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Original Article

Effectiveness of Videogames on Balance and Fear of Falling in Chronic Stroke Patient

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Objectives: Balance disorder is one of the most common problems after stroke causes falling and fear of falling in some patients. The balance based video games are newly used in people with motor problems. It is very important to use different interventions for balance issues. The aim of this study is to determine the effectiveness of videogame on balance and fear of falling in one participant.

Methods: This experimental study was done in a single subject system, A-B design for one patient with chronic stroke. This method including repetitive measures conducted in two phases, baseline and then twelve intervention sessions. Berg Balance Scale, Timed up and go, Functional Reach, the maximum weight bearing in different directions and the deviation from center were conducted for balance assessing. Fear of falling questionnaire was used to assess fear of falling. Analysis of results was done by C-statistic, Bayesian factor, Mann Whitney U, and visual analysis graphs.

Results: The results showed significant improvement for balance skills, the maximum force produced by lower extremities and reducing fear of falling parameters. But the deviation from center graphs did not showed distinct pattern.

Discussion: All analysis confirmed the efficacy of videogames on balance skills and fear of falling improvement. However, the deviation from center did not show improvement and it seems to need more studies.

Keywords: stroke, balance, fear of falling, videogames

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Introduction

Stroke is one the most common neurologic disorders and third cause of death after heart disease and cancer in the developed countries (1,2). About 800.000 people experience stroke in the United State each year, of these, about 610000 are recurrent attacks (1). Dalvandi et al reported the annual incidence of stroke is 372 in 100000 in Iran (3). Although two third of patients are above 65, stroke happens in any ages, even in childhood (4). Cerebrovascular Accident (CVA) is an important cause of long term disability, as 20% of patients need hospital care three months after occurrence and 15-30% suffers from permanent disability (1). Stroke survivors show a complex of sensory-motor, cognitive and emotional symptoms (5,6). Motor problems and changes in postural control components are the most common deficit after stoke and include the reduced ability to balance properly due to an increase in postural sway asymmetrical weight distribution (60-80% of weight on non-paretic limb),and loss of weight shift (7-14). Postural control is described as a perceptual motor process which includes body alignment maintenance in space in order to gain stability and orientation (15) Since normal postural control is one the most leading predictor to achieve independence in Activities of Daily Living (ADL) and social participation, (9) any deficits in that could cause difficulty for person. Therefore, improvement of the postural control impairments is one of the primary aim of rehabilitation professional, especially occupational therapists who work on postural control during activities of daily living (16). Various impairments caused by CVA make the patients face "falling". Falling after stoke, as an important medical complication, effects rehabilitation and one's functional improvement (17,18). Barclay-

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goddard et al, in 2004, reported postural stability impairments as the primary reason of falling in CVA survivors (19). After stroke, some patients experience fear of falling which described as lower or decreased perceived self-efficacy or confidence in avoiding falls while completing activities (20). Fear of falling is related with reduced person's satisfaction with community reintegration, physical function and quality of life decrease (21,22). In a cross sectional study, Wantanebe, in 2005, showed 29 out of33stroke patients, developed fear of falling in 8-27 months following a fall (23).
Most of Conventional rehabilitation programs such as neurodevelopmental techniques, task oriented approach, balance and gait trainings with aim of increasing range of motion, power, endurance and other balance components, (24-27) do not have measurable and gradable tools. These long term and repetitive programs could be tedious causing lack of person's interest, motivation and attention and decrease of their efficacy (24-28). All of these made therapists to use new therapeutic tools such as computer. In recent years, virtual reality programs and virtual reality based tasks such as video games which are parts of biofeedback exercises have entered to rehabilitation field (29,30). Due to some characteristics, the interactive balance games involved repetitive, voluntary, whole-body movements varied in direction, speed, amplitude, and precision could improve balance problems (31). The researches have proved motor learning facilitation in chronic stroke patients following auditory and visual feedbacks (32). Entertaining videogames provide feedbacks that cause patients more participation in therapy and use of residual functional capacity in order to achieve success. Cho et al, indicated significant improvement in dynamic balance scores following intervention with Wii (7). Brumels et al, demonstrated decrease in postural sway and high level of enjoyment after intervention with Wii comparing to other therapies (33). There are limited studies of investigating the effect of videogames on fear of falling. Sheryl et al, reported significant efficacy of videogames on falling risk reduction and motor planning improvement in one stroke patient following playstation2 usage, but not mentioned fear of falling decrease (32). Today, in spite of computer influence in people lives, therapeutic usage of this tool is not common in rehabilitation. Most of the studies in this field has not adopted a precise protocol or just used commercial systems not designed for therapeutic goals. In addition, Iran there was no study investigating videogames efficacy in postural control and fear of falling in stroke. The therapeutically designed system used in the current study has been adopted for the first time, provided evaluation and intervention concurrently.
The aim of this study was investigating the feasibility and effect of videogames, as a part of virtual reality, in postural control and fear of falling in one chronic stroke patient. We hypothesized that these technology unique characteristics could be used as an efficient tool for balance training in people with motor deficits.

Methods

A single subject design, AB design, was conducted in the current study. This method including repetitive measures conducted in two phases, four pre intervention and then twelve intervention sessions.
At the beginning of the study, Timed Up & Go (TUG), Functional reach (FR), deviation from center in stance with eyes opened and closed, and the peak voluntary forces produced by any lower limbs repeated in four sessions, three times in a week. The assessment sessions took about 15 minutes. In order to eliminate the learning effect of repeated testing, BBS and FES-I were conducted three times at the first, sixth and last sessions of intervention phase. After four assessment sessions and completing baseline phase, the participant took part in a trial session in order to be familiar with process and suitable level of each games based on his ability selected. The twelve intervention sessions lasted for one month, conducted three times in a week. Each session took about one hour, including 15 minutes assessing, 19 minutes playing the games and rest time during evaluation and therapy based on patient's cooperation. Six videogames, with a fixed order, were played in every session. The games procedure was as; *Driving*: 2 minutes, change in weight distribution in frontal plane, *Skateboard*: 2 minutes, change in weight distribution in sagittal plane, *Catch balls*: 4 minutes, change in weight distribution in frontal plane, *Monkey*: 4 minutes, change in weight distribution in sagittal plane, *See-Saw*: one minute, maintain equal weight distribution on both lower extremities in frontal plane, See-saw: 1 minute, in sagittal plane, *Golf*: five minutes, change in weight distribution in frontal and sagittal plane.

The participant was a 63-year-old man who sustained a right ischemic stroke in pons, based on MRI and medical report, 18 months prior to the start of study. Dominant side of the body was left. Height and weight were measured 165 cm and 80 kg, respectively. Past medical history was significant for heart surgery 2 years before intervention, high blood pressure and diabetics. There was no report of any other neurologic or emotional disease. Based on MMSE his cognitive status was intact. Star cancellation confirmed no exists of hemi neglect. Hemi- anopsia and other visual problems were rejected by especial optometric evaluation. The participant reported previous falling more than 3 times during the last 6 months prior the study. He was able to stand independently and use a cane while walking. There was no change in his regular exercise regimen and not received any especial balance training during the course of study. The participant signed an informed consent statement, in accordance with requirement of Iran University of Medical Sciences.

The videogames used in this study was Biometrics Ltd, E-Link system, made in the UK, available in the occupational therapy laboratory of Iran University of Medical Sciences. Components for this system include a monitor, 4 force-plates (200*125*14 mm) attached to a central Hub by cables. The patient stood on plates and played the games by changes in weight distribution in medio- lateral and antro-posterior directions. The software of system registered the weight distribution sways in stance and also the peak voluntary force produced by each lower extremity in sagital and frontal planes. These forces, determined the sensitivity of force-plates used for doing the games.

Berg Balance Test (BBS) was developed for use with community-dwelling elderly individuals. It can also be used in patients with stroke. It contains 14 static and dynamic balance tests. The maximum score is 56 and higher scores indicates higher balance skills (34). Timed Up & Go (TUG) test is a general physical performance test used to assess mobility, balance and locomotors performance. From sitting in a chair, the patient stands up, walks 3 meters, turns around, walks back, and sits down (35). Functional reach (FR) test is used for balance assessment. The distance between the head of 3th metacarpus of a fisting hand is compared in normal stance and leaning forward (36). Persian Version of Falls Efficacy Scale-International (FES-1) questionnaire includes 16 questions about fear of falling while doing different activities. The score of 16 and 64 is the minimum and maximum scores in order. The higher score is related to more fear (37).

Weight distribution graphs and peak voluntary force produced by each extremity recorded by Biometrics Ltd, E-Link: in these test, weight distribution changes were measured with eyes opened and closed in normal stance for 30 seconds, while the patient standing on faceplates. Based on these data, the deviation from center was recorded as percentage. Peak voluntary force produced by each extremity in antro-posterior and medio-lateral directions also recorded as percentage of whole body weight.

Results

Visual analysis, C-statistic and Man-Whitney-U were used to assess the effect of videogames on balance and fear of falling. Based on the table (1), the BBS and FES-1 scores show increase and decrease, respectively.

Table1. Changes in BBS and FES-I scores in 3 assessments

TEST	1th evaluation	2th evaluation	3th evaluation
BBS	48	51	54
FES-I	30	24	21

- BBS: berg balance scale
- FES: fear efficacy scale-inventory

Based on figure (1), the acceleration line of FR test in intervention phase shows steep slope compared with baseline phase .Chang in balance between baseline and intervention phases confirmed with C-statistic ($P<0.001$). Bayes Factor shows strong to very strong effect. The upward trend in this test indicates improvement in balance. Based on figure (1), the acceleration line of TUG test in intervention phase shows downward trend vice versa baseline phase .Chang in speed of walking between baseline and intervention phases confirmed with C statistic ($P<0.01$). Bayes Factor shows moderate to strong effect. The downward pattern for this test reveals walking speed increase.

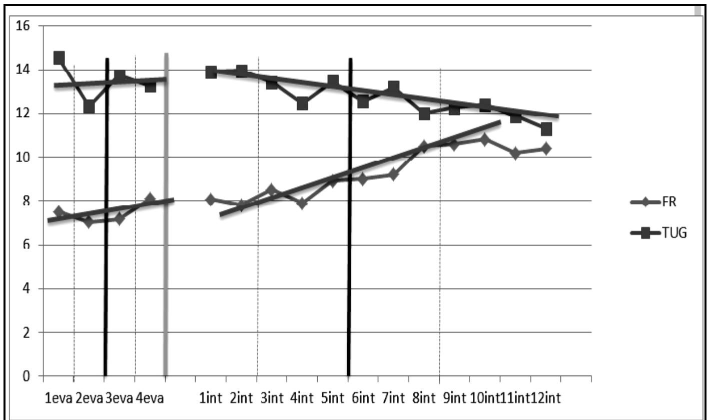

Figure1.the trend of changes in baseline and intervention phases for Functional Reach and Timed up & go tests

According to the results shown in table (2), the changes between baseline and intervention phases for peakfront, peakleft, peakright and standard deviation from center with eyes closed were significant.(Posterior probability < 0.05).These changes confirmed with Mann Whitney U test. Based on Bayesian Factor test, the intervention had moderate to strong effect in mentioned parameters.

Table 2. Changes in maximum force and deviation from center

Parameters	C	Bayesian Factor	Posterior Probability	Mann Whitney U	Explanation
Peakback	0.8	4	0.8	0.5	Weak
Peakfront	0.01	0.01	0.01	0.01	Moderate to strong
Peakleft	0.04	0.04	0.046	0.04	Moderate
Peakright	0.01	0.01	0.01	0.01	Moderate to strong
DoC-O	0.9	99	0.9	0.03	weak
DoC-C	0.01	0.01	0.01	0.02	Moderate to strong

- DoC-O: deviation of center with eyes opened
- DoC-C: deviation of center with eyes closed
- Peak(back, front, left and right) indicates the maximum force recorded in these directions

The deviation with eyes opened was not significant based on Posterior Probability and Bayesian Factor, though Mann Whitney U test showed changes. The peakback factor was not significant with any tests.

Based on figure (2) , in eyes closed status, acceleration line has a downward trend in both baseline and intervention phases. Though, the line slope in intervention phase was faster, compared with the other phase. The upward and downward trend indicates more or less deviation from center, respectively.

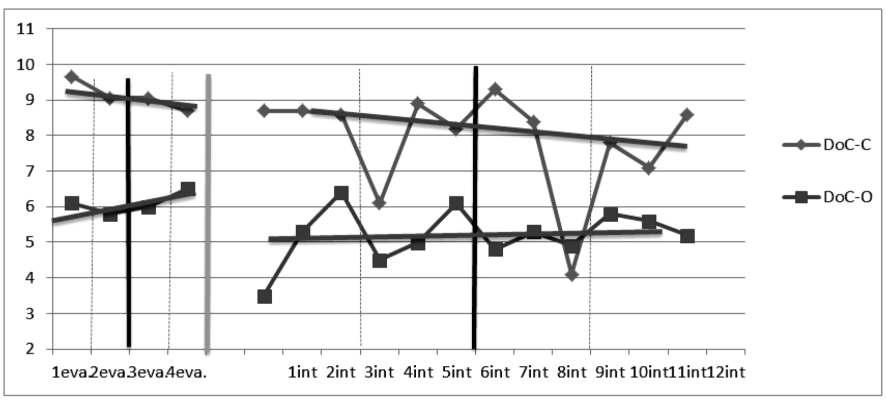

Figure2. The trend of deviation from center with eyes opened and closed in baseline and intervention phases

DoC-O:deviation of center with eyes opened
DoC-C: deviation from center with eyes closed

As figure (2) shows, for eyes opened condition, although lines in both phases pursue of an upward pattern, the line has a slower trend in intervention phase versus the baseline.

Discussion

In the current study conducted with the aim of investigating of therapeutic use of videogames in a chronic stroke patient therapy, the results showed improvement of balance skills and reduction of fear of falling .there was no report of pain or discomfort after intervention and in spite of no previous experience of working with videogames, the patient learned how to do necessary movements fast. Berg Balance Scale, TUG and FR tests used to assess balance status. According to the increased BBS scores, the static and dynamic balance skills generally improved. Statistics data of FR revealed the powerful effect of intervention and the steep slope of changes in intervention phase compared with baseline, confirmed the efficacy. The reason could be the similarity of exercises type with FR necessities in volitional forwarding movement. In addition, the significant improvement of Timed Up and Go scores indicated the intervention efficacy on speed of walking. Although there were no specific exercises on speed of walking, increased scores could be the result of improved self-confidence of patient in weight shifting and voluntary displacement abilities and decreased fear of falling.

These results are consistent with previous studies, with a difference of using Wii system in the most of them. Gomez G et al. in 2011, reported Wii games high efficacy on balance skills improvement in hemi paretic patients with BBS, FR, Brunel tests and less improvement in TUG, 10-Meter-Walking and Stepping tests.(38) Agmon et al, in 2011, showed improvement of BBS scores and speed of walking of 7 elderly more than 84 after doing Wii games (39). Clark R, also indicted the same results in an elderly in a case study (40). Chow et al, in 2013 reported the X-box 360 Kinect efficacy on BBS, 10-Meter-Walking and sensory organization test improvement in patients with stroke (41). The other improvement based on data analysis, was reduction of fear of falling scores by using FES-I. Devinder, in 2012, indicated reduction of risk and fear of falling scores using Physiological Profile Approach (PPA) and Activity Specific Balance Scale (ABC-6)in women elderly after intervention with Wii (42).

In the current study, the maximum patient ability to produce the force in frontal and sagital planes measured as the maximum weight bearing in front, back, left and right directions. Analysis with both C-statistic and Man-Whitney-U in forward and medio-lateral direction scores, in contrast with backward, revealed significant improvement. These data are consistent with Mirelman results in knee and ankle strategies improvement and increased push-off power in stroke patients after using virtual reality intervention (43). The reason of non-significant data for backward direction seems to be the slower improvement ankle strategies for dorsi-flexion in these patents, although this needs more studies.

In the current study, the deviation from center was measured by the standard deviation reported as percentage by the system in both frontal and sagital plane concurrently. The data recorded in both opened and closed eyes status. The acceleration line in intervention phase sloped more sharply, compared with baseline with eyes closed. The moderate to strong significance by statistics data also confirmed the efficacy of intervention in reduction of deviation of center. On the other hand, although C-statistic was not significant with eyes opened, the significance of Man-Whitney-U showed changes in intervention phase compared with baseline. Similarly, based on visual analysis, the acceleration line pattern confirmed reduction of deviation from center with eyes opened. Maybe, with longer intervention, the changes were more remarkable in this condition.

Winstein et al, in 1989, indicated increased speed of walking and static postural symmetry after using virtual reality in hemi paretic patients (44). McGough et al, in 2012, reported Wii balance board efficacy in evaluation and weight shifting improvement in normal people (45). Though, the effect of virtual reality on dynamic postural symmetry and gait pattern improvement needs more studies. The conventional rehabilitation treatment could be tedious and boring, causing motivation and interest reduction in patients. In the current study, the patient satisfaction from this type of therapy assessed comparing previous conventional therapies. The results revealed high satisfaction and in response to a question the patient indicated more self-confidence in walking without stick and reduction of fear of falling while going around in community.

Conclusion

The current study, conducted in a single subject design (AB), showed the improvement of balance and fear of falling after use of videogames in a chronic stroke patient.

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References

1. Roger VL, Go AS, Lloyd-Jones DM, Benjamin EJ, Berry JD, Borden WB, et al. Heart Disease and Stroke Statistics-2012 Update A Report From the American Heart Association. Circulation. 2012;125(1):e2-e220.
2. Warlow C vGJ, Dennis M, et al. Stroke: practical management. 3rd ed. Oxford: Blackwell Publishing; 2008.
3. Dalvandi A, Ekman S-L, Maddah SSB, Khankeh HR, HeikkilÃ¤ K. Post Stroke life in Iranian people: used and recommended strategies. Iranian Rehabilitation Journal. 2009;7(9):17-24.
4. Warlow CP. Stroke. UK: Blackwell Publishers; 2001.
5. Warlow CP, Van Gijn J, Dennis MS, Wardlaw JM, Bamford JM, Hankey GJ, et al. Stroke: practical management. New York: John Wiley & Sons; 2011.
6. Hochstenbach J, Donders R, Mulder T, Van Limbeek J, Schoonderwaldt H. Long-term outcome after stroke: a disability-orientated approach. International Journal of Rehabilitation Research. 1996;19(3):189-200.
7. Cho KH. Virtual reality balance training with video games system improves dynamic balance in chronic stroke patients. Tohoku JExpMed. 2012 Sep;228(1):69-74.
8. Geurts AC, de Haart M, van Nes IJ, Duysens J. A review of standing balance recovery from stroke. Gait & posture. 2005;22(3):267-81.
9. Lin CL, Hsieh SF, Hsiao MH, Huang J. Predicting long-term care institution utilization among post-rehabilitation stroke patients in Taiwan: a medical centre-based study. Disability & Rehabilitation. 2001;23(16):722-30.
10. Geiger RA, Allen JB, O'Keefe J, Hicks RR. Balance and mobility following stroke: effects of physical therapy interventions with and without biofeedback/forceplate training. Physical therapy. 2001;81(4):995-1005.
11. Trombly CA, Scott AD. Occupational therapy for physical dysfunction. Baltimore Williams & Wilkins Co; 1995. 102-22 p.
12. Levangie PK, Norkin CC. Joint structure and function: A comprehensive analysis. 4 ed. Philadelphia: Davis; 2005.
13. Marigold DS, Eng JJ. The relationship of asymmetric weight-bearing with postural sway and visual reliance in stroke. Gait & posture. 2006;23(2):249-55.
14. Messier S, Bourbonnais D, Desrosiers J, Roy Y. Dynamic analysis of trunk flexion after stroke. Archives of Physical Medicine and Rehabilitation. 2004;85(10):1619-24.
15. Shumway-cook. motor control:theory and practical applications: Lippincott Williams & Wilkinsvvh; 2001.
16. Wolfson L. Gait and balance dysfunction: a model of the interaction of age and disease. The Neuroscientist. 2001;7(2):178-83.
17. Hyndman D, Ashburn A, Stack E. Fall events among people with stroke living in the community: circumstances of falls and characteristics of fallers. Archives of Physical Medicine and Rehabilitation. 2002;83(2):165-70.
18. Schmid AA, Van Puymbroeck M, Knies K, Spangler-Morris C, Watts K, Damush T, et al. Fear of falling among people who have sustained a stroke: a 6-month longitudinal pilot study. The American Journal of Occupational Therapy. 2011;65(2):125-32.
19. Barclay-Goddard R, Stevenson T, Poluha W, Moffatt M, Taback S. Force platform feedback for standing balance training after stroke. The Cochrane database of systematic reviews. 2004;4.
20. Tinetti ME, Richman D, Powell L. Falls efficacy as a measure of fear of falling. Journal of gerontology. 1990;45(6):P239-P43.
21. Andersson ÅG, Kamwendo K, Appelros P. Fear of falling in stroke patients: relationship with previous falls and functional characteristics. International Journal of Rehabilitation Research. 2008;31(3):261-4.
22. Pang MY, Eng JJ, Miller WC. Determinants of satisfaction with community reintegration in older adults with chronic stroke: role of balance self-efficacy. Physical therapy. 2007;87(3):282-91.
23. Watanabe Y. Fear of falling among stroke survivors after discharge from inpatient rehabilitation. International Journal of Rehabilitation Research. 2005;28(2):149-52.
24. Buchner D, Cress M, De Lateur B, Esselman P, Margherita A, Price R, et al. A comparison of the effects of three types of endurance training on balance and other fall risk factors in older adults. Aging (Milan, Italy). 1997;9(1-2):112-9.
25. Leroux A, Pinet H, Nadeau S. Task-oriented intervention in chronic stroke: changes in clinical and laboratory measures of balance and mobility. American journal of physical medicine & rehabilitation. 2006;85(10):820-30.
26. Lord SR, Tiedemann A, Chapman K, Munro B, Murray SM, Ther GR, et al. The effect of an individualized fall prevention program on fall risk and falls in older people: a randomized, controlled trial. Journal of the American Geriatrics Society. 2005;53(8):1296-304.
27. Werner C, Von Frankenberg S, Treig T, Konrad M, Hesse S. Treadmill Training With Partial Body Weight Support and an Electromechanical Gait Trainer for Restoration of Gait in Subacute Stroke Patients A Randomized Crossover Study. Stroke. 2002;33(12):2895-901.
28. Szturm T, Betker AL, Moussavi Z, Desai A, Goodman V. Effects of an interactive computer game exercise regimen on balance impairment in frail community-dwelling older adults: a randomized controlled trial. Physical Therapy. 2011;91(10):1449-62.
29. Schultheis MT, Rizzo AA. The application of virtual reality technology in rehabilitation. Rehabilitation Psychology. 2001;46(3):296-311b.
30. You SH, Jang SH, Kim Y-H, Hallett M, Ahn SH, Kwon Y-H, et al. Virtual reality-induced cortical reorganization and associated locomotor recovery in chronic stroke an experimenter-blind randomized study. Stroke. 2005;36(6):1166-71.
31. Teasell R, Meyer MJ, McClure A, Pan C, Murie-Fernandez M, Foley N, et al. Stroke rehabilitation: an international perspective. Topics in stroke rehabilitation. 2009;16(1):44-56.

32. Flynn S, Palma P, Bender A. Feasibility of using the Sony PlayStation 2 gaming platform for an individual poststroke: a case report. Journal of neurologic physical therapy. 2007;31(4):180-9.
33. Brumels KA, Blasius T, Cortright T, Oumedian D, Solberg B. Comparison of efficacy between traditional and video game based balance programs. Clin Kinesiol. 2008;62(4): 26-31.
34. Berg K. Measuring balance in the elderly: preliminary development of an instrument. Physiotherapy Canada. 1989;41(6):304-11.
35. Podsiadlo D, Richardson S. The timed" Up & Go": a test of basic functional mobility for frail elderly persons. Journal of the American geriatrics Society. 1991;39(2):142-8.
36. Duncan PW, Weiner DK, Chandler J, Studenski S. Functional reach: a new clinical measure of balance. Journal of gerontology. 1990;45(6):M192-M7.
37. Khajavi D. Validation and Reliability of Persian Version of Fall Efficacy Scale-International (FES-I) in community-dwelling older adults. Iranian Journal of Ageing. 2013; 8(29):39-47.
38. Gil-Gómez J-A, Lloréns R, Alcañiz M, Colomer C. Effectiveness of a Wii balance board-based system (eBaViR) for balance rehabilitation: a pilot randomized clinical trial in patients with acquired brain injury. Journal of neuroengineering and rehabilitation. 2011;8(1):30.
39. Agmon M, Perry CK, Phelan E, Demiris G, Nguyen HQ. A pilot study of Wii Fit exergames to improve balance in older adults. Journal of Geriatric Physical Therapy. 2011;34(4):161-7.
40. Clark R, Kraemer T. Clinical use of nintendo Wii (TM) bowling simulation to decrease fall risk in an elderly resident of a nursing home: A case report. Journal of geriatric physical therapy. 2009;32(4):174-80.
41. Chow RTK, Chan ACM, Tong JMC. Effectiveness of virtual reality in balance training in stroke rehabilitation: A pilot study. Hong Kong Physiotherapy Journal. 2013;31(2):100.
42. Singh DK, Rajaratnam BS, Palaniswamy V, Pearson H, Raman VP, Bong PS. Participating in a virtual reality balance exercise program can reduce risk and fear of falls. Maturitas. 2012;73(3):239-43.
43. Mirelman A, Patritti BL, Bonato P, Deutsch JE. Effects of virtual reality training on gait biomechanics of individuals post-stroke. Gait & posture. 2010;31(4):433-7.
44. Winstein C, Gardner E, McNeal D, Barto P, Nicholson D. Standing balance training: effect on balance and locomotion in hemiparetic adults. Archives of physical medicine and rehabilitation. 1989;70(10):755-62.
45. McGough R, Paterson K, Bradshaw EJ, Bryant AL, Clark RA. Improving lower limb weight distribution asymmetry during the squat using Nintendo Wii Balance Boards and real-time feedback. The Journal of Strength & Conditioning Research. 2012;26(1):47-52.