fall versus individuals who had a seizure leading to a fall and head injury, a prospective study concluded that out of a total of 1760 elderly patients, the rate of head injuries was greater if the person fell due to a seizure. This study found that, 582 head injuries (33.1%) were due to falls and 22 (3.8%) of these were caused by seizures. The incidence of intracranial hematomas was significantly greater in the 22 patients injured in falls due to seizures (90.9%) than in the 560 patients injured in other falls (39.8%).[7]

The majority of successful physical therapy programs addressing neuromuscular re-education and therapeutic exercises for elderly patients who are at a falls risk have included interventions such as balance training and resistance training to reduce the number of falls.[8] Both elderly men and women are able to increase muscular strength and mass, reduce functional impairments and decrease their risk for falls through these exercise programs. Evidence has also shown similar results to hold true in long-term care facilities.[9,10]

Virtual-reality systems are emerging as an alternative physical therapy balance intervention. Due to vast improvements in virtual-reality devices and technology, there are now many different interactive devices available such as the Sony PlayStation 2 EyeToy* and the interactive 2-

* Sony Computer Entertainment America, 919 Et Hillside Blvd, 2nd floor, Foster City, CA 94404

dimensional virtual-reality games system, the Nintendo Wii†. Evidence is beginning to surface that supports the efficacy of various virtual reality systems in rehabilitation settings. In a review study by Weiss et al[11], it was concluded that virtual-reality demonstrates great promise for many therapeutic goals including cognitive, motor and functional rehabilitation. The Nintendo Wii is one physical therapy intervention that has been growing in popularity in rehabilitation programs. There is a paucity of research related to use of the Wii in the physical therapy setting; however, it may be an alternative intervention option to the typical static and dynamic standing exercises. Unlike traditional balance exercise, the Wii can be used to improve not only balance, but also concentration and motivation during physical therapy treatment sessions. The Wii has been anecdotally described as promoting patient enthusiasm, motivation and adherence to exercise when used as an intervention in outpatient and inpatient rehabilitation settings.[12,13] Betker et al[13] utilized a video-based exercise program to improve subjects' dynamic balance control. Subjects demonstrated increased motivation and were able to increase their attention span and practice volume during training resulting in improved dynamic standing balance. This finding is important as it supports that interventions which increase attention span and practice volume lead to more effective balance training.[14]

Despite the growing popularity of the Wii in rehab, there is a lack of research related to its use in physical therapy settings and the research that does exist does not include randomized control trials.[12] Currently there are two published case reports addressing the utilization of the Wii. In these two case reports the Wii was used as the sole intervention and both reported positive

† Nintendo Domestic Distributor, 2525 N. 7th St. Harrisburg, PA 17110

outcomes. In one case report, the pediatric patient with cerebral palsy improved visual-spatial processing, postural control and functional mobility.[12,15] In the second case report the patient demonstrated functional balance improvements as shown by valid and reliable outcome measures in an elderly nursing home resident.[16]

The purpose of this case report is to describe the clinical use of the Nintendo Wii as a neuromuscular re-education intervention with an elderly male who had AD and balance deficits, in order to decrease his risk for falls. The Nintendo Wii was used in conjunction with other interventions including lower extremity strengthening, gait training, therapeutic activities and other neuromuscular re-education interventions. The patient and his spouse gave written informed consent for the writing of this case report. This case report met the institution's requirements of the Health Insurance Portability and Accountability Act for patients' health information.

Case Description

The patient was an 83-year-old male with a medical diagnosis of a cerebral vascular insult (CVI), and a closed head injury due to a fall secondary to a seizure. According to the physician's note, he was walking across the kitchen to the breakfast table when he suddenly fell and hit the back of his head, which was witnessed by his wife. According to his wife it was a normal morning, he took his medications in the morning and waited 45 minutes to eat, as he normally does. He lost consciousness and 3-4 minutes of tonic-clonic activity occurred. This activity is also known as a grand-mal seizure, which features a loss of consciousness and violent muscle contractions.[17] The event was not recalled by the patient and he had no previous history of seizures or falls.

Computerized tomography (CT) of the head showed a left parietal scalp hematoma, cerebral atrophy and changes consistent with small vessel ischemic disease but no evidence of an intracranial hemorrhage. A CT of the cervical spine was also performed and there was no evidence of fracture or dislocation. Two days before he was admitted to the transitional care unit (TCU), the physician's report stated that he had suffered a closed head injury with evidence of seizure activity. It may have been possible that the acute CVI caused the seizure but the patient did not receive a full MRI and the images were not conclusive of a CVI.

The patient was diagnosed with AD two years prior which was being controlled with Aricept, a cholinesterase inhibitor. This medication is an oral tablet intended to improve mental function such as memory, attention, social interaction, reasoning and language abilities, and ability to perform activities of daily living. One of the side effects of Aricpet is seizures.[18]

The patient was evaluated by physical therapy (PT) during his hospital admission. During his hospital stay, he experienced a second seizure and a fall as he attempted to close a window in his room. This event was observed by a nursing assistant and an injury did not occur. The patient was also evaluated by occupational therapy (OT) and speech therapy (SLP) during his hospital admission and all were continued at the TCU. On the day of his initial TCU physical therapy evaluation the patient's long term goal was to return home with his wife. Home PT was also recommended upon discharge from the TCU in order to continue PT and improve the patient's safety in his home. According to the physician's note, the patient was impulsive. He lived in a

town home with his wife and prior to his seizure he enjoyed walking his dog one to two blocks each day and wood-carving.

Examination

The PT examination consisted of tests and measures used to identify functional limitations and physical limitations related to strength and neuromuscular deficits. The examination was performed during the patient's first PT visit. The patient wore glasses and used bilateral hearing aids. The examiners were a student physical therapist and the student's supervising clinical instructor. The patient's vitals were taken during the initial visit with the patient in a seated position and were documented as: blood pressure was 157/71, oxygen on room air was 97% and heart rate was 65.

Bed Mobility/Transfers

The patient independently demonstrated his ability to roll from side to side without use of bed rails. He needed supervision with sit to supine, supine to sit, sit to stand, chair to bed and bed to chair due to increased trunk sway upon changing positions.

Range of Motion (ROM)

A lower extremity ROM screen was performed in a seated position by physical therapy. Occupational therapy screened the upper extremities. All lower extremity ROM exhibited bilateral symmetry and was demonstrated to be within functional limits. All upper extremity ROM demonstrated bilateral symmetry and was also within functional limits per the occupational therapist's initial evaluation.

Manual Muscle Test (MMT)

The bilateral lower extremities were screened in order to determine strength deficits secondary to the patient's hospitalization and CVI. The screens were done with the patient in a seated position and were given estimated grades as they were not performed in the standard MMT positions. The left lower extremity strength screen scores were: 4/5 for hip flexion, extension, abduction, adduction, plantar flexion, and dorsiflexion and a 3+/5 for knee flexion. The right lower extremity strength scores were: 4/5 hip flexion, extension, abduction, adduction and 3+/5 for knee flexion, plantar flexion and dorsiflexion.

Posture/Gait Analysis

Gait was observed from a posterior and lateral view as the patient ambulated at a "self-selected pace" with a front-wheeled walker (FWW) and contact guard assist (CGA) defined as having one hand on the gait belt when the patient was ambulating. During ambulation, the patient demonstrated deviation to the left along with decreased cadence, shuffling gait, and bilateral lower extremity external rotation, with the left lower extremity more prominently rotated than the right lower extremity. He also demonstrated difficulty with left lower extremity toe off during pre-swing, decreased eccentric control of knee flexion on the left during terminal swing and difficulty with left lower extremity dorsiflexion during terminal stance. The patient needed multiple verbal cues to improve posture, as he demonstrated a moderate kyphotic posture and path deviations during the 350 feet of ambulation.

Balance

In order to examine the patient's static and dynamic balance with regards to functional balance, postural control and stability, both the Berg Balance Test (BBS)[19] and Tinetti Balance Assessment (POMA)[20] were used. The BBS is a 14-item multitask balance test. It is considered to be the gold-standard for balance outcome measures as it exhibits strong psychometric properties with regards to functional balance and high inter- and intra-rater reliability.[19] The patient initially scored 32 out of 56 on the BBS, indicating a high falls risk. The POMA consists of two components; gait and balance. It too exhibits strong psychometric properties such as test-retest reliability and predictive validity for fall occurrences.[19, 21, 22] The patient's initial POMA score was 16 out of 28, indicating a high falls risk. Patients who score below a 19 are at a high risk for falls and patients who score in the range of 19-24 indicate that the patient has a risk for falls.[20]

Evaluation

On the day of the evaluation, the patient appeared to be pleasant and was able to follow one-step commands. He needed verbal cues for multi-step commands. He was alert and orientated to "person" but needed verbal cues for "place" and "time." The patient was impulsive and needed verbal cues for proper hand placement in order to safely transfer from sit to stand and stand to sit. A FWW was chosen and placed in his room due to his high falls risk. A wheelchair and tab alarm were also issued for the patient's safety.

Two cognitive tests were administered to the patient by occupational therapy. The mini-mental examination (MMSE) measures memory, language and orientation.[23] A score of 19 out of 30 was

noted, which indicated a moderate cognitive impairment. The Allen Cognitive Level Screen (ACLS)[24] is a standardized assessment of a person's current cognitive function. The patient scored 4.4 out of 5.8 which indicated 24-hour supervision secondary to decreased safety awareness, judgment and problem solving skills. Driving was also not recommended.

The patient presented with impaired mobility function, ambulation, and balance, and decreased safety awareness and activity tolerance secondary to a CVI and past medical history. According to *The Guide to Physical Therapist Practice*[25] the patient's preferred practice pattern was Neuromuscular Pattern 5D: Impaired Motor Function and Sensory Integrity Associated With Nonprogressive Disorder of the Central Nervous System- Acquired in Adolescence or Adulthood.

Prognosis

Based on the clinical instructor's clinical judgment and experience and the *Guide to Physical Therapist Practice*[25] the patient's prognosis for the established goals (see Table 3) ranged from fair to good secondary to his diagnosis of AD and past medical history. The patient was treated twice daily, Monday through Friday, and once daily on the weekends for a total of 42 treatment sessions over 4 weeks. The patient's wife and grown children were functionally able to assist. A home physical therapist, home health aide and FWW were recommended pending his discharge and documented during his initial evaluation.

Intervention

The patient was seen over the course of four weeks for a total of 42 treatments. The primary interventions included lower extremity strengthening, transfer and gait training, advanced balance activities and the Nintendo Wii.

Initial Treatment Session

As the patient did not walk with an assistive device at home, an assistive device was not used during the first treatment session in order to further evaluate his gait and posture. The patient ambulated 144, 140 and 204 feet with CGA on carpet without an assistive device; he lost his balance twice, once laterally and once in an anterior direction. He ambulated with a shuffled gait pattern and slow cadence. He needed verbal cues to "keep his toes pointed towards the ceiling" during initial contact bilaterally and was able to perform sit-to-stand and stand-to-sit transfers from a lounge chair with supervision. He also needed two verbal cues for proper hand placement during sit-to-stand and stand-to-sit transfers.

Therapeutic Exercise

The therapeutic exercises that were chosen included lower extremity strengthening of the: hip flexors, extensors, abductors, and adductors, knee extensors and flexors, and the plantarflexors and dorsiflexors. The lower extremity strengthening exercises were chosen in order to improve the patient's functional mobility and balance to decrease his risk of falls. These were performed in either standing or sitting over the course of four weeks. Lower extremity exercises were performed

four to ten times per week in either sitting or standing using a combination of body weight, therabands, ankle weights and a 23 inch ball. See Appendices 1 and 2 for lower extremity standing home exercise program (HEP) strengthening exercises and the progression of lower extremity strengthening exercises.

Over the course of four weeks, the patient performed either standing or seated lower extremity strengthening exercises. Research has indicated that lower extremity weakness particularly at the ankle and knee is significantly associated with recurrent falls in the elderly.[26] Progression was increased weekly and he was observed for proper technique during each exercise. According to Baker et al[26] if the strengthening prescription is two sets of 10 repetitions, the amount of weight can be increased when the patient can perform more than 12 repetitions with correct technique. The patient was given between 45 seconds and two minutes for a rest break after every two standing exercises. A total of eight standing exercises and seven sitting exercises were prescribed. The American College of Sports Medicine[27] recommends two to three days per week of strength training in order to improve musculoskeletal fitness with 8 to 15 repetitions. Research demonstrates that strength training increases muscle and bone mass, muscle strength, dynamic balance and flexibility; it also demonstrates that strength training reduces falls in older adults with functional limitations.[28,29, 30] See Appendix 2 for a full description and progression of the lower extremity strengthening program.

Gait

Gait was chosen as the patient demonstrated decreased ability to ambulate independently during the initial evaluation. He also needed multiple verbal cues as he exhibited decreased cadence, shuffled gait, moderate kyphotic posture, left-sided gait deviation and bilateral lower extremity external rotation. A FWW was issued during his initial evaluation and he was instructed to use it at all times. A gait belt was used 100% of the time during ambulation. Gait distance was measured using a tape measure on wheels or estimated by the physical therapist's stride length. See Table 2 for progression of the patient's gait intervention.

During the second week, the OT noted that the patient would often sit on his four-wheeled walker seat and push himself with his feet. This was a safety concern as he often forgot to lock his breaks before transferring from a standing to sitting position. He was subsequently issued a FWW walker with castor wheels.

Therapeutic Activity

Therapeutic activity was utilized to increase independence with transfers such as sit-to-stand and bed mobility in order to increase safety awareness and return to prior level of function. Transfer training activities included: sit-to-stand, sit-to-supine, supine-to-sit, stand-to-sit, chair-to-bed and bed-to-chair. Due to his past medical history of AD, he demonstrated decreased safety awareness as noted by ambulating in his room without a walker, not using grab bars in the restroom and by needing multiple verbal cues over the course of the 42 treatment sessions to use his upper extremities for support during sit-to-stand and stand-to-sit transfers.

Neuro-muscular re-education (NMR) / Balance Training

Neuromuscular re-education (NMR) was used to improve balance to decrease risk of falls. The activities chosen to improve his static and dynamic standing balance included challenge activities to static and dynamic standing balance, posture, and the Nintendo Wii. A variety of standing postures and a four-inch height foam mat were utilized with the Wii. Traditional neuromuscular interventions such as advanced ambulation and balance activities were chosen to improve dynamic stabilization and balance. These activities included; utilizing a floor ladder, cones, throwing and catching balls during ambulation, retro-walking, ambulating with eyes-closed and head turns in the frontal and transverse planes.

The Wii activities that were chosen were used to improve static and dynamic standing balance, posture, motivation, and attention impairments. The Nintendo Wii was used three times a week for 10-30 minutes for four weeks in order to improve static and dynamic standing balance in anterior-posterior and lateral directions. A 2009 study by Clark et al[31] looked at the validity and reliability of the Nintendo Wii Balance Board for the assessment of standing balance and concluded that the Wii Balance Board exhibited excellent test-retest reliability for detecting a person's center-of-pressure and has also shown concurrent validity when compared to a laboratory-grade force plate. During the first treatment session using the Nintendo Wii, the patient placed his hands on the balance platform that was set on a table at waist height in order to maneuver the balance games. This position was first utilized to increase his points of contact to improve his base of support when weight shifting in anterior-posterior and lateral directions. The patient was given rest breaks during each Wii session; the rest breaks lasted anywhere from two minutes to five minutes.

A four-inch height foam mat and a variety of standing postures were also utilized with the Wii. Over the course of 42 treatment sessions the Wii was used as an intervention a total of 11 times. See Figures 1, 2 and 3 for pictures demonstrating the balance activities using the Wii and Figures 4, 5 and 6 for the Wii game scores.

A gait belt was used 100% of the time during all neuro-muscular re-education interventions including the Nintendo Wii. Static dynamic balance was practiced using the Wii Tilt table and Balance Bubble games. Both the Tilt Table and Balance Bubble games are played using the Wii Balance Board (WBB). The games can be maneuvered by either the upper extremities, lower extremities or sitting on the WBB. The purpose of the Tilt Table game is to move a ball or multiple balls into holes found on the platform, weight shifting in all directions is needed to maneuver the ball into the platform holes. The purpose of the Balance Bubble game is also to weight shift in all directions in order to maneuver a bubble down a river without the bubble touching the sides of cliffs. Both games are timed and depending on what level or how long it takes the person to get through the game, one of the following balance levels is awarded: “unbalanced”, “amateur”, “balanced” and “professional.” Over the course of four weeks, the patient remained either in the “unbalanced” or “amateur” categories in both the Tilt Table and Balance Bubble games. The Nintendo Wii’s balance board was first placed on a waist-height dinner table in order to increase the patient’s points of contact for increased stability and to allow him to maneuver the games with his upper extremities. There is a built-in center of pressure force plate which provides real time feedback to the participant during balance games.[30] Weight shifting in all directions is needed to successfully maneuver these games. As he progressed, the balance board was placed under his

feet and the games were maneuvered by his lower extremities to further decrease his points of contact from four to two in order to challenge his static and dynamic standing balance.

Figure 1: Static standing balance with upper extremities on

Figure 2: Static standing balance on WBB

Dynamic standing balance was also practiced using the Wii golf game. The golf game includes playing 3, 6, or 9 holes. The patient held a hand-held controller with one-hand, holding down the 'A' button while simultaneously swinging the hand-held controller in order to hit the ball. The hand-held controller has a sensor that measures motion and provides the participant with sensory feedback. There is a gauge on the right side of the screen where the player can change clubs and the ball's trajectory or determine how far the pin is from their current ball placement. The object of the game is the same as the actual game; to get the ball in the hole with the fewest strokes possible.[12,15] See Table 1 for the Wii golf description for each treatment session. Feedback was given at the beginning of each Nintendo Wii session as the patient needed either a visual demonstration or verbal cues to recall how each of the games were played.

Figure 3: Dynamic standing balance with Wii golf while standing on four-inch foam

Figure 4: Nintendo Wii Balance Bubble Scores

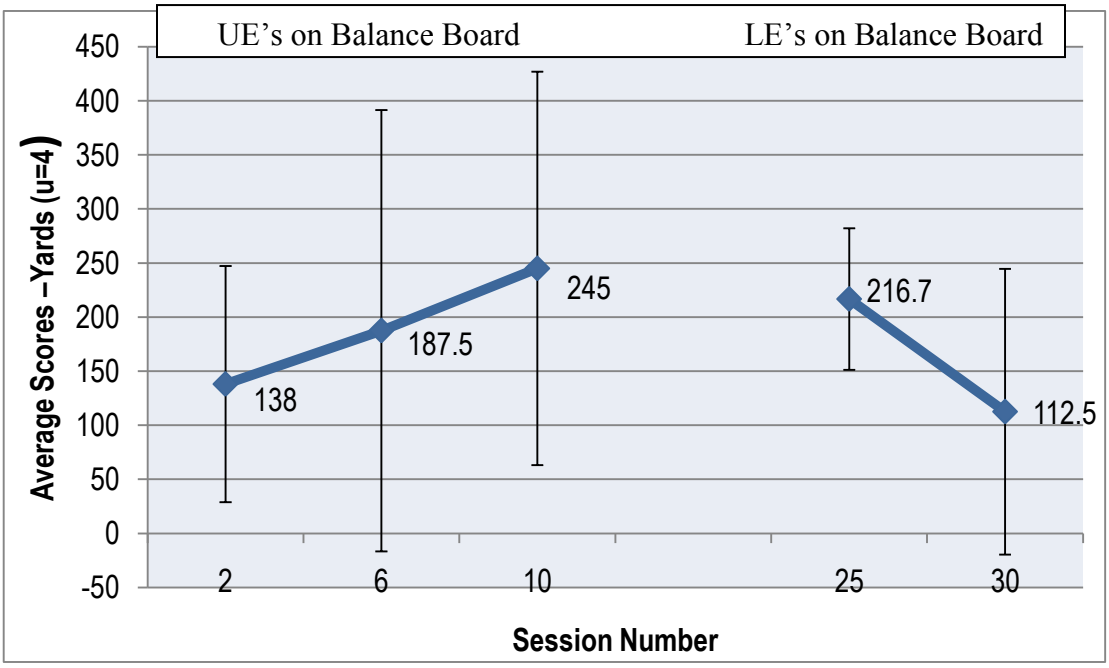


Figure 4 displays the Balance Bubble Scores that were obtained from the Nintendo Wii during each session. The x-axis represents the session number and the y-axis represents the average score in yards. As the balance bubble game was utilized multiple times during each treatment session the

first four scores were averaged and are recorded. The line graph on the left represents the patient's scores recorded when the patient used his upper extremities to maneuver the balance bubble game; these scores ranged from 138 on session number two to 245 on session number 10. The line graph on the right represents the scores that were recorded when the patient's lower extremities maneuvered the balance board; these scores ranged from 216.7 on his 25th treatment session to 112.5 on his 30th treatment session. The large standard deviation bars represent a large variation in the Nintendo Wii scores. Because of this variability, practitioners should continue to use valid and reliable outcome measures to measure functional balance improvements.

Figure 5: Nintendo Wii Tilt Table Scores

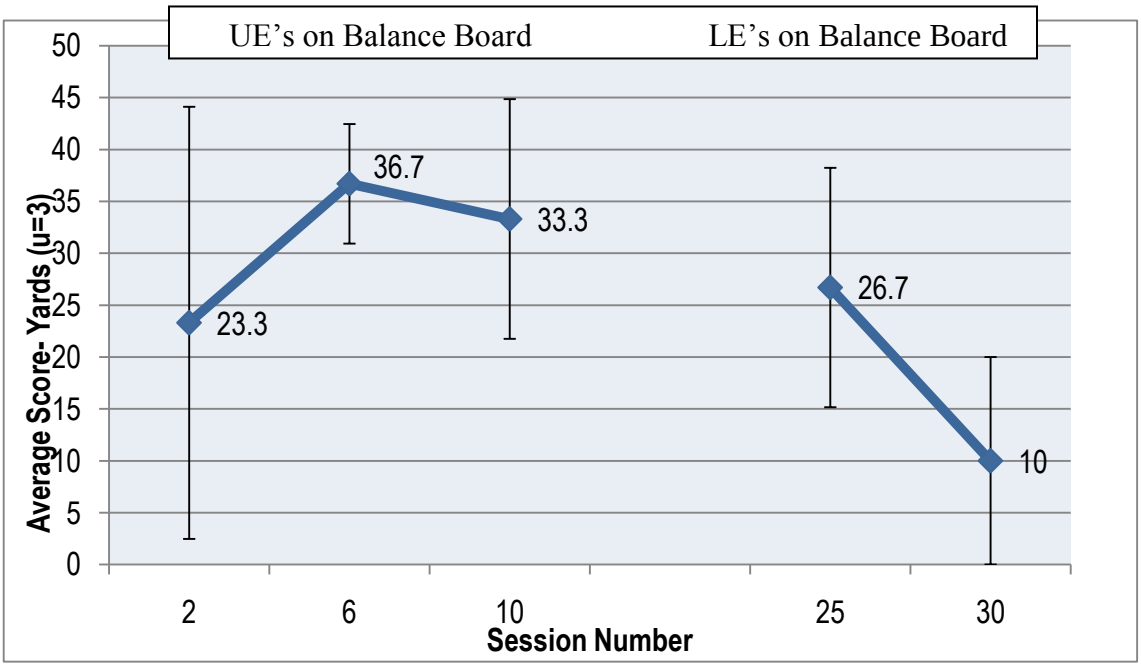


Figure 5 displays the Tilt Table Game scores and is similar to the previous graph depicting the large variation in the Nintendo Wii scores.

Figure 6: Nintendo Wii Golf Scores

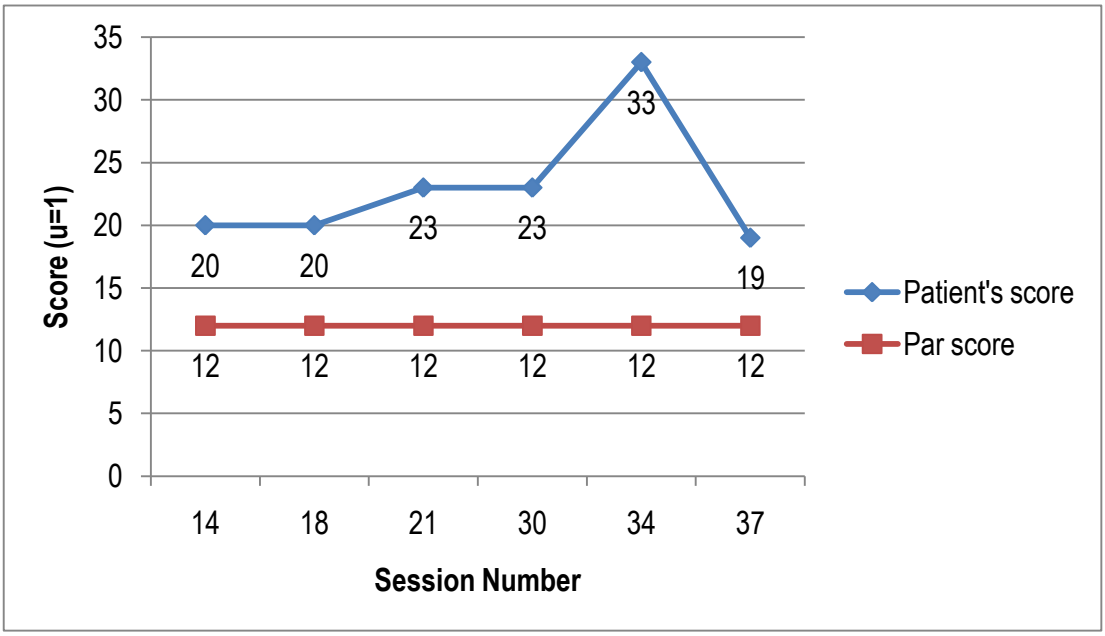


Figure 6 demonstrates the patient's increased par score during the Wii golf game. The patient consistently scored above the game's par score. Each score above represents three holes of golf.

Table 1: Nintendo Wii-Golf Game Description

Session	Level	Total time
14 The patient stood with a NBOS with SBA→CGA, on 4-inch foam. He utilized head turns in both the frontal and transverse plane and LOB twice. He demonstrated an increase in ↔sway about 4 to 5 inches, while standing on the 4 inch foam.	Beginner	22 minutes with three seated rest breaks between each hole for 2 minutes
18 The patient stood with a WBOS with SBA for 2 minutes and utilized head turns in both the frontal and transverse plane. He then stood with a NBOS with supervision for 6 minutes; demonstrated an increase in ↕ sway. 4-inch foam was utilized and he stood with a WBOS with supervision for 10 minutes.	Intermediate	18 minutes with a 2 minute seated rest break
21 The patient first stood in a tandem stance with his right foot forward for 3 minutes bilaterally; he demonstrated a LOB in an anterior direction and a LOB twice with his left foot forward. He then stood with a NBOS for 3 minutes.	Beginner	18 minutes with a 2 minute seated rest break
30 The patient first stood in tandem stance with left leg forward facing the television screen for 3 minutes with SBA-→ CGA; he demonstrated an increase in ↔sway. He then stood with his feet together for four minutes with SBA→CGA; again demonstrating an increase in ↔sway.	Intermediate	10 minutes with a 2 minute seated rest break
34 The patient first stood with a WBOS on 4-inch foam with CGA for 8 minutes, with head turns in the transverse plane; he demonstrated a LOB in an anterior direction. He then stood with a NBOS on 4-inch foam with CGA for 5 minutes, with head turns in the transverse plane; demonstrating a LOB in a posterior direction.	Intermediate	15 minutes with a 2 minute seated rest break
37 The patient first stood with his feet together with CGA for 3 minutes with head turns in the transverse plane; he demonstrated a LOB in an anterior direction. He then stood with a WBOS on 4-inch foam with CGA for 5 minutes.	Beginner	10 minutes with a 2 minute seated rest break

↔ = medial-lateral weight shift directions, ↕ = anterior-posterior weight shift directions, NBOS = narrow base of support, WBOS = wide base of support, SBA = stand-by assist, CGA = contact guard assist

The Nintendo Wii was not the sole balance intervention utilized. Advanced walking balance activities were also chosen to improve the patient's balance. These activities included utilizing a floor ladder, cones, throwing and catching balls standing and during ambulation, retro-walking, and ambulating with eyes-closed and head movements in the saggital and transverse planes. See Appendix 3 for neuromuscular re-education/balance interventions.

Outcomes

The patient was discharged during the fourth week of treatment after a total of 42 treatment sessions. At the time of discharge, he had made substantial improvements in his impairments and functional limitations.

Balance outcomes were measured and administered utilizing the BBS and POMA, four different times over the course of four weeks. The balance assessments were either scored by the student physical therapist, physical therapist or physical therapist assistant. See Figures 7 and 8 for weekly balance scores. Improvement in the BBS was demonstrated by a seven-point improvement from week one to week four. A change of seven points is needed to show a minimal detectable change if the patient initially scored within 25-34.[19] An eight-point improvement was demonstrated from week one to week four for the POMA. An improvement of five points is needed to demonstrate true change.[20]

Figure 7: Weekly Berg Balance Scale Scores

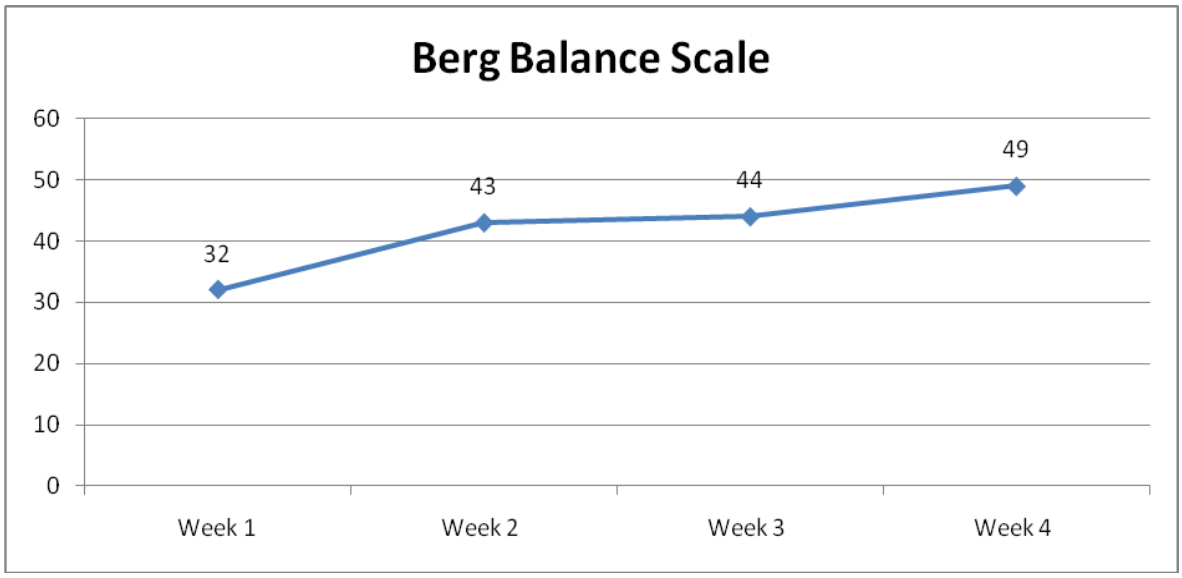
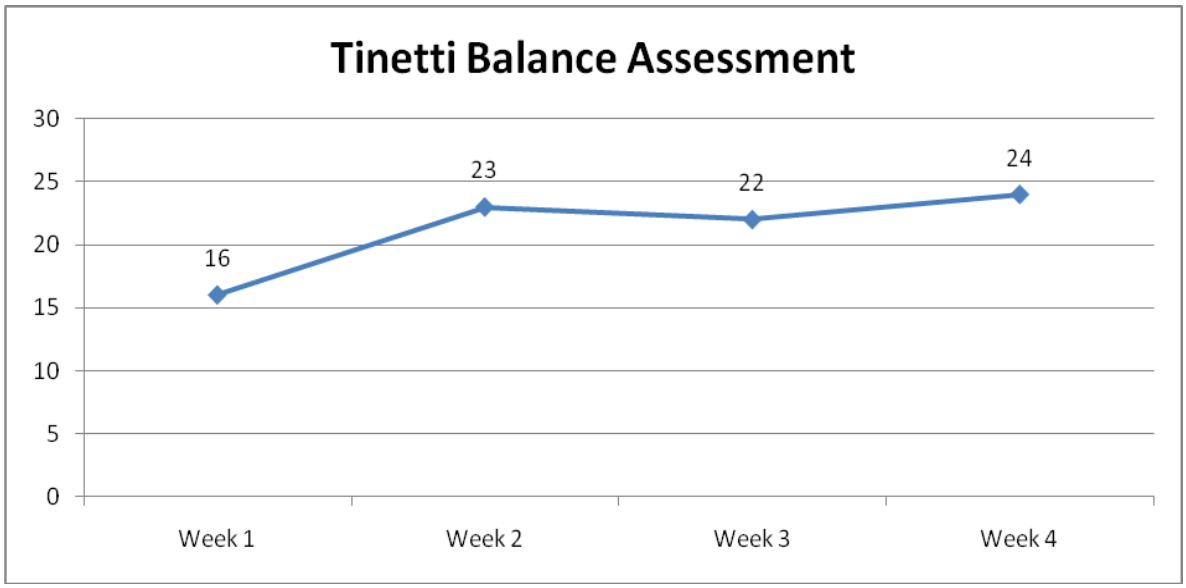


Figure 8: Weekly Tinetti Balance Assessment Scores



During the four weeks of treatment, therapeutic activity was used as an intervention a total of four times and ranged from five minutes to ten minutes. At the end of the fourth week, the patient was able to independently transfer from sit-to-stand and stand-to-sit demonstrating consistent safety awareness and proper hand placement when transferring from lounge chairs, restroom, bed and outdoor benches. He demonstrated proper hand placement to his wife during his last week of treatment.

Functional mobility (ambulation with FWW with castor wheels) increased from 350 feet to over 3,000 feet on even and uneven surfaces both indoors and outdoors over the course of 32 sessions of gait interventions. Upon discharge the patient was set-up with home physical therapy, a home health aide and a FWW. See Table 2 for average distance that was ambulated over the course of four weeks, number of times ambulated and level of assistance.

At discharge the patient continued to be at risk for falls and demonstrated a need for supervision at all times. This outcome was based on his POMA and BBS outcome scores, his past medical history of falls, two falls occurring over two weeks and his current medical history of AD. Both he and his wife were instructed on how to properly use his FWW. A written and pictorial lower extremity standing strengthening HEP was issued and the patient's wife verbally agreed to supervise and assist him with it daily. The patient presented with a positive attitude and motivation to return home over the course of four weeks. Table 3 documents the patient's goals and if the goals were attained at the time of discharge.

Table 2: Gait

Week	Number of times ambulated	Weekly ambulated distance (ft)	Surface and other comments	Assistive device used
1	9	140 →1,416	▪ Tile and carpet ▪ Pt. ambulated without AD with CGA 6 times during initial two weeks-LOB twice	FWW with supervision
2	9	180 →1,000	▪ Tile and carpet	FWW with castor wheels issued and supervision
3	9	120 →975	▪ Tile and carpet ▪ Demonstrated NBOS ▪ Verbal cues: WBOS, posture and direction to room ▪ Decreased heel strike	FWW with castor wheels and supervision→SBA
4	5 Outdoors = 2	600 → 3,000	▪ Tile and carpet ▪ Sidewalk ▪ Grass-LOB twice ▪ Verbal cues to stay on sidewalk ▪ Curb cuts ▪ Increased path deviation when simultaneously walking and talking	Without AD on grass and FWW with castor wheels on sidewalk with supervision→SBA

AD = Assistive Device, ft = feet (distance), LOB= loss of balance, NBOS = narrow base of support WBOS = wide base of support, CGA = Contact guard assist, SBA= Standby assist

Table 3: Patient's Goals

Patient's goals	
Independent with bed mobility in 2 weeks, without use of bed rails in order to transfer in and out of bed without assistance at home.	Goal met
Demonstrate safety awareness by demonstrating ability to lock wheelchair breaks and proper hand placement 100% of the time when transferring sit ↔ stand in 2 weeks in order to decrease risk of falls.	Goal met
Independent with ambulation with front-wheeled walker in 2 weeks in order to ambulate at home and in community and to walk his dog 1000 feet on even and uneven surfaces.	Goal partially met as PT/OT recommend supervision with ambulation from wife and family
Increase POMA score to 24/28 in 4 weeks to decrease risk of falls in order to return to prior level of function.	Goal met
Increase BBS score to 50/56 in 4 weeks to decrease risk of falls in order to return to prior level of function.	Goal not met- scored 49/56 at discharge
Independent with standing home exercise program, without verbal cues in one week in order to decrease risk of falls and return to prior level of function.	Goal not met- needed verbal cues; wife stated she was able to assist

Discussion

Falls commonly occur in persons over the age of 65. They may be due to a number of reasons including intrinsic factors (i.e. dizziness), extrinsic factors (i.e. slippery surface), or medical events (i.e. stroke or seizure). Regardless of the cause, falls are a major cause of morbidity and mortality.[2] Physical therapists play an essential role in the prevention of falls and balance improvements, especially in the elderly population.

The purpose of this case report was to describe the clinical use of the Nintendo Wii as a neuromuscular re-education intervention with an elderly male who had AD and balance deficits, in order to decrease his risk for falls. As technology advances, virtual reality game systems will likely play an integral role in many rehabilitation settings. Virtual reality game systems are now

becoming more affordable and clinically appropriate.[32] Few studies have examined interactive dynamic balance exercises in the elderly as a potential intervention to improve postural control and decrease falls risk.[33]

In this case report, the Wii was chosen as a non-traditional balance intervention for a patient who demonstrated both static and dynamic standing balance deficits. The Wii was used in conjunction with traditional physical therapy interventions including progressive muscle strengthening, gait training and neuromuscular re-education. He participated in a total of 11 sessions over the course of four weeks utilizing the Nintendo Wii Balance Bubble, Tilt Table and golf simulations. At discharge, the patient demonstrated a decrease in falls risk as shown by an increase in BBS and POMA scores, both of which fell above the fall risk cut-off scores. Despite his Nintendo Wii scores falling into the "unbalanced" and "amateur" categories for both the Tilt Table and Balance Bubble, his balance scores as measured by BBS and POMA showed significant improvement over the course of four weeks. His initial BBS score was 32 out of 56 and at the time of discharge improved to 49 out of 56. The patient's initial POMA score was 16 out of 28 and improved to 24 out of 28 at the time of discharge. Thus, at the time of discharge the patient had progressed on both the BBS and POMA above the fall risk cut off scores.

There are several plausible reasons for the patient's improved balance. The balance improvements could have been due to the Nintendo Wii balance games. The level of difficulty on the Wii was progressed by using four-inch foam and a variety of standing postures (i.e. tandem stance). More likely, the balance improvements were due to the combination of interventions of

lower extremity strengthening, gait and therapeutic activity. Other contributing factors to the patient's improved balance were his motivation to return home, supportive family, and the pharmacological control of his AD. Despite his moderate cognitive impairment the patient demonstrated a positive attitude and appeared to be motivated to perform any intervention that PT offered. He was very friendly and enjoyed the passerby's cheering and watching him play the Wii. The patient was initially unfamiliar with how to play the Nintendo Wii, however, when the patient was asked what he thought of the Nintendo Wii after the first few sessions, his response was, "this is a neat idea." He also expressed that he liked to play all of the prescribed games. The games were limited to the three previously described due to his cognitive level; these three appeared to be easier than other Wii games as determined by the student physical therapist and physical therapist. Subsequent to this patient being treated in the TCU, it was found that having a past medical history of seizures, may be a contraindication for the use of the Wii.[34] This patient, however, did not experience any seizures during his care at the TCU. It was determined that his safety was accounted for as he was in a TCU where nurses were easily accessible. He was also closely monitored by a student physical therapist and physical therapist during each treatment session.

The use of the Wii for this patient was feasible as the TCU previously owned the Wii, which included the WBB and balance games. There was also space available in an open dining room where the flow of traffic and distractions were lower compared to the PT and OT gym. The current price of the Nintendo Wii is approximately $200.00 and includes: one remote controller, one nunchuck controller, Wii sports games, sensor bar, composite cable and power cord.[35] The Wii Fit

games and balance board are priced around $120.00.[36] The Wii Fit includes: strength training, aerobics, yoga, and balance games including the Tilt Table and Balance Bubble. The Nintendo Wii console and balance board is compact, light-weight and can be easily stored and set up in a few minutes. It can be used in a variety of rehabilitation settings and homes.[37]

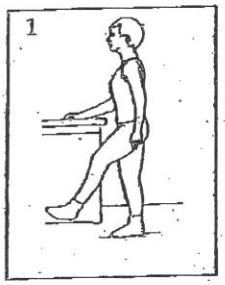
Further research is needed to determine if the clinical use of the Nintendo Wii is a valid and reliable balance intervention for the geriatric population to decrease their risk of falls. Specifically, methods to be researched include Wii parameters, such as appropriate frequency and duration, and their relationship to the reduction of falls and functional mobility improvements. Specific Wii games as the sole balance intervention as compared to a combination of Wii games with traditional balance interventions to determine the best results for decreasing the risk of falls need to be studied. Research could also include the use of other balance outcome measures such as the Dynamic Gait Index (DGI), which provides a predictive score for falls in the elderly. The DGI is also able to measure functional mobility and dynamic balance.[22,38] A randomized control trial may be beneficial to evaluate balance improvements in a larger geriatric population as the results of the patient in this case report cannot be generalized to other patient populations. The primary limitation of this case report is that the Wii was used in combination with traditional physical therapy interventions, thus it cannot be determined exactly what led to the patient's balance improvement.

Conclusion

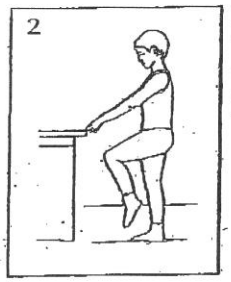
The results of this case report, demonstrate that the Nintendo Wii may be a reliable non-traditional balance intervention for an elderly patient to improve static and dynamic standing balance and

decrease risk of falls. The Wii was used in conjunction with traditional physical therapy interventions: therapeutic activity, functional mobility and therapeutic exercise, all of which were intended to return the patient to his independent prior level of function. The patient had a past medical history of AD, seizures, closed head injury and falls. He participated in a total of 42 physical therapy treatment sessions at a TCU, 11 of which included using the Nintendo Wii as an alternative balance intervention. Balance improvements were measured on a weekly basis, a total of four times, as measured by the BBS and POMA. After four weeks, he returned home with his wife utilizing a FWW. Home physical therapy was recommended to continue to improve his balance impairment and decrease his falls risk.

Appendix 1: Lower Extremity Exercises-HEP

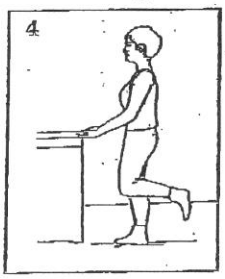


Stand, holding on to a secure object. Lift one of your legs forward off the ground.

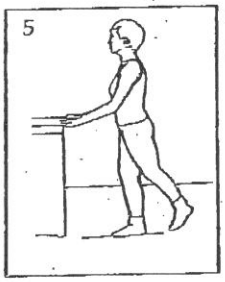


Bring your knee up – not past 90 degrees of hip flexion

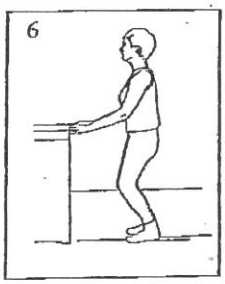
Lift your leg out to the side.



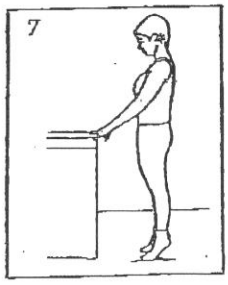
Bend your knee, bringing your heel toward your buttocks.



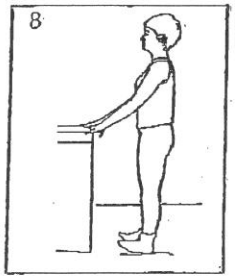
Slowly kick (lift) your leg backward.



Bend your knees slightly. Hold briefly.



Raise up onto the balls of your feet.



Raise your forefoot off the floor.

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Appendix 2: Lower Extremity Strengthening Exercises

All eight lower extremity standing exercises from the Appendix 1 HEP were utilized at each of the indicated sessions below, both sitting and standing lower extremity exercises strengthened hip flexors, extensors, abductors, and adductors, knee extensors and flexors, and the plantarflexors and dorsiflexors.

Lower extremity strengthening exercises - Week 1

Session	Upper extremity support	Sitting or Standing	Sets & Repetitions	Weight
2	Bilateral in parallel bars	Standing	1 set, 15 repetitions	BW
3	Bilateral in parallel bars	Standing	3 sets, 10 repetitions	3 pound ankle weights
4	Bilateral in parallel bars	Standing	3 sets, 10 repetitions	3 pound ankle weights (difficulty tapping L foot)
5	Sitting in arm chair	Sitting	1 set, 30 repetitions	2 pound ankle weights, orange theraband, ball
6	Sitting in arm chair	Sitting	1 set, 30 repetitions *only hip flexors & ball squeezes	2 pound ankle weights, ball
7	Bilateral in parallel bars	Standing	1 set, 20 repetitions	2 pound ankle weights
8	Sitting in arm chair	Sitting	1 set, 20 repetitions	3 pound ankle weights, green theraband, ball
9	Bilateral in parallel bars	Standing	1 set, 30 repetitions	body weight
10	Sitting in arm chair	Sitting	1 set, 30 repetitions	2 pound ankle weights, green theraband, ball
12	Sitting in arm chair	Sitting	1 set, 25 repetitions	3 pound ankle weights, purple theraband, ball

BW= body weight, ball= 23 inch ball for adductor strengthening

Lower extremity strengthening exercises - Week 2

Session	Upper extremity support	Sitting or Standing	Sets & Repetitions	Weight
13	Sitting in arm chair	Sitting	1 set, 25 repetitions	3 pound ankle weights, purple theraband
14	Sitting in arm chair	Sitting	1 set, 25 repetitions	3 pound ankle weights, orange theraband, ball
15	Bilateral in parallel bars	Standing	1 set, 25 repetitions	3 pound ankle weights
16	Bilateral in parallel bars	Standing	1 set, 20 repetitions	4 pound ankle weights
18	Unilateral in parallel bars	Standing	1 set, 20 repetitions	4 pound ankle weights
21	Unilateral in parallel bars	Standing	1 set, 20 repetitions	4 pound ankle weights
23	Sitting in arm chair	Sitting	1 set, 30 repetitions	Blue theraband (only knee flexion, PF and DF exercises)

Lower extremity strengthening exercises - Week 3

Session	Upper extremity support	Sitting or Standing	Sets & Repetitions	Weight
24	Unilateral finger tip hold on parallel bars	Standing	1 set, 22 repetitions	3 pound ankle weights
25	Bilateral in parallel bars	Standing	1 set, 30 repetitions	3 pound ankle weights
27	Sitting in arm chair	Sitting	1 set, 30 repetitions	3 pound ankle weights, green theraband, ball
29	Unilateral finger tip hold on parallel bars	Standing	1 set, 25 repetitions	3 pound ankle weights
31	Sitting in arm chair	Sitting	1 set, 25 repetitions	4 pound ankle weights, black theraband
33	Unilateral finger tip hold on parallel bars	Standing	1 set, 25 repetitions	3 pound ankle weights

Lower extremity strengthening exercises - Week 4

Session	Upper extremity support	Sitting or Standing	Sets & Repetitions	Weight
35	Sitting in arm chair	Sitting	1 set, 30 repetitions	3 pound ankle weights, orange theraband, ball
37	Bilateral in parallel bars	Standing	1 set, 20 repetitions	BW
40	Sitting in arm chair	Sitting	1 set, 20 repetitions	Only hip flexion, PF & DF performed
41	Bilateral at counter	Standing	1 set, 30 repetitions	BW

BW= body weight, PF= plantarflexion, DF =dorsiflexion

Appendix 3: Neuromuscular Re-Education/Balance Interventions

Session	Intervention(s) & level of assistance	Parameters/conditions	Total time
3	Side-stepping	• UE support for 8 ft, performed 3 x to the right and left	5 minutes
5	Static and dynamic standing balance	• 1-minute standing with NBOS • 1- minute standing NBOS with EC • 1-minute: head turns in frontal and transverse planes with feet together • 30 seconds: separated tandem stance- left and right foot forward x 2 • 30 seconds: separated tandem stance eyes closed- left and right foot forward x 2 • Forward ambulation for 30 feet x 2 with head turns in transverse and saggital planes with CGA	20 minutes
7	Dynamic balance- (CGA)	• Colored plastic feet (5) used as targets on floor, right and left side-stepping x 5 and diagonal steps x 5	5 minutes
13	Side-stepping and reaching (CGA)	• No AD used • Side-stepped right and left 15 ft x 2 • LE crossover at counter right and left 10 feet, VC needed for technique, LOB x 1 • Beach ball toss with side-step to the right and left 15 ft • Dynamic reach for bean bags at various heights (ground, knee, shoulder and overhead) in order to track moving target and tossed bean bags; encouraged trunk rotation and weight shifting	20 minutes
14	Dynamic balance (CGA)	• Side-stepping for 10 ft x 2 without UE support • Side-stepping with EC for 10 ft x 2 without UE support retro-walked for 10 ft with CGA • Forward ambulation 10 ft without UE support	
17	Side-stepping, four square and single-leg stance (CGA, without use of assistive device)	• Head rotation in transverse plane 30 feet x 2 • EC, 30 feet x 2 • Head turns in saggital and transverse planes, 30 ft x 2 • Side-stepped to the right and left, 30 ft x 2 • Four square (stepping forward, side, back, side) used four colored feet on floor as markers, 4 x to left and right • SLS with bilateral UE hold on railing; held for 10 seconds x 2 for each leg • Ambulated 400 ft with head turns in saggital and transverse planes	24 minutes
19	Ambulation with ball toss (CGA, without use of AD)	Medial and lateral ball toss 200 feet forward ambulation and retro-walking, LOB x 2 • Side-stepping 30 feet x 2 to the right and left with ball toss, LOB x 2 to the right	16 minutes

Neuromuscular Re-Education/Balance Interventions (cont)

Session	Intervention(s) & level of assistance	Parameters/conditions	Total time
20	Agility ladder (CGA), single leg stance, static and dynamic standing balance on 4 inch foam	• Forward and retro step (length of ladder x 12) performed 3 x • Side-step over ladder rungs x 12, performed 3 x • SLS with foot rolling on bolster bilaterally 1 minute x 2 • Static standing balance on 4-inch foam for 3 minutes • Dynamic standing balance on 4-inch foam; trunk side bend to the right and left, forward reach outside BOS, picking up object on floor, 5 minutes	30 minutes
22	Standing balance, side-stepping (SBA, without use of assistive device)	• Side-stepping to the right and left 15 ft x 4 • Dynamic standing balance by tapping a balloon back and forth with PT in medial, lateral and overhead directions. BOS also varied; WBOS, NBOS and semi-tandem; unsteady x 1 but was able to regain balance with 1-2 steps	25 minutes
25	Single leg stance and perturbations applied during standing (SBA→CGA)	• Bilateral hand hold on railing 30 seconds x 2 on right and left legs • Unilateral hand hold 30 seconds x 2, unable to stand on right leg • Left leg standing balance without support for 4 seconds • Perturbations applied in ↔ and ↕ directions, posterior LOB x 4 and anterior LOB x 2 utilizing stepping strategy to correct	10 minutes
28	Static standing balance and side-stepping (SBA)	• Static standing balance on 5 inch foam with eyes closed 30 seconds x 2 • Side-stepping bilaterally 10 feet x 2	8 minutes
31	Ambulation balance (CGA)	• Retro walking 30 feet x 3 and verbal cues-to point toes straight ahead and widen stance • Forward ambulation with EC 30 feet x 2, LOB x 2 to the left • Ambulation with head turns in transverse plane 30 ft	10 minutes
32	Standing balance (without assistive device, CGA),	• SLS with foot on 6-inch bolster with EO 1 minute x 2 and with EC standing on left foot able to hold for 30 to 60 seconds and right foot able to hold for 15 seconds to 55 seconds (posterior LOB) • 4 square balance (unsteady but improved when modeled by the PTA) x 10 bilaterally • Ambulation with head turns in transverse plane 100 ft, path deviation but no LOB	20 minutes
33	Perturbations and step-ups (supervision)	• Perturbations applied in medial-lateral and anterior-posterior direction for 30 seconds, LOB x 2 utilizing stepping strategy backwards • Step-ups on 5.5 inch block bilaterally performed 10 x 2	25 minutes

Neuromuscular Re-Education/Balance Interventions (cont)

Session	Intervention(s) & level of assistance	Parameters/conditions	Total time
34	Obstacle course	• Ambulated 120 feet without assistive device with CGA, retro walking 15 feet x 3; 2 times with EC; demonstrated LOB x 1 backwards • Side-stepping 15 ft to both the right and left without upper extremity support • Ambulated 30 ft x 2 with head turns in the transverse plane • Ambulated 15 ft x 4; stepping over 4 inch foam and 4-inch black box; patient demonstrated loss of balance twice when standing on 4 inch foam and one time when stepping over the black box with his right foot	25 minutes
35	Retro-walking, side-stepping and forward walking	• Retro-walking 45 ft x 4; two times with EC; patient demonstrated LOB backwards 2 x with CGA • Side-stepping 45 ft with CGA • Forward walking 45 ft x 2; one time with EC with CGA	10 minutes
36	Dynamic balance using floor ladder	• Floor ladder: 1) Patient stood perpendicular to floor ladder and one foot at a time stepped inside the box of ladder until both feet were inside box followed by stepping in retro direction one foot at a time until both feet were once again outside the ladder 2) 4-square using the last rung and box of the ladder x 3: first side-stepping, then 2 steps inside rung of ladder and 2 steps out so patient is perpendicular to the ladder; followed by side-stepping and the 4-square begins again. The pattern: →,↓←,↑	10 minutes

x = number of times/repetitions, VC = verbal cues, →,↓←,↑ = left, back, right, forward, ft= feet, CGA = contact guard assist, EC = eyes closed, LOB = loss of balance, SBA = stand-by assist, ↔ = medial-lateral, ↕ = anterior-posterior

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