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The impact of Nintendo Wii to physical education students' balance compared to the traditional approaches

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ABSTRACT

The purpose of this study was to determine whether there is a difference between an exergame-based and a traditional balance training program, in undergraduate Physical Education students. Thirty two third-year undergraduate students at the Democritus University of Thrace were randomly divided into two training program groups of 16 students each, a traditional and a Nintendo Wii group. The two training program groups performed a specific balance program for 8 weeks, two times per week, and 24 min per session. The Nintendo Wii group used the interactive games Wii Fit Plus of the Nintendo Wii console, as a training method to improve their balance, while the traditional group used an exercise program with mini trampoline and inflatable discs. Before and after the completion of the eight-week balance program, participants completed a single leg static balance assessment for both limbs on the Biodex stability system. Two-way analyses of variance (ANOVAs), with repeated measures on the last factor, were conducted to determine effect of training program groups (traditional, Nintendo Wii) and measures (pre-test, post-test) on balance test indices (SI, API, and MLI). Where initial differences between groups were verified, one-way analyses of covariance (ANCOVAs) were applied. Analysis of the data illustrated that both groups demonstrated an improvement in SI, API and MLI mean scores for the right and the left limp as well. Conclusively, findings support the effectiveness of using the Nintendo Wii gaming console as an intervention for undergraduate Physical Education students, and specifically, its effects on physical function related to balance competence.

1. Introduction

Physical activity is of inestimable value for health and the motoric development of young people. But in the course of late childhood and adolescence, it becomes less important compared to other leisure activities which do not contain any physical exercise.

Specifically, balance's ability has a fundamental role in many athletic activities and skills in postural control affecting peoples' successful performance (Erkmen, Taskin, Sanioglu, Kaplan, & Basturk, 2010; Hrysomallis, 2011). Results from prospective studies reinforce the perception that balance training can be a worthwhile supplement to the usual training of non-elite athletes to enhance certain motor skills (Hrysomallis, 2011). Traditional balance programs have included a variety of exercises aimed to increase balance by performing single and double leg stance activities on different stable and unstable surfaces, performing simultaneously other distracting tasks. Although these activities have proven helpful in improving balance they can be considered by young people performing them, boring and not very stimulating. This lack of interest in the exercises can lead to limited engagement and lower performance less than the desired engagement and performance. Hence, strategies are required to maintain the young people's motivation in physical activity. Video games, due to the enormous popularity they are enjoying, could possibly be such a strategy because exergames give an access to sport or to a more active lifestyle.

Active video games or exergames are becoming increasingly popular among children and adolescents (Coveart, 2008; Papastergiou, 2009), and these games seem to hold promise for Health Education and Physical Education (Papastergiou, 2009). Exergames are new innovative technologies that provide an interactive environment requiring gestures and movements of the upper or lower extremities in order to simulate on-screen game play. Although various forms of exergames are available, the introduction of wireless motion sensor technology was made popular by the Nintendo Wii.

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The Nintendo Wii is a recently released gaming system that features a motion sensing remote controller. The controller responds to a player's body movements and players can participate in games by interacting with on-screen environments and objects using their own body movements. The Wii offers multiple interactive games, which provide players with more choice and opportunity to select games according to their preferences. 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 (Ewalt, 2008).

According to Papastergiou (2009) the exergames are appealing to young people and effective in helping them improve their fitness levels and develop motivation for physical exercise. Patsi, Antoniou, Batsiou, Bebetsos, and Lymnioudis (2011) reported that the exergames are a popular alternative to the involvement of people with physical activities, combining entertainment with the performance. On the other hand, previous studies of exergames focused more on the various negative characteristics, such as addiction and increased aggressiveness of users (Chou & Ting, 2003; Chumbley & Griffiths, 2006; Wan & Chiou, 2006a,b) and not on their effectiveness in Health and Physical Education (Ioannidis, Vernadakis, Gioftsidou, Antoniou, & Giannousi, 2011; Papastergiou, 2009).

With the lack of research on the use of the Nintendo Wii, this study addresses the impact of Nintendo Wii to Physical Education students' balance compared to the traditional approaches. The GameFlow concept, as described below, was applied as the theoretical framework for this study, incorporating a good practice in the prescription of balance training regimes.

2. Review of literature

2.1. Flow theory in exergaming

Motivating young adult to be physically active can be a difficult challenge for physical education professionals. Motivation is defined as being an internal state that arouses, directs, and sustains human behavior (Aultman, Glynn, & Owens, 2005). Motivation is associated with students' desire to participate in activities. Although, students may be equally motivated to perform a task, there may be a difference at the foundation of their motivation. Students who are intrinsically motivated to perform a task often experience "flow" (Aultman et al., 2005). Csikszentmihalyi believed that people are most happy when they are in a state of flow or a state of total oneness with the activity at hand and the situation. The flow state is an optimal state of intrinsic motivation, where the person is fully immersed in what he or she is doing (Csikszentmihalyi, 1975). Csikszentmihalyi (1990) described flow as being an experience that is so gratifying that people are willing to do it for its own sake or with little concern for what they will get out of it, even when it is difficult. An important precursor to a flow experience is a balance between the persons' skills and the challenges associated with the task or activity. If the task is too easy or too difficult, flow cannot occur.

Csikszentmihalyi (1993) defined eight dimensions of the flow experience:

(1) Clear goals and immediate feedback
(2) Balance between the level of challenge and personal skill
(3) Merging of action and awareness
(4) Focused concentration
(5) Sense of potential control
(6) Loss of self-consciousness
(7) Time distortion
(8) Autotelic or self-rewarding experience.

Chen (2007) suggests the description of Csikszentmihalyi's Flow theory appears identical to what a player experiences when totally immersed in a video game. Although Csikszentmihalyi (1990) states that not all components are needed for an activity or technology to give users the experience of flow, most of today's video games incorporate all components (Chen, 2007).

The flow concept has been applied in many different domains, including several that relate to exergaming: sports, education and video games. Specifically, Sweetser and Wyeth (2005) present a modified version of flow, specialized to the video game domain, called "GameFlow". This model's components are:

(1) Clear Goals (Games should provide the player with clear goals at appropriate times)
(2) Feedback (Players must receive appropriate feedback at appropriate times)
(3) Challenge (Games should be sufficiently challenging and match the player's skill level)
(4) Player Skills (Games must support player skill development and mastery)
(5) Concentration (Games should require concentration and the player should be able to concentrate on the game)
(6) Control (Players should feel a sense of control over their actions in the game)
(7) Immersion (Players should experience deep but effortless involvement in the game)
(8) Social Interaction (Games should support and create opportunities for social interaction).

The GameFlow model applies these elements of flow to a person's participation in a game. These elements can thus be used to inform and evaluate game design, and provide a theoretical framework for ensuring that a participant is cognitively and emotionally involved in the game, which is necessary for the successful implementation of video games in educational exercise programs (Sweetser & Wyeth, 2005).

2.2. Previous studies in exergaming

The use of exergames in an educational context is an area of increasing research interest (Papastergiou, 2009). The use of a virtual environment such as those found in exergames has the potential for users to participate on equal terms regardless of academic achievement and to some extent, disability. Research has consistently shown that playing exergames increases reaction times, improves hand–eye coordination, raises players' self-esteem (Russell & Newton, 2008), improves players' fitness levels and develop motivation for physical exercise (Papastergiou, 2009; Patsi et al., 2011). However, several researchers have also been questioning the use video games and the promotion of inactive behaviors among adolescents and young adults (Leon & Abbott, 2007). Exergames have now become very popular due to technological advances. These new generations of video games, on the other hand, are different from previous ones because they require participants to be active in their play rather than the previously sedentary types of play (Graves, Stratton, Ridgers, & Cable, 2007).

The research on exergames has confirmed their significant contribution in increasing the participation of individuals in exercise programs (Chin et al., 2008; Patsi et al., 2011), and their impact on a healthy lifestyle and health-related activities (Baranowski, Buday, Thompson, & Baranowski, 2008; Ioannidis et al., 2011; Kato, Cole, Bradlyn, & Pollock, 2008; Shih, 2011; Williams, Soiza, Jenkinson, & Stewart, 2010).

Specifically, Brumels, Basius, Cortright, Oumedian, and Brent (2008) examined the impact of video games on balance performance by comparing three training programs: Konami's Dance 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. Furthermore, the evaluation of perceived difficulty and enjoyment of the programs had shown that the video based games are perceived as less strenuous and more enjoyable than the traditional balance program.

In a different study, Kliem and Wiemeyer (2010) 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. In addition to balance tests a questionnaire was applied concerning mood state, self-efficacy, physical activity enjoyment, flow and subjective experience in order to evaluate psychological effects of the interventions. The results indicated that the traditional group had a significantly greater improvement in SEBT and ball-handling, whereas the Wii group showed a significantly greater improvement in Ski Slalom. Psychological questionnaires revealed neither significant pre-post effects nor differences between the groups for pre and post-test measurements.

Shih (2011), evaluated whether two people with developmental disabilities would be able to actively perform simple physical activities by controlling their favorite environmental stimulation using Nintendo Wii Balance Boards. Results showed that both participants significantly increased their physical activity to activate the control system to produce environmental stimulation during the intervention phases. While, Abdel Rahman (2010) examining the effectiveness of Nintendo Wii Fit balance games in children with Down syndrome, aged from 10 to 13 years old, concluded that the Wii Fit balance games as a virtual reality-based therapy could improve balance of these children.

In another pilot study, Ioannidis et al. (2011) evaluated the impact of a balance training program with Nintedo Wii Fit. Participants were 24 undergraduate students, aged from 20 to 24 years old. The intervention lasted eight weeks and the participants attended the training program for 24 min, two times per week. Students were evaluated before and after the intervention with Biodex Stability Test. Results showed that the interactive games of Nintendo Wii Fit had a positive effect in balance.

Rogers, Slimmer, Amini, and Park (2010) examined whether Wii Fit is an effective older adult exercise program compared to a traditional exercise program with respect to functional fitness and balance. They concluded that using Wii Fit appears to be as effective as traditional exercise program for balance, but not effective for improving other measures of functional fitness. Similarly, Gokey and Odland (2010) investigated the effect of "balance game" play using Nintendo Wii Fit balance board on clinical tests of balance, postural sway, and fear of falling in elderly women. Results indicated that the 4 weeks of Wii Fit balance board training improved clinical tests of balance and mobility, but had no effect on postural sway or fear of falling in elderly women.

Finally, Williams et al. (2010), 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. Participants were interviewed on completion of the study to determine whether the intervention was acceptable. 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.

From the above, seems that exergames could be used within the framework of Health and Physical Education programs to improve the health and physical status of today's youth. However, this assertion needs to be further supported by relevant theory, application experiences and by empirical evidence. Nevertheless, to the best of the author's knowledge, little research has specifically focused on how Nintendo Wii games can be used in sports science for learning and training.

Thus, the purpose of this study was to determine whether there is a difference between an exergame-based and a traditional balance training program, in undergraduate Physical Education students. The study looked into the following main research statements:

(1) Do students, on average, report differently on the balance tests (stability index, anterior–posterior index, medial–lateral index) using the Nintendo Wii and the Traditional training program?
(2) Do students, on average, report differently on the balance tests (stability index, anterior–posterior index, medial–lateral index) for the pre-test and post-test measurements?
(3) Do the differences in means for the balance tests (stability index, anterior–posterior index, medial–lateral index) between the Nintendo Wii and the Traditional training program groups vary between the pre-test and post-test measurements?

3. Methods

3.1. Participants

This research involved thirty two ($n = 32$) third-year undergraduate students of the Department of Physical Education & Sport Sciences at the Democritus University of Thrace (DPESS-DUTh). Their age ranged from 20 to 22 years old ($M = 20.56$, $SD = .62$), while 18 of them were male (56.2%) and 14 were female (43.8%). The study population included students enrolled in every class section of 336 – New Technology in Health course offered in spring semester of the academic year 2010–2011. The sampling frame used for this study was self-selected sampling. Participants were randomly assigned to one of the two different training program groups: Traditional (6 males and 10 females) and Nintendo Wii (12 males and 4 females) creating two independent groups of 16 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. Students were informed that participation was voluntary and would have impact on their grades (two bonus points).

3.2. Instrumentation

Balance ability was assessed in all participants at baseline and after the completion of the eight-week balance program. Measurements of balance ability in the experimental and control group were taken before and immediately after the balance training program (pre-training and post-training, respectively). The balance ability assessment was performed with the Biodex Stability System. 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 (Arnold & Schmitz, 1998). The participants completed a single leg static balance assessment for both limbs (dominant and no dominant) and they tried to maintain the unstable balance platform on the horizontal position. Specifically, 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. Any balance platform deviations where reported numerically by the system in degrees (°). The system provided three different indices according to the direction of the deviations from the horizontal plane; the total stability index (SI), the anterior–posterior index (API) and the medial–lateral index (MLI), (Biodex Stability System, 1998; Rozzi, Lephart, Sterner, & Kuligowski, 1999). Three test trials were carried out and the one with the lowest score (best performance) in each of the three different indices (SI, API, and MLI) was further processed.

3.3. Procedure

Participants were randomly divided into two training program groups of 16 students each, a control group (Traditional) and an experimental group (Nintendo Wii). The two training program 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-min introductory session on how to use the Nintendo Wii Fit Plus games and its tools.

The experimental group used the interactive games Wii Fit Plus of the Nintendo Wii console, as a training method to improve their balance. Table 1 describes characteristics of these games. 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.

The Wii Fit Balance Board was placed about two meters from the television in front of the screen. The personal profile of the participant was entered into the system to allow logical progression of difficulty across the training period. The system allowed the user to map daily

Table 1
Characteristics of the Wii Fit Plus Games and Exercises used in this study.

Name	Description	Objective	Movement required for game success	Pose type	Advance level
Tree	You balance one foot against the other leg's thigh, then raise your hands together above your head	Strengthens your legs and improves your balance	Anterior–posterior & lateral weight shifting of the center of gravity over base of support	One legged	No
Standing Knee	You raise your knee in front of you while maintaining your center of gravity	Improves your thigh flexibility and lower body balance while helping your ability to concentrate	Anterior–posterior & lateral weight shifting of the center of gravity over base of support	One legged	No
King of the Dance	Hold your right foot behind you with your right hand, & then hold your left arm directly up. As you lower your left arm parallel to the floor, pull your right knee out behind you.	Strengthens your legs, improves your balance and stretches the shoulders	Anterior–posterior weight shifting of the center of gravity over base of support	One legged	No
Soccer Heading	Head the soccer balls, but avoid the cleats and pandas	Tests your balance, coordination & concentration	Full lateral weight shifting of the center of gravity over base of support	Two legged	Yes
Table Tilt	Tilt the board to roll the marbles into the holes	Tests your overall balance & coordination	Anterior–posterior & lateral weight shifting of the center of gravity over base of support	Two legged	Yes
Penguin Slide	Tilt the ice berg to have the penguin catch the fish	Tests your overall balance & coordination	Full lateral weight shifting of the center of gravity over base of support	Two legged	Yes
Ski Slalom	Ski down the mountain while navigating between the flag gates	Tests your balance & agility	Anterior–posterior & lateral weight shifting of the center of gravity over base of support	Two legged	Yes
Tightrope Walk	Cross the tightrope without losing balance but watch out for the trap	Test your overall balance & concentration	Anterior–posterior & lateral weight shifting of the center of gravity over base of support	Two legged	Yes
Snowboard Slalom	Snowboard around the flags	Tests your balance & agility	Anterior–posterior & lateral weight shifting of the center of gravity over base of support	Two legged	Yes
Balance Bubble	Maneuver the bubble through the course without touching the walls	Tests your lower body balance & agility	Anterior & lateral weight shifting of the center of gravity over base of support	Two legged	Yes

progress, set goals, and chart activities. The system also provided an on-screen trainer to lead the user through exercise and demonstrate proper form. The participants were instructed to step on the Wii Fit balance board, and follow the instructions for the different games available. At the beginning and at the end of each session the participants performed a series of yoga exercises (a. tree pose, b. standing knee pose, and c. king of the dance pose) for a total duration of 10 min. In the meantime, they had to deal with Nintendo Wii Fit Plus interactive balance games for 14 min. After each exercise – game there was a 15 s break. Specifically, the training program of the Nintendo Wii group is presented below on Table 2.

The control group used an exercise program with mini trampoline and inflatable discs, as a training method to improve their balance. The participants performed two balance exercises in mini trampoline for a total duration of 3 min on each leg and then followed 6 balance exercises in inflated rubber hemisphere attached to a rigid platform (BOSU) for a total duration of 9 min on each leg. The training program was the same for each session. Specifically, the program followed by the control 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 s 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 s each leg).
(2) Exercises in inflated rubber hemisphere attached to a rigid platform (BOSU)
   a. Standing on BOSU's round soft surface with one foot, in an attempt to maintain balance (2 repeats of 45 s each leg).
   b. Standing on BOSU's round soft surface with one foot, in an attempt to maintain balance, while lifting the non-support leg forward and backward (2 repeats of 45 s each leg).
   c. Standing on BOSU's round soft surface 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 s each leg).
   d. Standing on BOSU's flat hard surface with one foot, in an attempt to maintain balance (2 repeats of 45 s each leg).
   e. Standing on BOSU's flat hard surface with one foot, in an attempt to maintain balance, while lifting the non-support leg forward and backward (2 repeats of 45 s each leg).
   f. Standing on BOSU's flat hard surface 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 s each leg).

Between repetitions on balance exercises each session break 15 s elapse.

Before and after the completion of the eight-week balance program, participants completed a single leg static balance assessment for both limbs (dominant and no dominant). Participants were tested in three different indices provided from the Biodex Stability System (SI, API, and MLI) and performed three 20 s practice trials and three 20 s test trials out of which only the best score was recorded for each stability index.

3.4. Design

The experimental design used for the purpose of the study was a pre-test/post-test control group design, where participants were randomly assigned to the groups. Random assignment was accomplished by computerized generation of random student numbers and assignment to training program groups based on those numbers. According to Gall, Gall, and Borg (2007), this experimental design was controlled for all major threats to internal validity except from one threat of external validity associated with interaction between pre-testing and experimental treatments. To avoid this threat, both groups (Traditional, Nintendo Wii) had the same training conditions and were examined by the same subject experts. The equivalence between participants of both groups ensured that the main variation was in the training program delivery. In this case, post-test changes in the experimental group, could be attributed to the experimental treatment. Specifically, the experiment on balance tests was a factorial design with training program groups (Traditional, Nintendo Wii) and repeated measurements (pre-test and post-test) as independent variables, and balance performance as dependent variable.

Table 2
Training program of the Nintendo Wii group.

Week	Yoga exercises (6 min)	Balance games (14 min)	Yoga exercises (4 min)
Weeks 1–2	King of the Dance (2 min – one minute each leg) Tree (2 min – one minute each leg) Standing Knee (2 min – one minute each leg)	Ski Slalom (5 min) Table Tilt (5 min) Soccer Heading (4 min)	Tree (2 min – one minute each leg) Standing Knee (2 min – one minute each leg)
Weeks 3–4	King of the Dance (2 min – one minute each leg) Tree (2 min – one minute each leg) Standing Knee (2 min – one minute each leg)	Balance Bubble (4 min) Penguin Slide (4 min) Ski Slalom (3 min) Snowboard Slalom (3 min)	Tree (2 min – one minute each leg) Standing Knee (2 min – one minute each leg)
Weeks 5–6	King of the Dance (2 min – one minute each leg) Tree (2 min – one minute each leg) Standing Knee (2 min – one minute each leg)	Penguin Slide (3 min) Ski Slalom (3 min) Snowboard Slalom – advance level (4 min) Balance Bubble – advance level (4 min)	Tree (2 min – one minute each leg) Standing Knee (2 min – one minute each leg)
Week 7	King of the Dance (2 min – one minute each leg) Tree (2 min – one minute each leg) Standing Knee (2 min – one minute each leg)	Soccer Heading – advance level (4 min) Ski Slalom – advance level (3 min) Table Tilt – advance level (3 min) Tightrope Walk – advance level (4 min)	Tree (2 min – one minute each leg) Standing Knee (2 min – one minute each leg)
Week 8	King of the Dance (2 min – one minute each leg) Tree (2 min – one minute each leg) Standing Knee (2 min – one minute each leg)	Snowboard Slalom – advance level (3 min) Balance Bubble – advance level (3 min) Table Tilt – advance level (4 min) Tightrope Walk – advance level (4 min)	Tree (2 min – one minute each leg) Standing Knee (2 min – one minute each leg)

Table 3
Means and standard deviations for pre-test and post-test scores (right and left limp) of the two groups on balance tests (SI, API, MLI).

Measurements	Traditional ($N = 16$)		Nintendo Wii ($N = 16$)	
	M	*SD*	*M*	*SD*
SI – right limp 1st measure	4.41	2.21	5.46	2.64
SI – right limp 2nd measure	2.9	1.14	4.04	2.05
SI – left limp 1st measure	3.87	1.89	5.4	3.01
SI – left limp 2nd measure	2.68 (3.01*)	.84 (.23*)	3.84 (3.51*)	1.81 (.23*)
API – right limp 1st measure	3.96	2.14	4.78	2.27
API – right limp 2nd measure	2.44	1.13	3.24	1.65
API – left limp 1st measure	3.22	1.77	4.63	2.89
API – left limp 2nd measure	2.1 (2.39*)	.71 (.23*)	3.24 (2.95*)	1.75 (.23*)
MLI – right limp 1st measure	2.14	.89	2.48	1.09
MLI – right limp 2nd measure	1.71	.49	2.06	.97
MLI – left limp 1st measure	2.34	1.01	2.82	1.28
MLI – left limp 2nd measure	1.94	.59	2.25	.86

* Adjusted mean & standard deviation.

4. Results

Homogeneity of variance and Sphericity was verified by the Box's *M* test, the Levene's test and the Mauchly's test (Green & Salkind, 2007). 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 effect of training program groups (traditional, Nintendo Wii) and measures (pre-test, post-test) on balance test indices (SI, API, and MLI). Each variable was tested using an alpha level of significance .05. Where initial differences between groups or correlation between means were verified, one-way analyses of covariance (ANCOVAs) were applied (Green & Salkind, 2007). Means and standard deviation for the traditional and the Nintendo Wii group in pre-test and post-test are presented on Table 3, while results of each analysis are presented separately below.

4.1. Balance stability index comparison

The balance stability index comparison on the right limp showed a significant main effect for the Time, $F(1, 30) = 30.41$, $p < .001$. Two paired-sample *t* tests were conducted to follow up the significant Time main effect and assess differences across time within each training program group. Differences in mean ratings of the balance performance (SI) in traditional group were significantly different between pre-test and post-test, $t(15) = 3.96$, $p < .001$. Similarly, differences in mean ratings of the balance performance (SI) in the Nintendo Wii group were significantly different between pre-test and post-test, $t(15) = 3.84$, $p < .001$. The magnitude of the effect as assessed by Cohen's *d* was large for both training program groups, traditional ($d = .98$) and Nintendo Wii ($d = .96$). As shown in Fig. 1, the post-test balance SI scores were remarkably greater than pre-test balance SI scores for both groups.

The balance stability index comparison on the left limp showed significant initial differences between the two training program groups $t(30) = 3.45$, $p < .05$. For removing the obscuring effects of pre-existing individual differences among participants, one-way analysis of covariance (ANCOVA) was applied. Preliminary checks verified that there was no violation of the assumptions of normality, linearity, homogeneity of variances, homogeneity of regression slopes, and reliable measurement of the covariate. After adjusting for pre-intervention scores, there was no significant difference between the two training program groups on balance SI post-test scores, $F(1, 29) = 2.17$, $p = .15$, partial eta squared = .07 (see Fig. 2). There was a medium to strong relationship between the pre-test and post-test balance SI scores, as indicated by a partial eta squared value of .59.

4.2. Balance anterior–posterior index comparison

The balance anterior–posterior index comparison on the right limp showed a significant main effect for the Time, $F(1, 30) = 33.08$, $p < .001$. Two paired-sample *t* tests were conducted to follow up the significant Time main effect and assess differences across time within

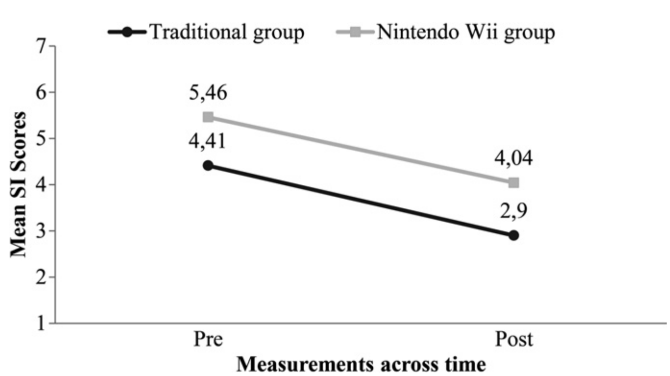

Fig. 1. Right limp's performance of the two groups on all measurements across time of the SI test.

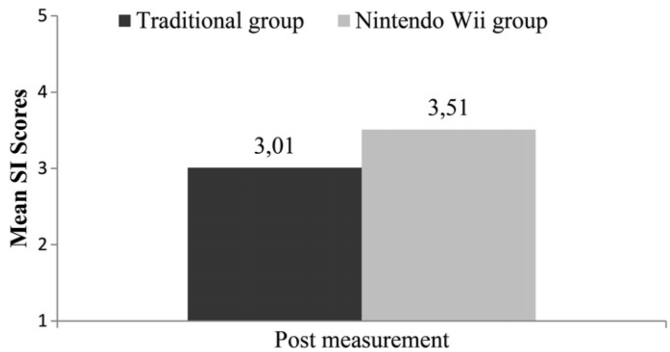

Fig. 2. Left limp's performance of the two groups on all measurements across time of the SI test.

each training program group. Differences in mean ratings of the balance performance (API) in traditional group were significantly different between pre-test and post-test, t (15) = 3.98, p < .001. Similarly, differences in mean ratings of the balance performance (API) in the Nintendo Wii group were significantly different between pre-test and post-test, t (15) = 4.16, p < .001. The magnitude of the effect as assessed by Cohen's d was large for both training program groups, traditional (d = .99) and Nintendo Wii (d = 1.04). As shown in Fig. 3, the post-test balance API scores were remarkably greater than pre-test balance API scores for both groups.

The balance anterior–posterior index comparison on the left limp showed significant initial differences between the two training program groups t (30) = 3.33, p < .05. For removing the obscuring effects of pre-existing individual differences among participants, one-way analysis of covariance (ANCOVA) was applied. Preliminary checks verified that there was no violation of the assumptions of normality, linearity, homogeneity of variances, homogeneity of regression slopes, and reliable measurement of the covariate. After adjusting for pre-intervention scores, there was no significant difference between the two training program groups on balance API post-test scores, F (1, 29) = 2.79, p = .11, partial eta squared = .09 (see Fig. 4). There was a medium to strong relationship between the pre-test and post-test balance API scores, as indicated by a partial eta squared value of .55.

4.3. Balance medial–lateral index comparison

The balance medial–lateral index comparison on the right limp showed a significant main effect for the Time, F (1, 30) = 5.33, p < .05. Two paired-sample t tests were conducted to follow up the significant Time main effect and assess differences across time within each training program group. Differences in mean ratings of the balance performance (MLI) in traditional group were significantly different between pre-test and post-test, t (15) = 3.98, p < .001. Moreover, differences in mean ratings of the balance performance (MLI) in the Nintendo Wii group were significantly different between pre-test and post-test, t (15) = 4.16, p < .001. The magnitude of the effect as assessed by Cohen's d was medium d = .49 for traditional and small to medium d = .33 for Nintendo Wii training group. As shown in Fig. 5, the post-test balance MLI scores were remarkably greater than pre-test balance MLI scores for both groups.

Similarly, the balance medial–lateral index comparison on the left limp showed a significant main effect for the Time, F (1, 30) = 7.97, p < .05. Two paired-sample t tests were conducted to follow up the significant Time main effect and assess differences across time within each training program group. Differences in mean ratings of the balance performance (MLI) in traditional group were significantly different between pre-test and post-test, t (15) = 3.98, p < .001. In addition, differences in mean ratings of the balance performance (MLI) in the Nintendo Wii group were significantly different between pre-test and post-test, t (15) = 4.16, p < .001. The magnitude of the effect as assessed by Cohen's d was medium for both training program groups, traditional (d = .50) and Nintendo Wii (d = .51). As shown in Fig. 6, the post-test balance MLI scores were remarkably greater than pre-test balance MLI scores for both groups.

5. Discussion

The empirical evidence to support the effectiveness of exergame systems in Health and Physical Education is still rather limited. However, as deduced from the conducted review of literature, overall it presents a positive picture. Therefore, the purpose of this study was

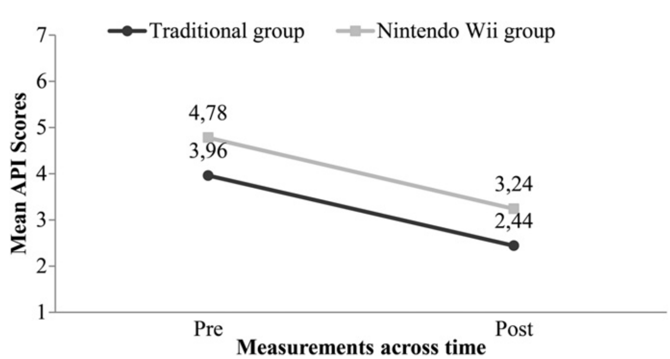

Fig. 3. Right limp's performance of the two groups on all measurements across time of the API test.

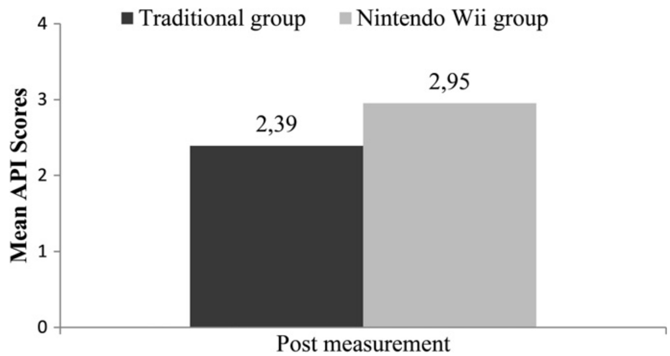

Fig. 4. Left limp's performance of the two groups on all measurements across time of the API test.

to compare the effects of an intervention using the Nintendo Wii and a Traditional balance training program in undergraduate Physical Education students. Data were collected through the use of the Biodex Stability System measuring three different indices: the SI, the API and the MLI.

Analysis of the data illustrated that both the traditional and the Nintendo Wii training program groups demonstrated a decrease in SI, API and MLI mean scores over the eighth week of the intervention for the right and the left limp as well. While this decrease suggests an improvement in balance for both groups, the difference between the traditional student scores and the Nintendo Wii student scores in the above stability indices (right and left limp) was not significant. Overall, this decrease in scores to perform the SI, API and MLI tests indicated that both groups demonstrated an increase in functional mobility, which is related to balance.

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 (Abdel Rahman, 2010; Ioannidis et al., 2011; Shih, 2011; Williams et al., 2010). However, there are other studies in the literature with mixed results regarding the comparison of the two different training methods (Traditional & Nintendo Wii). For example, Kliem and Wiemeyer (2010) reported that the traditional group had a significantly greater improvement in SEBT and ball-handling, whereas the Wii group showed a significantly greater improvement in Ski Slalom. Similarly, Brumels et al. (2008) mentioned a significant improvement in single leg stance on a force plate for the Wii group, while the traditional group improved significantly in the SEBT measurement.

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 explanation could be that the balance training program was task driven and required problem solving. These features of training have been shown to promote behavioral changes as well as the further development of physical abilities in adolescents and young adults.

Another possible explanation could be that the use of the Nintendo Wii gaming console allowed students to become active participants in the training process. Specifically, Nintendo Wii Fit Plus software allowed motor learning to take place through the use of its interactive balance games and yoga exercises, supporting 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 regarding 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 (Swanson & Lee, 1992). 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 (Schmidt & Lee, 1999).

Evaluating the outcomes of the present research study, several limitations should be noted. The first limitation was the duration of the training program. The sessions were 24 min of activity, two times per week, for 8 weeks. Although some variables indicated change, longer study duration may have been helpful to show changes in function. In addition, more time should be provided for participants to become comfortable with the activities and learn how to correctly use the equipment and participate in the activities.

A second 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. Additionally, the results reported in this study are based on single

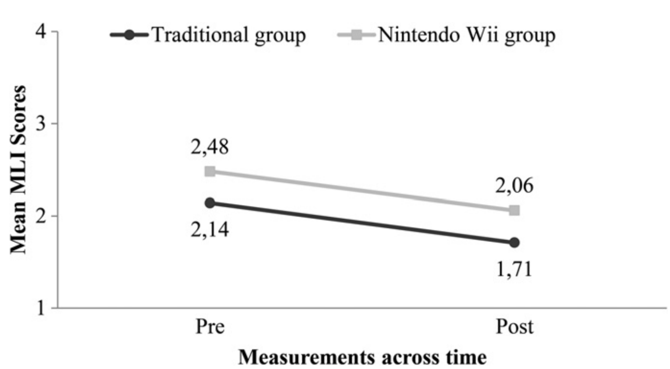

Fig. 5. Right limp's performance of the two groups on all measurements across time of the MLI test.

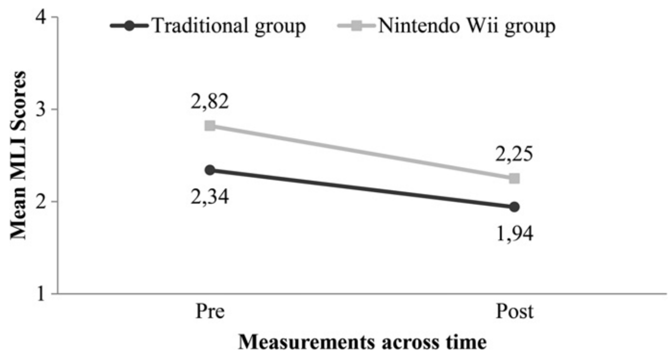

Fig. 6. Left limp's performance of the two groups on all measurements across time of the MLI test.

interactive gaming software (Nintendo Wii Fit Plus). This is a case-specificity problem. It is possible that different gaming software covering different games & exercises would yield different results.

Another limitation to be noted was the heterogeneity of the participants concerning the gender (male, female). It is likely that a more homogeneous sample might have shown different results for the balance improvement.

A further limitation was that special consideration has not been made for special needs of people with learning difficulties. The participants taking part in this research were considered academically sound and therefore the researcher was not made aware at any time that any of the participants fell into the category of "slow learners". These participants had not been given any extra help or extra benefits at any time while this research was been conducted.

Finally, no attempt was made to limit participation in other activities offered by the university or outside of them, so there is no knowledge of which training program, other than the Nintendo Wii and traditional training the participants were involved in.

Despite these limitations, researchers hope that this study adds to the knowledge base for Physical Education practice in terms of using exergames to improve balance ability. In addition, it will empower Physical Education professionals and researchers to be innovators and seek out, develop, and research newly emerging technology and ideas to further the Physical Education field.

6. Conclusion

Based on the research and the analysis of the data, this study not only has significant practical implications for the educators at DPESS-DUTh in Greece and it's students, but also provides contributions to the current literature related to the use of Nintendo Wii gaming console on Physical Education training programs. In particular, the findings of this study can be used to inform Physical Education professionals serving a variety of clients, including undergraduate Physical Education students about the opportunities that exergames provide in physical abilities development. For example, as a form of alternative teaching method to train small groups of children with multiple abilities, disabilities and health issues, producing fair and reasonable results (Papastergiou, 2009; Shih, 2011).

In addition, while previous research has shown that VR systems and video games can be beneficial in improving physical function in adolescents and young adults, the Nintendo Wii offers a more affordable and accessible option. With the advancement in technology offered by the Nintendo Wii, making it a readily available and reasonably priced system when compared to previously developed VR systems, more facilities will be able to incorporate its use into their programming to improve physical function. As opposed to previous home-based gaming systems designed to improve physical function through game play (Flynn, Palma, & Bender, 2007), the Nintendo Wii does not require any additional equipment and offers players more choice in games available.

Finally, since video game play is considered a leisure activity, the Physical Education profession should be a leader in the use of the Nintendo Wii and development of research examining its effectiveness in improving functioning and quality of life.

Conclusively, findings support the effectiveness of using the Nintendo Wii gaming console as an intervention for undergraduate Physical Education students, and specifically, its effects on physical function related to balance competence. 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. Physical Education professionals can benefit from the features of the console and the opportunities it provides to improve the balance ability of their students or clients as effectively as the traditional training method. Of course, the interactive gaming console Nintendo Wii cannot replace real sports games, but may promote audience participation in leisure activities that can lead to physical functional improvements as well as competence in leisure activities.

Research and development in this area will continue with the view to refining any kind of exergame environment so that it meets and fulfills all expectations for supporting and enhancing Health and Physical Education training programs. Future research should examine other areas of physical function, including ability to perform activities of daily living, range of motion, grip strength, coordination, upper extremity use, lower extremity use, trunk control, and endurance. In addition, the literature should focus not only on improving physical function, but also on its possible impact on psychological function. Cognitive function, attention, and memory are also areas that should be examined. Finally, as more research on the use of the Nintendo Wii in Health and Physical Education settings is completed and evidence of its effectiveness emerge; its use could be expanded to multiple settings and populations.

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