Journal of Back and Musculoskeletal Rehabilitation 26 (2013) 299–305
DOI 10.3233/BMR-130725
IOS Press

Typical balance exercises or exergames for balance improvement?

Asimenia Gioftsidou[a,*], Nikolaos Vernadakis[a], Paraskevi Malliou[a], Stavros Batzios[a], Polina Sofokleous[a], Panagiotis Antoniou[a], Olga Kouli[a], Kyriakos Tsapralis[b] and George Godolias[a]
[a]*Department of Physical Education and Sports Science, Democritus University of Thrace, Komotini, Greece*
[b]*Isokinetic Medical Center, Bologna, Italy*

Abstract.
BACKGROUND AND OBJECTIVES: Balance training is an effective intervention to improve static postural sway and balance. The purpose of the present study was to investigate the effectiveness of the Nintendo Wii Fit Plus exercises for improving balance ability in healthy collegiate students in comparison with a typical balance training program.
METHODS: Forty students were randomly divided into two groups, a traditional (T group) and a Nintendo Wii group (W group) performed an 8 week balance program. The "W group" used the interactive games as a training method, while the "T group" used an exercise program with mini trampoline and inflatable discs (BOSU). Pre and Post-training participants completed balance assessments.
RESULTS: Two-way repeated measures analyses of variance (ANOVAs) were conducted to determine the effect of training program. Analysis of the data illustrated that both training program groups demonstrated an improvement in Total, Anterior-posterior and Medial Lateral Stability Index scores for both limbs. Only at the test performed in the balance board with anterior-posterior motion, the improvement in balance ability was greater in the "T group" than the "W group", when the assessment was performed post-training ($p = 0.023$).
CONCLUSIONS: Findings support the effectiveness of using the Nintendo Wii gaming console as a balance training intervention tool.

Keywords: Balance board, proprioception, active video games, balance training

1. Introduction

Poor balance or otherwise postural control is associated with injury or falls in many populations and consequently is considered to be a critical component of common motor skills [1–3]. Balance is generally defined as the ability to maintain the body's center of gravity within its base of support and can be categorized as either static or dynamic balance. Static balance is the ability to sustain the body in static equilibrium or within its base of support [4,5]. Dynamic balance is believed to be more challenging because it requires the ability to maintain equilibrium during a transition from a dynamic to a static state [6]. Both static and dynamic balance require effective integration of visual, vestibular, and proprioceptive inputs to produce an efferent response to control the body within its base of support [7, 8].

An interruption or deficit in any part of the sensorimotor system can result in a loss of balance, which can result in injury. Balance training is an effective intervention to improve static postural sway and dynamic balance in both athletes and non-athletes [9]. Improving balance with training in a healthy population has positive effects on reducing injury. Balance training has decreased the rates of ankle sprains [10,11], as well as overall lower extremity injury rates [12,13] in several types of athletes. Unstable surface types of equip-

*Corresponding author: Asimenia Gioftsidou, Department of Physical Education and Sport Sciences, Democritus University of Thrace, Komotini 69100, Greece. Tel.: +30 2531039662; Fax: +30 2531039662; E-mail: agioftsi@phyed.duth.gr.

ISSN 1053-8127/13/$27.50

ment such as wobble board, foam rollers, Swiss balls and balance discs have traditionally been used in the rehabilitative and preventive setting [14–18].

Although it may seem commonplace, the importance of addressing proprioception and postural control in either fitness or rehabilitation training is still a relatively new concept and current research is ongoing [19, 20]. Furthermore, the increased interest in these areas has led to advances in proprioception and balance training equipment, and more of this equipment is being used [20–22]. Various balance platform systems have been created to increase proprioception in injured patients [20–22]. Subsequently, more advanced computerized mechanical platforms have been designed to challenge both the muscular and visual systems in response to calculated perturbations [20].

Active video games or exergames are becoming increasingly popular among children and adolescents [23,24] due to the low cost, independence and ease of use in the home. As an alternative, one such system that is increasing in popularity for use in fitness and balance training is the Nintendo Wii Fit (Nintendo of America, Redmond, WA, USA), a commercially available gaming system. Recently, Wii Fit training has received significant attention by healthcare professionals as an individual training tool [25,26]. Wii-Fit Plus is one of the Nintendo Wii games that is played using a special Wii balance board in order to perform activities like yoga, jogging and aerobics [27]. Also, it includes training games (e.g. ski slalom, ski jump, table tilt) requiring from the player to perform well-controlled movement [28].

Studies in the literature seem to indicate that Nintendo Wii gaming console was effective in improving the overall balance abilities of learners [26,29]. However, there are other studies in the literature with mixed results regarding the comparison of the two different training methods (Traditional and Nintendo Wii) [30, 31].

More specifically, Kliem and Wiemeyer [30] compared the efficiency of traditional and exergame-based balance training programs. Participants were randomly assigned to two experimental groups: one group underwent a traditional training program, while the other group trained using the Nintendo Wii Fit Balance Board. Between pre and post-test procedures, training sessions were performed three times a week for three weeks. The results indicated that the traditional group had a significantly greater improvement in balance test (Star Excursion Balance Test) and ball-handling, whereas the Wii group showed a significantly greater improvement in Ski Slalom.

Similarly, Brumels et al. [31] examined the impact of video games on balance performance by comparing three training programs: Konami's Dance Revolution (DDR), the Wii Fit game collection including the Wii Fit Balance Board and a traditional balance training program. Before and after the treatments the balance performance of subjects was assessed using the Star Excursion Balance Test (SEBT) and a single leg stance on a force plate. Participants exercised three days a week for four weeks. The results showed on the one hand a significant reduction of postural sway for average displacement and average deviation on the y-axis in the DDR_ group, while only significant average deviation improvements were observed in the Wii group. On the other hand, the traditional group improved significantly in the SEBT. No pre to post-test improvements were observed in postural sway for the traditional balance group.

Considering the mixed results regarding the comparison of the two different training methods (Traditional and Nintendo Wii), the low cost, simplicity and availability of the Wii Fit system, it would be even more desirable for use as a training tool if it can be shown to have a positive effect on balance control. Thus, the purpose of the present study was to investigate the effectiveness of the Nintendo Wii Fit Plus exercises for improving balance ability in healthy collegiate students in comparison with a typical balance training program.

2. Methods

The study was conducted on 40 undergraduate students of the Department of Physical Education and Sport Sciences at the Democritus University of Thrace (DPESS, DUTH), aged 20 to 22 years ($M = 20.36$, $SD = 0.68$), while 22 of them were male and 18 were female. The sampling frame used for this study was self-selected sampling. The participants were free of injuries in their lower limbs for the past 3 years. They were randomly assigned to one of the two different training program groups: Traditional (T group) (11 males and 9 females) and Nintendo Wii (W group) (11 males and 9 females) creating two independent groups of 20 students respectively. Prior to group assignments, participants were orientated to the purpose of the study, the training program group to which they belonged and the obligations for participation in the experiment. Each student was asked to give consent to participation in the study. The experimental procedures complied with the Helsinki declaration of 1975 and were

approved by the Ethical Committee of the Democritus University of Thrace.

The balance ability assessment was performed with the Biodex Stability System and three different balance boards (boards 1a, 1b, and 2). The Biodex Stability System is a dynamic postural stability assessment and training system which assesses the ability of the body to balance on an unstable platform [32]. In the Biodex test, the participants maintained single-limb stance for 20 s, with the Biodex platform set to freely move by up to 20° from level in any direction. From the variance of the platform displacement (°) in the antero-posterior (AP) and medio-lateral (ML) directions from level during the test, instability indices (I) Total (SI), Anterior-Posterior (API) and Medial-Lateral (MLI) stability indices was computed from the Biodex system. Three test trials were carried out and the one with the lowest Ii (best performance) was further processed.

As concern the balance boards, board 1a restricted movement in the antero-posterior direction only, board 1b restricted movement in the medio-lateral direction only, and board 2 allowed movement in both antero-posterior and medio-lateral directions. In the balance board tests, the subjects maintained single-limb stance for as long as possible. Three test trials were timed on each balance board and the best trial was considered for further analysis.

2.1. Procedure

Participants were randomly divided into two training program groups of 20 students each, a typical balance exercise group ("group" and an exergame group ("group". The two training groups performed a specific balance program for 8 weeks, two times per week, and 24 min per session. Before the intervention started, the experimental group was given a 90-minute introductory session on how to use the Nintendo Wii-Fit Plus games and its tools.

The "W group" used the interactive games Wii-Fit Plus of the Nintendo Wii console, as a training method to improve their balance. The games varied each week starting with the easiest and ending with the most difficult. Participants had the opportunity to choose the order in which they will play the balance games, but without allowing them to change their time engagement. At the beginning and at the end of each session the participants performed a series of yoga exercises (a. tree pose, standing exergames knee pose b. and c. king of the dance pose) for a total duration of 10 minutes. In the meantime, they had to deal with Nintendo Wii-Fit Plus interactive balance games for 14 minutes. Specifically, the first and second week the participants played the balance games ski slalom and table tilt, for 5 minutes each and the headings for 4 minutes. The third and fourth week the participants played the balance games balance bubble and penguin slide, for 4 minutes each and the games ski slalom and snowboard slalom for 3 minutes each. The fifth and sixth week, participants played the balance games balance bubble and snowboard slalom at an advanced level for 4 minutes each and the games penguin slide and ski slalom for 3 minutes each. On the seventh week the participants played the balance games headings for 4 minutes, and ski slalom for 3 minutes at the advanced level, and the games skateboard arena for 4 minutes and table tilt for 3 minutes at the advanced level. The last week the participants played the balance games skateboard arena for 4 minutes and snowboard slalom for 3 minutes in the advanced level, and the balance bubble plus games and table tilt plus for 3 and 4 minutes, respectively. After each exercise – game there was a 15 second break (Table 1).

The "Traditional group" performed an exercise program with mini trampoline and inflatable discs (BOSU), as a training method to improve their balance. The participants performed two balance exercises in mini trampoline for a total duration of 3 minutes on each leg and then followed 3 balance exercises on BOSU flat side and the same 3 exercises on BOSU bladder side, for a total duration of 9 minutes on each leg. The training program was the same for each session (Table 2). Specifically, the program followed by the "Traditional group" described below:

(1) Exercises in mini trampoline
   a. High skipping (jump on spot 3 times on each leg) and landing on a limb every time (2 repeats of 45 seconds each leg).
   b. Standing on one leg and try to catch the ball thrown at them in various directions by the researcher (2 repeats of 45 seconds each leg) (Table 2).

(2) Exercises in inflated rubber hemisphere attached to a rigid platform (BOSU) (Table 2)
   a. Standing on BOSU's bladder side with one foot, in an attempt to maintain balance (2 repeats of 45 seconds each leg).
   b. Standing on BOSU's bladder side with one foot, in an attempt to maintain balance, while lifting the non-support leg forward and backward (2 repeats of 45 seconds each leg).

Table 1
Interactive balance games-exercises

Weeks	Games
1^{st} & 2^{nd}	ski slalom (5 min), table tilt (5 min), headings (4 min)
3^{rd} & 4^{th}	balance bubble (4 min), penguin slide (4 min), ski slalom (3 min) and snowboard slalom (3 min)
5^{th} & 6^{th}	balance bubble (4 min) and snowboard slalom at an advanced level (4 min) and games penguin slide (3 min), ski slalom (3 min)
7^{th}	at an advanced level: balance headings (4 min), ski slalom (3 min), skateboard arena (4 min) and table tilt (3 min)
8^{th}	balance skateboard arena (4 min), snowboard slalom (3 min) at an advanced level, and balance bubble plus (3 min), table tilt plus (4 min)

Table 2
Typical balance exercises

Exercises in trampoline	high skipping and landing on one limb each time
(2 reps of 45 sec per leg)	1-leg stance, attempt to catch the ball
Exercises in flat and bladder side of BOSU	1-leg stance, attempt to maintain the balance
(2 reps of 45 sec per leg)	1-leg stance, attempt to keep the balance while move the non-supporting leg
	1-leg stance, attempt to catch the ball

c. Standing on BOSU's bladder side with one foot, in an attempt to maintain balance, while trying to catch the ball thrown at them by the experimenter in various directions (2 repeats of 45 seconds each leg).
d. Standing on BOSU's flat hard side with one foot, in an attempt to maintain balance (2 repeats of 45 seconds each leg).
e. Standing on BOSU's flat hard side with one foot, in an attempt to maintain balance, while lifting the non-support leg forward and backward (2 repeats of 45 seconds each leg).
f. Standing on BOSU's flat hard side with one foot, in an attempt to maintain balance, while trying to catch the ball thrown at them by the experimenter in various directions (2 repeats of 45 seconds each leg).

Between repetitions on balance exercises each session break 15 seconds elapse (Table 2).

Before and after the completion of the eight weeks balance program, participants completed a single leg static balance assessment for both limbs (dominant and no dominant) on Biodex Stability System (SI, API, MLI) and on the three balance boards (time on balance).

2.2. Statistical analyses

Initial differences between the two groups for the mean balance scores were tested using independent-samples t test. Two-way analyses of variance (ANOVAs), with repeated measures on the last factor, were conducted to determine the effect of training program groups (Traditional and Wii) and measures (pre-test, post-test) on balance test indices (SI, API, and MLI) and time on balance (boards 1a, 1b, and 2). Each variable was tested using an alpha level of significance 0.05.

3. Results

Means and standard deviation for the "W group", and "T group" in pre-test and post-test are presented on Table 3. The 8-week balance training program improved all the balance performance indicators examined. More specific, analysis of the data illustrated that both groups, "W group" and "T group" demonstrated significant improvements on Biodex stability tests, in SI ($F(1, 38) = 32.22$, $p < 0.001$), API ($F(1, 38) = 32.96$, $p < 0.001$) and MLI ($F(1, 38) = 18.71$, $p = 0.007$) for the right and the left limp as well. Similarly for the balance boards, the results revealed for both groups significant improvements ($p < 0.001$) for the right and the left leg. However, improvement in balance ability with board 1a was greater ($F(1, 38) = 7.03$, $p = 0.023$) in the "T group" than the "W group" when the assessment was performed post-training.

4. Discussion

Injury prevention is important not only for professional athletes but for recreational ones, as well [9]. Balance training is an effective means of intervention to improve static postural sway and dynamic balance [9] with positive effect on injury reduction [10–13]. Unstable surface types of equipment, such as wob-

Table 3
Balance assessments

	Pre-training		Post-training	
	"W Group" M ± SD	"T Group" M ± SD	"W Group" M ± SD	"T Group" M ± SD
Biodex SI Right Leg (°)	5.3 ± 1.9	5.0 ± 1.7	4.0 ± 1.4[a]	3.4 ± 0.9[a]
Biodex SI Left Leg (°)	4.7 ± 1.7	4.9 ± 1.5	3.6 ± 1.3[a]	3.0 ± 1.0[a]
Biodex API Right Leg (°)	4.2 ± 1.4	3.9 ± 1.7	3.2 ± 1.2[a]	2.8 ± 0.8[a]
Biodex API Left Leg (°)	4.3 ± 1.2	4.0 ± 1.5	3.0 ± 1.3[a]	2.7 ± 1.0[a]
Biodex MLI Right Leg (°)	2.6 ± 1.0	2.3 ± 1.3	1.9 ± 0.5[b]	1.7 ± 0.6[b]
Biodex MLI Left Leg (°)	2.5 ± 0.9	2.2 ± 1.5	2.0 ± 0.4[b]	1.6 ± 0.8[b]
Board 1a Right Leg (s)	3.9 ± 1.0	4.1 ± 1.6	5.7 ± 1.3[a]	6.8 ± 1.4[a,c]
Board 1a Left Leg (s)	3.7 ± 1.1	4.0 ± 1.4	5.5 ± 1.7[a]	6.9 ± 1.8[a,c]
Board 1b Right Leg (s)	3.8 ± 1.5	3.9 ± 1.7	5.4 ± 1.5[a]	5.9 ± 1.8[a]
Board 1b Left Leg (s)	3.5 ± 1.2	3.7 ± 1.3	5.3 ± 1.9[a]	5.7 ± 1.9[a]
Board 2 Right Leg (s)	3.7 ± 0.9	3.9 ± 1.6	5.3 ± 1.7[a]	5.6 ± 1.4[a]
Board 2 Left Leg (s)	3.6 ± 1.0	3.7 ± 1.9	5.1 ± 1.7[a]	5.9 ± 1.5[a]

SI: Total stability index, API: antero-posterior stability index, MLI: medio-lateral stability index, board 1a: antero-posterior board motion, board 1b: medio-lateral board motion, board 2 antero-posterior and medio-lateral board motions. Data are presented as the mean ± SD ($n = 20$ in each group). [a]Indicates $p < 0.001$ between pre-training and post-training; [b]Indicates $p < 0.01$ between pre-training and post-training; [c]Indicates $p < 0.05$ between groups at post-training.

ble boards, foam rollers, swiss balls, and balance discs, have traditionally been used in the rehabilitative and preventive setting [14–18].

Analysis of the data illustrated that both the "T group" and the "W group" demonstrated a similarly decrease in instability in Total, AP and ML mean scores and increase in time on balance (boards 1a, 1b and 2) over the eight week period of the intervention for the right and the left limp as well. Only in the balance board 1a the improvement in balance ability was greater in the "T group" than the "W group".

This finding was fairly consistent with other studies in the literature, which seem to indicate that Nintendo Wii gaming console was effective in improving the overall balance abilities of learners [26,29]. Williams et al. [29] examined whether the Nintendo Wii Fit was a feasible and acceptable intervention in community-dwelling older fallers. Twenty-one community-dwelling fallers over 70 years were recruited and attended for computer-based exercises or standard care. Balance and fear of falling were assessed at weeks 0, 4 and 12. Results indicated that Nintendo Wii Fit appeared to be an acceptable falls intervention in the community-dwelling older individuals who have fallen and had the potential to improve balance and self-perceived confidence.

However, there are other studies in the literature with mixed results regarding the comparison of the two different training methods (Traditional and Nintendo Wii).

More specifically, Kliem and Wiemeyer [30] compared the efficiency of traditional and exergame-based balance training programs. Participants were performed training sessions three times a week for three weeks. The results indicated that the traditional group had a significantly greater improvement in balance test (Star Excursion Balance Test) and ball-handling, whereas the Wii group showed a significantly greater improvement in Ski Slalom.

Similarly, Brumels et al. [31] examined the impact of video games on balance performance by comparing three training programs: Konami's Dance Revolution (DDR), the Wii Fit game collection including the Wii Fit Balance Board and a traditional balance training program. Participants exercised three days a week for four weeks. According to their results, the three different training groups appeared different balance performance without clear superiority of a training program.

There is a variety of explanations why the undergraduate Physical Education students of DPESS-DUTH improved their balance ability after training with the Nintendo Wii gaming console. One possible explanation could be that the use of the Nintendo Wii gaming console allowed students to become active participants in the training process. Research has consistently shown that playing exergames increases reaction times, and improves hand – eye coordination [33]. The exercise stimuli provided during training were important enough to improve balance, at least similarly compared with the traditional exercise protocol.

Specifically, Nintendo Wii-Fit Plus software allowed motor learning to take place through the use of its interactive balance games and yoga exercises, motivating learners to become discoverers and examiners of the balance-based activities.

Moreover, another factor contributing to the balance ability could be the specificity and frequency of the feedback provided to the students by the system re-

garding both the knowledge of their performance and the knowledge of the results of their actions. Augmented feedback in the form of either knowledge of performance or knowledge of results is known to enhance motor skill learning [34]. Feedback provides information about the success of the action, it informs the learner about movement errors and it is known to motivate the learner by providing information about what has been done correctly [35].

Evaluating the outcomes of the present research study, some limitations should be noted. The first limitation was that students were only from the DPESS-DUTH. A larger and more diverse sample would provide a more stringent test for balance development on an exergame training program. Other limitation was the absence of follow-ups evaluations, in order to determine which training program could better maintain the balance ability improvements.

In conclusion, findings support the effectiveness of using the Nintendo Wii gaming console as an intervention for undergraduate Physical Education students with respect to their balance ability.

4.1. Practical applications

Thereby, the incorporation of an interactive gaming console like the Nintendo Wii in the balance training process probably constitutes an important and powerful tool available to the Physical Education professionals and sports trainers. They can benefit from the features of the console and the opportunities it provides to improve the balance ability of their students or athletes (healthy or injured) as effectively as the traditional training method. Of course, the interactive gaming console Nintendo Wii cannot replace real sports games; however it can be used by healthy athletes as a supplement exercise for balance improvement and injury prevention or by injured athletes as a part of the rehabilitation process by simulating sports specific activities.

References

[1] Burke-Doe A, Hudson A, Werth H, Riordan, DG. Knowledge of osteoporosis risk factors and prevalence of risk factors for osteoporosis, falls, and fracture in functionally independent older adults. J Geriatr Phys Ther. 2008; 31: 11–17.

[2] Gabbard CP. Lifelong Motor Development (5th ed). San Francisco, CA: Pearson Benjamin Cummings, 2008.

[3] McGuine TA, Greene JJ, Best T, Leverson G. Balance as a predictor of ankle injuries in high school basketball players. Clin J Sport Med. 2000; 10: 239–244.

[4] Goldie PA, Bach TM, Evans OM. Force platform measures for evaluating postural control: Reliability and validity. Arch Phys Med Rehabil. 1989; 70: 510–517.

[5] Olmsted LC, Carcia CR, Hertel J, Shultz SJ. Efficacy of the star excursion balance tests in detecting reach deficits in subjects with chronic ankle instability. J Athletic Train. 2002; 37: 501–506.

[6] Ross SE, Guskiewicz KM. Examination of static and dynamic postural stability in individuals with functionally stable and unstable ankles. Clin J Sport Med. 2004; 14: 332–338.

[7] Guskiewicz KM, Perrin DH. Research and clinical applications of assessing balance. J Sport Rehabil. 1996; 5: 45–63.

[8] Irrgang JJ, Whitney S, Cox E. Balance and proprioceptive training for rehabilitation of the lower extremity. J Sport Rehabil. 1994; 3: 68–83.

[9] Zech A, Hubscher M, Vogt L, Winfried B, Hansel F, Pfeifer K. Balance Training for Neuromuscular Control and Performance Enhancement: A Systematic Review. Journal of Athletic Training. 2010; 45(4): 392–403.

[10] McGuine TA, Keene JS. The effect of a balance training program on the risk of ankle sprains in high school athletes. Am J Sports Med. 2006; 34: 1103–1111.

[11] Wedderkopp N, Kaltoft M, Holm R, Froberg, K. Comparison of two intervention programmes in young female players in European handball – With and without ankle disc. Scand J Med Sci Sports. 2003; 13: 371–375.

[12] Malliou P, Gioftsidou A, Pafis G, Beneka A, Godolias G. Proprioceptive training (balance exercises) reduces lower extremity injuries in young soccer players. J Back Musculoskeletal Rehabil. 2004; 17: 101–104.

[13] Olsen OE, Myklebust G, Engebretsen L, Holme I, Bahr R. Exercises to prevent lower limb injuries in youth sports: Cluster randomised controlled trial. BMJ. 2005; 330: 449.

[14] Caraffa A, Cerulli G, Projetti M, Aisa G, Rizzo1 A. Prevention of anterior cruciate ligament injuries in soccer. A prospective controlled study of proprioceptive training. Knee Surg Sports Traumatol Arthrosc. 1996; 4: 19–21.

[15] Emery CA, Cassidy JD, Klassen TP, Rosychuk RJ, Rowe BH. Effectiveness of a home-based balance-training program in reducing sports-related injuries among healthy adolescents: A cluster randomized controlled trial. CMAJ. 2005; 172: 749–754.

[16] Gioftsidou A, Malliou P, Pafis G, Beneka A, Godolias G, Maganaris C. The effects of soccer training and timing of balance training on balance ability. European Journal of Applied Physiology 2006; 96: 659–664.

[17] Paterno MV, Myer GD, Ford KR, Hewett TE. Neuromuscular training improves single-limb stability in young female athletes. J Orthop Sports Phys Ther. 2004; 34: 305–316.

[18] Rozzi SL, Lephart SM, Sterner R, Kuligowski L. Balance training for persons with functionally unstable ankles. J Orthop Sports Phys Ther. 1999; 29: 478–486.

[19] Kawaguchi J. Ankle: Proprioceptive exercises balance rehabilitation. Biomechanics Rehabil Suppl. 1999; 23: 133–140.

[20] Yaggie JA, Campbell BM. Effects of balance training on selected skills. J Strength Cond Res. 2006; 20: 422–428.

[21] Fiore RD, Leard JS. A functional approach to the rehabilitation of the ankle and rear foot. J Athl Train. 1980; 15: 231–235.

[22] Soderberg GL, Cook TM, Rider SC, Stephenich BL. Electromyographic activity of selected leg musculature in subjects with normal and chronically sprained ankles performing on a BAPS Board. Phys Ther. 1991; 71: 514–522.

[23] Coveart T. Nintendo Wii: Getting seniors active – virtually. Long Term Care. 2008; 18(2): 24–29.
[24] Papastergiou M. Exploring the potential of computer and video games for health and physical education: A literature review. Computers and Education. 2009; 53(3): 603–622.
[25] Clark RA, Bryant AL, Pua Y, McCrory P, Bennell K, Hunt M. Validity and reliability of the Nintendo Wii Balance Board for assessment of standing balance. Gait Posture. 2010; 31: 307–310.
[26] Shih CH, Shih CT, Chu CL. Assisting people with multiple disabilities actively correct abnormal standing posture with a Nintendo Wii balance board through controlling environmental stimulation. Res Develop Disabil. 2010; 31: 936–942.
[27] Ewalt DM. Nintendo's power up: How an oddly-named gizmo rebooted the video game industry. Harvard Asia Pacific Review. 2008; 9: 38–40.
[28] Bateni H. Changes in balance in older adults based on use of physical therapy vs the Wii Fit gaming system: A preliminary study. Physiotherapy 2011.
[29] Williams MA, Soiza RL, Jenkinson AM, Stewart A. Exercising with Computers in Later Life (EXCELL) – pilot and feasibility study of the acceptability of the Nintendo Wii Fit in community-dwelling fallers. BMC Research Notes. 2010; 3(1): 238.
[30] Kliem A, Wiemeyer J. Comparison of a Traditional and a Video Game Based Balance Training Program. International Journal of Computer Science in Sport. 2010; 9: 80–91.
[31] Brumels KA, Basius T, Cortright T, Oumedian D, Brent S. Comparison of Efficacy between Traditional and Video Game Based Balance Programs. Clinical Kinesiology. 2008; 62(4): 26–31.
[32] Arnold BL, Schmitz RJ. Examination of balance measures produced by the biodex stability system. Journal of Athletic Training. 1998; 33(4): 323–327.
[33] Russell WD, Newton M. Short-term psychological effects of interactive. Video game technology exercise on mood and attention. Educational Technology and Society. 2008; 11(2): 294–308.
[34] Swanson LR, Lee TD. Effects of aging and schedules of knowledge of results on motor learning. Journal of Gerontology. 1992; 47: 406–411.
[35] Schmidt RA, Lee TD. Motor control and learning: A behavioral emphasis (3rd ed.). Champaign, IL: Human Kinetics Publishers, 1999.