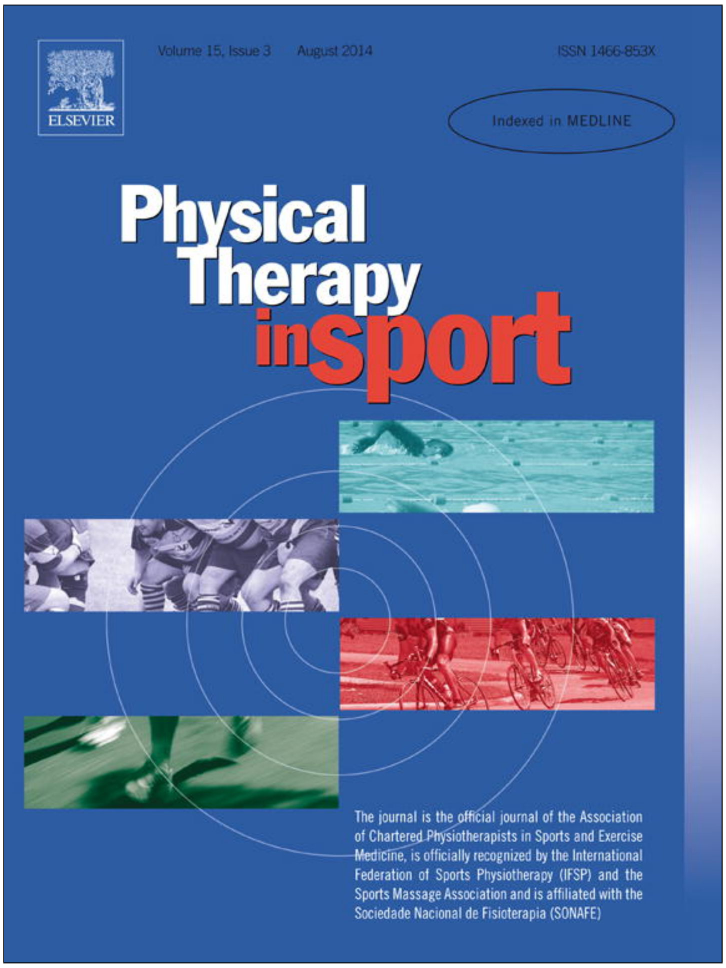
ELSEVIER
Volume 15, Issue 3 August 2014
ISSN 1466-853X
Indexed in MEDLINE
Physical Therapy in sport
The journal is the official journal of the Association of Chartered Physiotherapists in Sports and Exercise Medicine, is officially recognized by the International Federation of Sports Physiotherapy (IFSP) and the Sports Massage Association and is affiliated with the Sociedade Nacional de Fisioterapia (SONAFE)

Physical Therapy in Sport 15 (2014) 148–155

Contents lists available at ScienceDirect

Physical Therapy in Sport

journal homepage: www.elsevier.com/ptsp

Original research

The effect of Xbox Kinect intervention on balance ability for previously injured young competitive male athletes: A preliminary study

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A R T I C L E I N F O

Article history:
Received 20 November 2012
Received in revised form
21 July 2013
Accepted 21 August 2013

Keywords:
Male soccer players
Exergaming
Ankle
Balance control
Enjoyment
Compliance

A B S T R A C T

Objectives: To explore the outcomes of an Xbox Kinect intervention on balance ability, enjoyment and compliance for previously injured young competitive male athletes.
Design: Experimental pre-/post-test design with random assignment.
Participants: Sixty-three previously injured young competitive male athletes, aged 16 ± 1 years.
Interventions: Participants were divided into three groups: one group received Xbox Kinect (XbK) training, one group received Traditional physiotherapy (TP) training, and one group did not receive any balance training (Control). Intervention involved a 24 min session, twice weekly for 10 weeks.
Main outcome measures: Overall stability index (OSI) and limits of stability (LOS) scores using the Biodex Stability System. Enjoyment using the Physical Activity Enjoyment Scale. Self-reported compliance.
Results: Both experimental groups demonstrated an improvement in OSI and LOS mean scores for the right and the left limb after the intervention. In addition, the results revealed important differences between the experimental groups and the control group on balance test indices. Group enjoyment rating was greater for XbK compared with TP, while the compliance rating was not.
Conclusions: These findings suggest that the use of XbK intervention is a valuable, feasible and pleasant approach in order to improve balance ability of previously injured young competitive male athletes.

1. Introduction

Dynamic balancing is a person's ability to maintain stability of posture during movement (Shin & Demura, 2012). Balance improvement is one of the most important therapeutic goals in a wide range of conditions like lower limb surgeries, joint sprains, amputations, risk of falls etc. (Hazime, Allard, Ide, Siqueira, Amorim, & Tanaka, 2012). In addition, balance ability has a fundamental role in many physical activities, and skill in postural control may designate successful performance (Erkmen, Taskin, Sanioglu, Kaplan, & Baştürk, 2010; Hrysomallis, 2011). Thus, a lot of physical education (PE) professionals and physiotherapists place balance exercises as a part of the daily training routine (Erkmen et al., 2010). Park, Kim, Komatsu, Park, and Mutoh (2008) declared that the ability to efficiently maintain balance relies on physical fitness factors such as muscle strength and anaerobic capacity. Freiwald, Papadopoulos, Slomka, Bizzini, and Baumgart (2006) mentioned the importance of coordinative balance training in science-based training programs to prevent injuries and improve performance. Traditional physiotherapy (TP) balance interventions are based on the automatic repetition of specific movements, using unstable balance platforms or exercises such as single-leg stance or single-leg hops in order to partly restore proprioceptive deficits and functional stability of the ankle (Holmes & Delahunt, 2009). Although these movements have proven helpful in improving balance they can be considered by young people performing them, boring and not very stimulating (Gil-Gómez, Lloréns, Alcañiz, & Colomer, 2011). This lack of interest in the movements can lead to limited engagement and lower performance. Therefore, strategies are required to maintain young people's motivation in physical activity.

In recent years there has been an increase in the development of exergaming (Papastergiou, 2009; Staiano & Calvert, 2011). Exergaming 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 (Vernadakis, Gioftsidou, Antoniou, Ioannidis, & Giannousi, 2012). An example of such a product is the Microsoft Xbox Kinect (XbK). This console is operated through movement of the player, without the need for a controller. The XbK holds the

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http://dx.doi.org/10.1016/j.ptsp.2013.08.004

Guinness World Record of being the “fastest selling consumer electronics device” by selling 8 million units in its first 60 days (Kampally, Durga, & Manohar, 2011). The sales records indicate the extreme popularity of XbK franchise and its use as alternative forms of exercise.

Exergaming has been integrated in to Health and PE programs to improve balance defects and has been shown to be a reliable and inexpensive way to improve neuromuscular control (Clark, Bryant, Pua, McCrory, Bennell, & Hunt, 2010; Shih, 2011; Young, Ferguson, Brault, & Craig, 2011). Research has also shown that easy access to a facility or equipment is a major factor in compliance with an exercise program (Nitz, Kuys, Isles, & Fu, 2010; vander Schee & Boyles, 2010). Since the XbK is relatively inexpensive and easily accessible, it has the potential to be an alternative exercise tool if proven to be effective.

Previous studies on exergaming have shown positive outcomes on the physiological benefits of exercise (Miyachi, Yamamoto, Ohkawara, & Tanaka, 2010; Penko & Barkley, 2010; Russell & Newton, 2008). Furthermore, there are studies concerning the impact of exergaming which have shown greater benefits in balance (Abdel Rahman, 2010; Vernadakis et al., 2012; Williams, Soiza, Jenkinson, & Stewart, 2010; Yamada et al., 2011), strength and burning calories (Nitz et al., 2010; Papastergiou, 2009). Specifically, Williams, Doherty, Bender, Mattox, and Tibbs (2011) explored the benefits that exergaming activities may have on the balance of 22 community living older adults. The results pointed out the potential effectiveness of utilizing exergaming as a therapeutic agent in occupational therapy practice. Similarly, Brumels, Basius, Cortright, Oumedian, and Brent (2008) compared the effects of exergaming training to traditional rehabilitation techniques for improving balance. In the experiment, a traditionally trained group and two exergaming groups (Dance Dance Revolution and Nintendo Wii) completed a four week training session on their assigned intervention. Results showed that balance was improved in the exergaming groups and in some cases improvements were better than the traditional group. Additionally, the evaluation of perceived difficulty and enjoyment of the programs showed that exergaming was perceived as less strenuous and more enjoyable than the traditional balance program.

As far as the XbK is concerned research has shown that playing on the XbK elicited greater energy expenditure than playing on the Nintendo Wii (O'Donovan, Hirsch, Holohan, McBride, McManus, & Hussey, 2012). Furthermore, Chang, Chen, and Huang (2011) assessed the possibility of rehabilitating two young adults with motor impairments using a Kinect-based system and concluded that the two participants significantly increased their motivation for physical rehabilitation, thus improving exercise performance during the intervention phases. Nevertheless, to the best of the author's knowledge, no studies exist demonstrating the outcomes of the XbK in previously injured young competitive athletes' balance performance. Thus, given the importance of exploring alternative forms of exercise, and considering the fact that low balance ability has been demonstrated to be associated with an increased risk of lower limb ligament injuries in young athletes' (Gstöttner, Neher, Scholtz, Millonlg, Lembert, & Raschner, 2009; Hrysomallis, McLaughlin, & Goodman, 2007; Plisky, Rauh, Kaminski, & Underwood, 2006), this study addresses the effect of XbK in previously injured young competitive athletes' balance, enjoyment and compliance compared to TP approaches. It was hypothesized that both XbK and TP training programs would improve young athletes' balance ability in contrast to a control group. It was also hypothesized that the XbK approach's effect on enjoyment and compliance would be greater than a TP approach.

2. Methods

2.1. Participants

Sixty-three young competitive male athletes were recruited from local soccer clubs of Western Macedonia in Greece to participate in the current study. Participants were included if they had sustained an ankle injury (lateral sprain) two or more times during the last year, but not during the last month. Individuals were excluded if they were still receiving treatment, were not back to sport or full activity, or had any co-existing musculoskeletal disorders. Body height and body weight were measured with standard techniques to the nearest 0.1 cm and 0.1 kg, respectively. In addition, the players were interviewed to estimate the number of years of regular experience/training in soccer. Participants did not have any previous exposure to exergaming, such as XbK, perceived to affect balance. Informed consent was obtained from each parent of the young athletes prior to their voluntary participation in the study. The experimental procedure complied with the Helsinki declaration of 1975 and was approved by the Institutional Review Board of the Democritus University of Thrace.

2.2. Instrumentation

2.2.1. Biodex Stability System

The Biodex Stability System (BSS) was used to assess the participant's ability to maintain dynamic postural stability on an unstable platform with a maximum of 20° of surface tilt (Arnold & Schmitz, 1998). The overall stability index (OSI) and the limits of stability (LOS) are two major indices to evaluate the progress of training effects using the BSS measures and therefore they have been used in this study (Hall & Brody, 2005).

In the OSI test the participants completed a single-leg static balance assessment for both limbs and they tried to maintain the unstable balance platform in 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 were reported numerically by the system in degrees (°).

The LOS test prompted participants to move a cursor, viewed on a liquid crystal display, by leaning toward a target while standing on the fully unstable platform. Participants were instructed to complete the test as quickly and accurately as possible, keeping their body in a straight line, using each ankle as the primary axis of rotation. The LOS test measured the time and accuracy with which participants transferred their estimated center of gravity, moving the cursor to intercept each of 8 successive targets on the display screen. The targets were positioned at 45° intervals around a central target that represented the participant's center of pressure under static conditions. Each target was randomly highlighted, and the athletes reached the target by leaning and returning to the center position before the next target was selected and displayed on the screen. The test was completed when all 8 targets had been reached. Target placement was preset by the manufacturer at 75% of the LOS.

The balance indices which included the OSI and the LOS scores as computed and given by the system were collected and used for further analysis. Lower values represented better stability than higher ones.

2.2.2. Physical Activity Enjoyment Scale

A modified Physical Activity Enjoyment Scale (PACES) was used to assess enjoyment while undertaking the activities, with 5 items from the original 18 items being included in the study (see

Table 1
Training program of the XbK group.

	Rally Ball	Reflex Ridge	River Rush	2000 Leaks
Game's description	There is a ball in front of you, just floating in the air. The player can use any body part to reach out and whack it.	An obstacle machine is hidden away in the mountains. When you see an obstacle coming, you have to jump, duck step to the right or left to avoid it. When you see pins coming at you, collect them by reaching up and grabbing them. The objective is to gather as many pins as possible.	The player controls the raft with his/her body by moving side to side and jumping.	Fish poke holes in the observatory glass and you have to fix them. The player uses all of his/her body parts to keep the water from leaking into the room.
Week 1–4	2 Repeats of 3 min in basic free play mode (9 levels). Break 60 s between repetitions.	2 Repeats of 3 min in basic free play mode (9 levels). Break 60 s between repetitions.	2 Repeats of 3 min in basic free play mode (6 levels). Break 60 s between repetitions.	2 Repeats of 3 min in basic free play mode (9 levels). Break 60 s between repetitions.
Week 5–7	2 Repeats of 3 min in intermediate free play mode (9 levels). Break 60 s between repetitions.	2 Repeats of 3 min in intermediate free play mode (9 levels). Break 60 s between repetitions.	2 Repeats of 3 min in intermediate free play mode (6 levels). Break 60 s between repetitions.	2 Repeats of 3 min in intermediate free play mode (9 levels). Break 60 s between repetitions.
Week 8–10	2 Repeats of 3 min in advanced free play mode (9 levels). Break 60 s between repetitions.	2 Repeats of 3 min in advanced free play mode (9 levels). Break 60 s between repetitions.	2 Repeats of 3 min in advanced free play mode (6 levels). Break 60 s between repetitions.	2 Repeats of 3 min in advanced free play mode (9 levels). Break 60 s between repetitions.

Appendix). Items were chosen to reflect the study aims. Individuals rated the extent to which they agreed with each item on a 7-point Likert-type scale. For each training session, participant's responses were summed to give a score ranging from 5 to 35, and an average enjoyment score of the total sessions was calculated. The PACES has been found to have both reliability and validity in physical activity environments (Kendzierski & DeCarlo, 1991). The reliability of the modified version was confirmed in the current study (Cronbach's alpha = 0.897).

2.2.3. *Self-reported compliance*

The degree of compliance with the program was determined with the question 'To what extent did you comply with the balance-training program?' Participants rated the extent to which they agreed with the question on a 10-point Likert-type scale. The mean self-reported compliance with the program was determined by calculating the mean score on this question for each training session.

2.3. *Procedure*

Participants were randomly divided into three individual groups of 21 athletes each, one control group and two experimental groups (XbK, TP). The control group did not receive any balance training, while the two experimental groups performed a specific balance program for 10 weeks, two times per week, and 24 min per session. According to Hoffman and Payne (1995) 10 weeks of proprioception ankle disk training on previously injured young healthy athletes can decrease postural sway parameters significantly. Before the intervention started, the XbK group was given a 45 min introductory session on how to use the XbK adventure games and its tools. All sessions were led by a single experienced physiotherapist (different to the physiotherapist who performed the balance tests) in order to provide instruction on how to perform each exercise.

The XbK group used the adventure games of the XbK console, as a training method to improve their balance. The playing area was

Table 2
Training program of the TP group.

	Description	Frequency
Exercises in mini trampoline (6 min)	1. High skipping (jump on spot 3 times on each leg) and landing on a limb every time	2 Repeats of 45 s each leg & break 15 s between repetitions
	2. 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 & break 15 s between repetitions
BOSU ball exercises (18 min)	3. Standing on BOSU's round soft surface with one foot, in an attempt to maintain balance	2 repeats of 45 s each leg & break 15 s between repetitions
	4. 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 & break 15 s between repetitions
	5. 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 & break 15 s between repetitions
	6. Standing on BOSU's flat hard surface with one foot, in an attempt to maintain balance	2 Repeats of 45 s each leg & break 15 s between repetitions
	7. 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 & break 15 s between repetitions
	8. 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 & break 15 s between repetitions

16 × 12 m, and the televisions used were three standard 32-inch flat screens. The participant's movements were monitored by a motion detecting camera as they played XbK games (Rally Ball, Reflex Ridge, River Rush & 2000 Leaks). The games varied each week starting with the easiest level and ending with the most difficult level. Participants had the opportunity to choose the order in which they would play the balance games, without allowing them to change their time engagement. Transitions between games within training periods of 24 min took approximately 60 s. Table 1 describes the training program of the XbK group.

The TP group used an exercise program with a mini trampoline and inflatable discs, as a training method to improve their balance. The participants performed two balance exercises on the mini trampoline for a total duration of 3 min on each leg and then followed 6 balance exercises on an inflated rubber hemisphere attached to a rigid platform (BOSU) for a total duration of 9 min on each leg. Participants attempted to maintain balance, while they tried to catch a ball thrown at them in various directions by the researcher. Although, the balance-training exercises were the same for each session, a progressive plan with increasing difficulty over the 10 week period was used. The progression for these exercises was achieved by throwing a (different) weighted ball at such a (different) distance that it is difficult for the participants to control the body within its base of support. Progression was based on the physiotherapist's opinion of successful completion of all the movements with no loss of balance during each 60 s trial (Rasool & George, 2007). Table 2 describes the training program of the TP group.

At the end of each balance-training session (XbK and TP) participants completed the modified PACES and the self-reported compliance. Furthermore, before and after the completion of the 10 weeks balance program, participants completed a single-leg static balance assessment for both limbs. Participants were tested on two different indices provided from the BSS. For the OSI, participants performed three 20 s practice trials and three 20 s test trials out of which only the best score was recorded. For the LOS, they performed three practice trials and three test trials out of which only the best score was recorded. The maximum movement time allowed was 3 min. During the experimental period, participants were specifically instructed not to perform exercises (balance or otherwise) outside of this regimen.

2.4. Data analysis

Normality of distribution was tested with the Kolmogorov–Smirnov test (Green & Salkind, 2007). A series of three-way analyses of variance (ANOVAs) with repeated measures were conducted to evaluate the effect of training programs and limb status on balance performance over a series of measurements across time. The dependent variable was balance test indices (OSI, LOS). The within-individuals factor was time with two levels (pre-test, post-test) and the between-subject factors were training program groups with three levels (XbK, TP, control) and limb status with two levels (injured, uninjured). The Training programs × Time, the Limb status × Time and the Training programs × Limb status × Time interaction effect, as well as the Training programs, Limb status and Time main effect were tested using the multivariate criterion of Wilks's lambda (Λ). Significant differences between the means across time were tested at the 0.05 alpha level. An effect size was computed for each analysis using the eta-squared statistic (η^2) to assess the practical significance of findings. Cohen's guidelines were used to interpret η^2 effect size: 0.01 = small, 0.06 = medium and 0.14 = large (Cohen, 1988). Furthermore, two independent-samples t tests were conducted to compare participants' enjoyment and compliance toward the XbK and the TP approaches. The dependent variables were the enjoyment and the compliance scores.

Table 3
Means and standard deviations for pre-test and post-test scores of the experimental groups and the control group on balance tests.

Measurements	Group	Limb status	N	Pre-test $M \pm$ SD	Post-test $M \pm$ SD
OSI – right limb	TP	Injured	13	4.61 ± 2.66	2.95 ± 1.38[a]
		Uninjured	8	4.59 ± 1.86	2.66 ± 0.56[a]
	XbK	Injured	9	4.47 ± 1.54	2.73 ± 1.34[a]
		Uninjured	12	5.09 ± 1.67	3.60 ± 1.19[a]
	Control	Injured	10	4.96 ± 2.17	4.87 ± 2.17
		Uninjured	11	5.00 ± 1.79	4.90 ± 1.79
OSI – left limb	TP	Injured	8	3.81 ± 2.25	2.53 ± 0.95[a]
		Uninjured	13	4.14 ± 1.40	2.95 ± 0.98[a]
	XbK	Injured	12	4.17 ± 1.07	2.96 ± 0.82[a]
		Uninjured	9	4.35 ± 0.94	2.72 ± 0.53[a]
	Control	Injured	11	4.71 ± 1.83	4.61 ± 1.83
		Uninjured	10	4.26 ± 0.93	4.17 ± 0.93
LOS – right limb	TP	Injured	13	136.69 ± 57.82	64.77 ± 27.77[a]
		Uninjured	8	137.50 ± 47.96	81.75 ± 24.22[a]
	XbK	Injured	9	133.89 ± 47.09	71.00 ± 42.10[a]
		Uninjured	12	128.33 ± 55.29	86.83 ± 38.57[a]
	Control	Injured	10	138.70 ± 54.37	132.10 ± 52.77
		Uninjured	11	127.73 ± 55.31	118.36 ± 53.77
LOS – left limb	TP	Injured	8	123.38 ± 62.21	68.00 ± 17.84[a]
		Uninjured	13	118.85 ± 59.92	61.08 ± 33.43[a]
	XbK	Injured	12	124.58 ± 49.12	67.42 ± 28.28[a]
		Uninjured	9	132.56 ± 58.06	70.11 ± 22.44[a]
	Control	Injured	11	122.55 ± 48.15	116.09 ± 47.83
		Uninjured	10	127.70 ± 58.31	121.80 ± 55.43

[a] Indicates $p < 0.001$ between pre-test and post-test (for any given leg).

3. Results

The mean age, height and weight of the participants was 16 ± 1 years (mean ± SD), 174 ± 2.5 cm and 64 ± 3.5 kg respectively, while the years of training were 4.7 ± 1.3 years and the average time from the last injury was 16 ± 4.2 weeks. Table 3 shows the mean scores and the standard deviations for the experimental and control groups across time.

3.1. Balance OSI comparison

The balance OSI comparison showed a significant (Training programs × Time interaction) effect on the right, $\Lambda = 0.72$, $F(2, 57) = 11.31$, $p < 0.001$, partial $\eta^2 = 0.284$ and the left limb, $\Lambda = 0.68$, $F(2, 57) = 13.54$, $p < 0.001$, partial $\eta^2 = 0.322$. The Limb status × Time [$\Lambda = 0.99$, $F(1, 57) = 0.198$, $p = 0.876$, partial $\eta^2 = 0.005$] and the Training programs × Limb status × Time [$\Lambda = 0.99$, $F(2, 57) = 0.213$, $p = 0.809$, partial $\eta^2 = 0.007$] interactions on the right limb and the Limb status × Time [$\Lambda = 0.99$, $F(1, 57) = 0.234$, $p = 0.630$, partial $\eta^2 = 0.004$] and the Training programs × Limb status × Time [$\Lambda = 0.98$, $F(2, 57) = 0.489$, $p = 0.616$, partial $\eta^2 = 0.017$] interactions on the left limb were not significant. Analyzing the interaction on the right limb for each level of the independent variable, a significant effect of repeated factor Time was only found in the XbK group, $\Lambda = 0.63$, $F(1, 57) = 33.44$, $p < 0.001$, partial $\eta^2 = 0.370$ and the TP group, $\Lambda = 0.58$, $F(1, 57) = 41.37$, $p < 0.001$, partial $\eta^2 = 0.421$, but not for the control group, $\Lambda = 0.99$, $F(1, 57) = 0.128$, $p = 0.722$, partial $\eta^2 = 0.002$. Pairwise comparisons using t-test with a Bonferroni adjustment revealed significant mean differences in OSI scores between pre-test and post-test in XbK and TP group. Similarly, analyzing the interaction on the left limb for each level of the independent variable, a significant effect of repeated factor Time was only found in

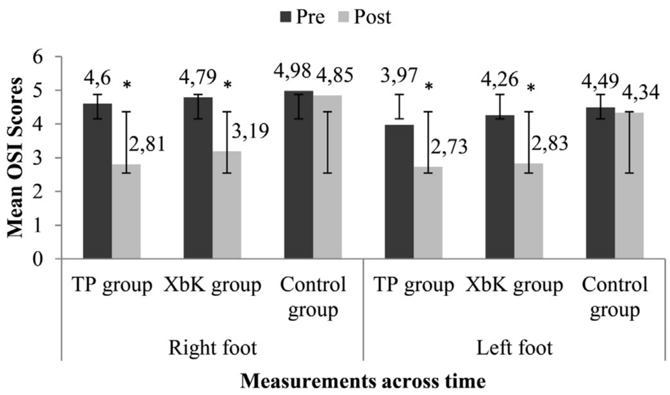

Fig. 1. Right and left limbs' performance of the three groups on all measurements across time of the OSI test.

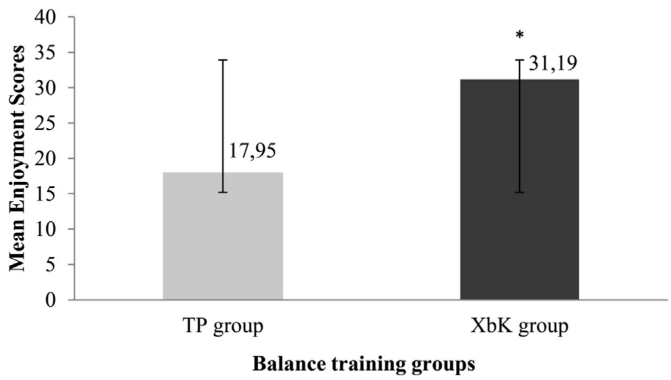

Fig. 3. Mean enjoyment scores as a function of training programs.

the XbK group, $\Lambda = 0.52$, $F(1, 57) = 53.46$, $p < 0.001$, partial $\eta^2 = 0.484$ and the TP group, $\Lambda = 0.59$, $F(1, 57) = 40.58$, $p < 0.001$, partial $\eta^2 = 0.416$, but not for the control group, $\Lambda = 0.99$, $F(1, 57) = 0.266$, $p = 0.608$, partial $\eta^2 = 0.005$. Pairwise comparisons using *t*-test with a Bonferroni adjustment showed significant mean differences in OSI scores between pre-test and post-test in XbK and TP group. As shown in Fig. 1, the post-test OSI scores were significantly lower than pre-test OSI scores for both experimental groups and not for the control group.

3.2. Balance LOS comparison

The balance LOS comparison showed a significant Training programs × Time interaction effect on the right, $\Lambda = 0.68$, $F(2, 57) = 13.32$, $p < 0.001$, partial $\eta^2 = 0.319$ and the left limb, $\Lambda = 0.72$, $F(2, 57) = 11.01$, $p < 0.001$, partial $\eta^2 = 0.279$. The Limb status × Time [$\Lambda = 0.97$, $F(1, 57) = 1.713$, $p = 0.196$, partial $\eta^2 = 0.029$] and the Training programs × Limb status × Time [$\Lambda = 0.98$, $F(2, 57) = 0.444$, $p = 0.644$, partial $\eta^2 = 0.015$] interactions on the right limb and the Limb status × Time [$\Lambda = 0.99$, $F(1, 57) = 0.051$, $p = 0.823$, partial $\eta^2 = 0.001$] and the Training programs × Limb status × Time [$\Lambda = 0.99$, $F(2, 57) = 0.026$, $p = 0.974$, partial $\eta^2 = 0.001$] interactions on the left limb were not significant. Analyzing the interaction on the right limb for each level of the independent variable, a significant effect of repeated factor Time was only found in the XbK group, $\Lambda = 0.59$, $F(1, 57) = 39.45$, $p < 0.001$, partial $\eta^2 = 0.409$ and the TP group, $\Lambda = 0.50$, $F(1, 57) = 56.83$, $p < 0.001$, partial $\eta^2 = 0.499$, but not for the control group, $\Lambda = 0.99$, $F(1, 57) = 0.620$, $p = 0.434$, partial $\eta^2 = 0.011$. Pairwise comparisons using *t*-test with a Bonferroni adjustment revealed significant mean differences in LOS scores between pre-test and post-test in XbK and TP group. Similarly, analyzing the interaction on the left limb for each level of the independent variable, a significant effect of repeated factor Time was only found in the XbK group, $\Lambda = 0.57$, $F(1, 57) = 43.24$, $p < 0.001$, partial $\eta^2 = 0.431$ and the TP group, $\Lambda = 0.61$, $F(1, 57) = 37.26$, $p < 0.001$, partial $\eta^2 = 0.395$, but not for the control group, $\Lambda = 0.99$, $F(1, 57) = 0.470$, $p = 0.496$, partial $\eta^2 = 0.008$. Pairwise comparisons using *t*-test with a Bonferroni adjustment showed significant mean differences in LOS scores between pre-test and post-test in XbK and TP group. As shown in Fig. 2, the post-test LOS scores were significantly lower than pre-test LOS scores for both experimental groups and not for the control group.

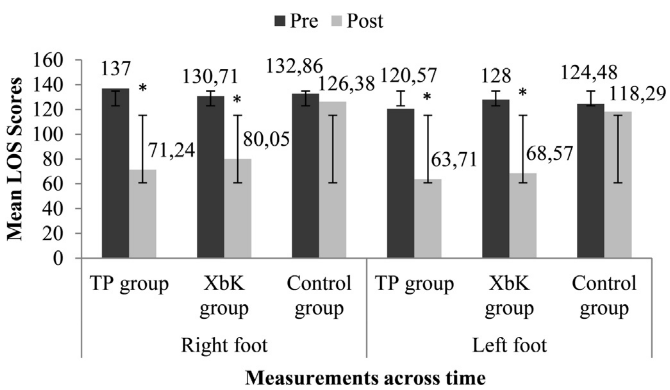

Fig. 2. Right and left limbs' performance of the three groups on all measurements across time of the LOS test.

3.3. Enjoyment comparison

An independent-samples *t* test was conducted to evaluate the hypothesis that the XbK approach's effect on enjoyment would be stronger than the TP approach. The test was significant, $t(40) = 20.44$, $p = 0.000$, and the results supported the research hypothesis. Participants in the XbK approach ($M = 31.19$, $SD = 2.18$) on average enjoyed the balance activities more than those in the TP approach ($M = 17.95$, $SD = 2.01$). The 95% confidence interval for the difference in means was quite narrow, ranging from 11.93 to 14.55. The magnitude of the effect as assessed by eta square index was large $\eta^2 = 0.91$. As shown in Fig. 3, the XbK approach mean scores on enjoyment were remarkably greater than the TP approach.

3.4. Compliance comparison

An independent-samples *t* test was conducted to evaluate the hypothesis that the XbK approach's effect on compliance would be stronger than on TP approach. The test was not significant, $t(40) = -1.198$, $p = 0.238$, and the results did not support the research hypothesis. Participants in the XbK approach ($M = 8.01$, $SD = 0.93$) on average complied with the balance activities as much as the TP approach ($M = 7.61$, $SD = 1.19$). The 95% confidence interval for the difference in means was quite narrow, ranging from −1.06 to 0.27. The magnitude of the effect as assessed by eta square index was small $\eta^2 = 0.03$. According to Warden et al. (2008), a self-reported compliance with the program of 60–65% seems to be a fair number.

4. Discussion

The purpose of this study was to compare the effects of an intervention using the XbK and a TP balance-training program in previously injured young competitive athletes. Data were collected through the use of the BSS measuring two different indices: OSI and LOS.

Analysis of the data illustrated that only the experimental groups demonstrated a decrease in OSI and LOS mean scores over the ten weeks of the intervention for the right and the left limb. While this decrease suggests an improvement in balance for both groups, the difference between the TP athletes scores and the XbK athletes scores in the above stability indices (right and left limb & injured versus uninjured limb) were not significant. Overall, this decrease in scores to perform the OSI and LOS tests indicated that only the experimental groups demonstrated an increase in functional mobility, which is related to balance, without the limb status (injured, uninjured) variable to affect their performances. These results support the hypothesis that XbK and TP training programs promotes the improvement of dynamic balance of young athletes, in contrast to the control group.

Few studies have investigated the use of exergaming and their effect on balance performance (Vernadakis et al., 2012). Some of them have used the Nintendo Wii-Fit games in children with Down's syndrome (Abdel Rahman, 2010) or in older adults with a history of falls (Williams et al., 2010, 2011; Yamada et al., 2011), and all reported improvements in balance ability. Although the participants in the present study were previously injured, young competitive athletes using the XbK adventure games, the findings are in agreement with those of the previous studies. Such agreement indicates that benefits of using exergaming are not limited and/or related only to those population's groups and to the Wii console.

The findings are also in agreement with three other studies based on small samples sizes (Nitz et al., 2010) and assessments of the short-term effects (Abdel Rahman, 2010; Williams et al., 2010, 2011; Yamada et al., 2011). The present study appears to be the only study that has assessed changes due to XbK adventure games, with a larger number of individuals, using a randomized control design without any balance exercises to account for naturally occurring balance over time.

Examination of the perceived enjoyment and compliance regarding the individual balance programs allowed the researchers to discover that XbK based balance programs were apparently more enjoyable and perhaps less difficult than the TP program exercises, while concerning the compliance rating was not. It is unclear whether these programs are actually easier, but the fact remains that XbK intervention led to increased enjoyment and compliance. These finding are in agreement with Brumels et al. (2008) who concluded that exergaming was perceived as less strenuous and more enjoyable than the traditional balance program, with similar compliance to the TP approach. A reason why the exergaming may be considered more enjoyable than TP programs, leading to similar compliance with them is because they may provide more mental stimulation and challenge for participants. Due to the nature of exergaming they may also be considered to be unstructured physical activity. Therefore, the young athletes may have not perceived themselves to be participating in physical activity when they were exergaming.

It can, thus, be deduced that XbK adventure simulation games are effective in favoring the acquisition of balance ability and their transfer to real-world contexts under certain conditions. However, this argument remains to be further supported by empirical research. It should also be noted that the findings of this study show that when it comes to specific motor skill acquisition, such as balance ability, the game should encourage intentional learning and should explicitly present – and let the player sense – the targeted skill through appropriate simulation.

It seems that the XbK balance software proved successful in providing games that incorporated competitiveness, goal achievement and interest. In addition, not only did the XbK gaming console provide the athletes with a choice over his or her own learning but with a sense of achievement in completing the training program effectively. For example, the participants could work at their own pace regardless of the level at which they are supposed to be. This promotes self-confidence because it gives the participants a feeling/sense of control over what they have learned and achieved. Papastergiou (2009) and Vernadakis et al. (2012) claim that the exergame-based intervention has allowed users to become a more active participant in his/her own learning.

There are several explanations for the improvement of young athletes' balance ability after training with the XbK. 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 XbK allowed young athletes to become active participants in the training process. Specifically, XbK software allowed motor learning to take place through the use of its interactive balance games, supporting players 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 participants 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 motivate the learner and enhance motor skill learning (Schmidt & Lee, 2005; Swanson & Lee, 1992).

Regarding, the comparison between the balance scores of the previously injured limb with the opposite uninjured limb, it appears that it may not adversely influence measurable balance ability. So, if a prior injury does not impair balance in the medium-to-long term, by what mechanism does a prior injury increase the risk of re-injuring? It could be postulated that, just because a prior injury may be the most commonly identified risk factor for re-injury, it may not be the most important. Intrinsic factors such as talar tilt and calcaneal eversion may potentially contribute to increased risk of ligament injury and re-injury (Beynnon, Renstrom, Alosa, Baumhauer, & Vacek, 2001).

This finding was consistent with other studies in the literature which indicated that soccer players (Hrysomallis, McLaughlin, & Goodman, 2005) and college athletes (Evans, Hertel, & Sebastianelli, 2004; Powers, Buckley, Kaminski, Hubbard, & Ortiz, 2004) with a history of ankle joint injury did not display increased postural sway. Therefore, whether balance ability was reduced by a prior ligament injury might be dependent on the severity, time elapsed since the injury, and adherence and effectiveness of the rehabilitation program. In the short term (several weeks after an ankle sprain), postural stability was reduced and significant differences between the injured and uninjured ankle were revealed (Hertel, Buckley, & Denegar, 2001; Holme, Magnusson, Becher, Bieler, Aagaard, & Kjaer, 1999; Leanderson, Bergqvist, Rolf, Westblad, Wigelius-Roovers, & Wredmark, 1999). However, at follow up, these differences were not maintained. As the participants in this study had all undergone a physiotherapy rehabilitation program it is possible that any postural deficits might have been resolved with the rehabilitation that participants had received. Nevertheless, the type of rehabilitation that participants received was not considered in this study. The findings from the current study suggested that postural control was not a problem at this stage of the rehabilitation process.

The current research was limited in some aspects. First, the young competitive athletes were only from local soccer clubs of

Western Macedonia in Greece. A larger and more diverse sample would provide a more stringent test for balance development on an exergame training program. Secondly, the results reported in this study are based on a single interactive gaming software (XbK adventures). This is a case-specificity problem. It is possible that different gaming software covering different games & exercises would yield different results. In addition, strength changes in the participants were not measured in the current study for logistical reasons and thus the influence of this cannot be clarified. Although, the information related to the improvement of balance competence revealed from this study does not give a complete picture of the balance-training process in previously injured young athletes. This information can be the premise for future prospective or intervention studies involving strength exercises in those with balance and adds to previous research on balance improvements in the lower extremity. Finally, the researchers did not control physical activity of the participants during the time of the experimental procedure but simply instructed them not to perform exercises (balance or otherwise) outside of this regimen. There is always a possibility that if young athletes participated in such activities this could significantly affect the results. Researchers did not assess any aspect of functional movement and the impact the training could have on these parameters.

Despite these limitations, several practical implications emerge from this study. First, exergaming could be used as a form of alternative method to train small groups of young adults and children with multiple abilities, disabilities and health issues, producing fair and reasonable results. Secondly, exergaming interventions may serve as effective prevention tools for improving balance and reducing injuries in young athletes. Moreover, in the prevention and rehabilitation setting, the potential use of exergaming with visual feedback can facilitate the reduction of physical time that the physiotherapist and the PE professional have to spend with the young athletes. Finally, given the fact that the XbK can be used at home, many of the barriers to training such as membership cost, need to travel, time restraints, dress requirements and lack of immediate quantifiable feedback are addressed, thereby increasing the likelihood of exercise compliance.

5. Conclusions

The findings support the effectiveness of using the XbK as an intervention for previously injured, young competitive athletes, and specifically, its effects on physical ability related to balance competence, enjoyment and compliance. Thereby, the incorporation of an interactive gaming console like the XbK, in the balance-training process, probably constitutes an important, powerful and affordable tool, available to the physiotherapist and the PE professional. Physiotherapists and PE professionals can benefit from the features of the console and the opportunities it provides to improve the balance ability of their athletes or clients as effectively as the TP training method. Future studies should explore preference when given choices between participating in traditional forms of functional mobility versus XbK games. Such information can be useful for families, physiotherapists, PE professionals, and functional mobility program coordinators to provide the most inviting activities for participation.

Conflict of interest

None declared.

Ethical approval

The experimental procedure complied with the Helsinki declaration of 1975 and was approved by the Institutional Review Board of Democritus University of Thrace.

Funding

None declared.

Appendix

Physical Activity Enjoyment Scale

Please rate how you feel at the moment about the physical activity you have just been doing.

[a]I enjoy it	1	2	3	4	5	6	7	I hate it
I dislike it	1	2	3	4	5	6	7	I like it
It's no fun at all	1	2	3	4	5	6	7	It's a lot of fun
[a]I feel good physically while doing it	1	2	3	4	5	6	7	I feel bad physically while doing it
I am very frustrated by it	1	2	3	4	5	6	7	I am not at all frustrated by it

[a] Item is reverse scored (i.e.: 1 = 7, 2 = 6. 3 = 5, 4 = 4, 5 = 3, 6 = 2, 7 = 1).

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