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Original Article

Utilizing physically interactive videogames for the balance training of adolescents with deafness within a physical education course

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Abstract:
Problem Statement: Adolescents with deafness exhibit lower levels of performance in balance ability compared to their hearing peers. Thus, innovative balance training methods are needed. **Purpose:** This study aimed at comparing the effectiveness of two physical activity intervention programs -a program involving Nintendo Wii Fit Plus physically interactive videogames (exergames) and a traditional adapted Physical Education (PE) program- for the balance training of adolescents with deafness. Furthermore, it investigated students' views and experiences, and their parents' and instructors' views, regarding the exergame program. **Approach:** The study was conducted within PE classes in a special school and involved 10 students with severe hearing loss (aged 17-19 years) split into two equal-sized groups, the exergame group (EG) and the traditional PE group (TG), five parents (one per EG student) and five instructors. Both programs had identical time duration (5 weeks, 2 weekly sessions, 15 minutes per session for each student). Both quantitative and qualitative data were elicited. Prior and after intervention, both groups underwent the Flamingo Balance Test for balance ability assessment. After intervention, EG students, their parents and instructors were interviewed. **Results:** Initially, the two groups did not differ in balance ability. Following intervention, both programs yielded an improvement in balance ability, although this improvement did not reach statistical significance. The EG students found the exergame program motivational, easy-to-follow and beneficial. Parents' and instructors' views were positive overall. **Conclusions:** Balance exergames constitute a feasible, well-accepted and motivational balance training mode for adolescents with deafness, the effectiveness of which should be further researched.
Key words: Physically interactive videogames, exergames, balance, deafness, adolescents, physical education.

Introduction

Triathlon A person is considered as having deafness in case hearing loss exceeds 70 decibels and it is so severe that the individual is not in position to process linguistic information through hearing, with or without amplification and use of hearing aids (Panteliadou, 2014). Hearing loss affects a person's communication, behavior, and also motor development (Wiegersma & Van der Velde, 1983; Kaltsatou, Fotiadou, Tsimaras, Kokaridas & Sidiropoulou, 2013) with limited physical activity, which, in turn, affects their general health condition and psychological state, causing individuals to experience depression and stress (Woodcock & Pole, 2007).

Children or adolescents with deafness often have reduced orientation, kinesthetic and rhythm perception ability, the latter impacting the development of various motor abilities that are related to the fundamental physical ability of balance (Gheysen, Loots & van Waelvelde, 2008; Kaltsatou et al., 2013). Numerous research studies have shown that children or adolescents with deafness exhibit lower levels of performance in balance ability compared to their hearing peers (e.g. Horak, Shumway-Cook, Crowe & Owen Black, 1988; Siegel, Marchetti & Tecklin, 1991; Zwierzchowska, Gawlik & Grabara, 2004; Azevedo & Samelli, 2008; Gheysen et al., 2008).

Children and adolescents with deafness need and can benefit from adapted Physical Education (PE) programs for the development of their motor abilities and skills, and should be offered equal exercise opportunities as their hearing peers (Gheysen et al., 2008; Kaltsatou et al., 2013). As for balance ability, adapted exercise programs are particularly important including exercises targeting the improvement of proprioception, namely the individual's ability to recognize the position of body in space and to control movements (Valovich McLeon, 2008; Di Stefano, Clark & Padua, 2009; Winnick, 2011). Balance exercises usually involve specialized equipment such as balance boards and inflated balance disks (Malliou, Gioftsidou, Pafis, Beneka, & Godolias, 2004).

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However, traditional therapeutic exercise programs are often boring and usually require specialized equipment that is more difficult or expensive to acquire than the widely available commercial gaming platforms that users can also have in their homes (Shih, Shih & Chu, 2010). As for balance, treating balance disorders is often a costly and time-consuming procedure. Thus, motivational, low-cost and easy-to-apply balance rehabilitation methods are needed (Gil-Gomez, Lozano, Alcaniz & Perez, 2009).

Physically interactive videogames -or ‘exergames’- are a relatively new generation of videogames, believed to have the potential to positively influence youngsters’ physical activity, given that they combine exercise and gaming (Yang, Smith, & Graham, 2008; Vernadakis, Gioftsidou, Antoniou, Ioannidis, & Giannousi, 2012). In such ‘exertainment’ games, the user's body movements control the virtual activity within the game environment (Epstein, Beecher, Graf & Roemmich, 2007). Exergames have attracted the interest of many researchers, who maintain that those games can spur motivation towards exercise (Yang et al., 2008; Papastergiou, 2009; Whitehead, Johnston, Nixon & Welch, 2010; Staiano, Abraham & Calvert, 2013; Vernadakis, Kouli, Tsitskari, Gioftsidou, & Antoniou, 2014). Furthermore, they may offer to individuals with disabilities opportunities to improve their motor performance within a non-threatening environment (e.g. Hilton, Attal, Best, Reistetter, Trapani & Collins, 2015).

In fact, Nintendo Wii Fit exergames and the Nintendo Wii Balance Board have been used for balance training in children with disabilities with positive results. Abdel Rahman (2010) compared the effectiveness of a 6-week program involving three Wii Fit balance exergames (‘Soccer Heading’, ‘Tightrope Walk’, ‘Penguin Slide’) to that of a 6-week traditional balance training program, in children with Down’s syndrome aged 10 to 13 years, reporting that the Wii Fit group significantly improved their balance ability compared to the traditional group. Shih and colleagues (2010) utilized the Wii Balance Board for correcting body posture in upright posture, in children (aged 8 to 9 years) with multiple disabilities, cerebral palsy and balance difficulties. A sequence of basic and intervention phases was applied and compared, revealing children’s balance ability in the intervention phases as being significantly higher, leading to the conclusion that the Wii Balance Board -a widely available commercial product- can help children with disabilities to actively regulate their body posture. Wii Fit exergames have also been found effective in improving balance ability in studies in children and adolescents with cerebral palsy (Tarakci, Ozdincler, Tarakci, Tutuncuoglu & Ozmen, 2013; Tarakci, Ersoz Huseyinsinoglu, Tarakci & Razak Ozdincler, 2016) and spastic cerebral palsy (Atasavun Uysal & Baltaci, 2016; Gatica-Rojas, Cartes-Velásquez, Méndez-Rebolledo, Guzman-Muñoz & Lizama, 2016) as well as in interventions in children with poor motor performance and balance control (Mombarg, Jelsma & Hartman, 2013) and children with probable developmental coordination disorder (Jelsma, Geuze, Mombarg & Smits-Engelsman, 2014; Jelsma, Smits-Engelsman, Krijnen & Geuze, 2016).

Exergames could, thus, be possibly used for the balance training of children and adolescents with deafness. However, reviewing the literature it seems that although various studies (such as the afore-mentioned ones) have examined the development of balance ability through exergames in children and adolescents with various disabilities, no study thus far has targeted adolescents -nor children- with deafness. Thus, the research study presented in this paper appears to be the first of its kind exploring the development of balance ability through exergames in adolescents with deafness.

The aim of this study was to compare two intervention programs of physical activity targeted at adolescent students with deafness for the development of balance skills -one comprising Nintendo Wii Fit Plus exergames and another one comprising traditional adapted PE exercises aiming to develop balance ability. Furthermore, the study investigated students’ views and experiences regarding the exergame-based intervention program, as well as their parents’ and instructors’ views regarding this program.

Material & methods

Participants

The sample of the study was 10 students (6 boys and 4 girls) aged 17 to 19 years (M=18.4, SD=0.7) with severe hearing loss exceeding 70 decibels (db). The students were attending a public special school for hard of hearing adolescents and adolescents with deafness located in Athens, Greece. All students did not have any motor or accompanying problems and did not bear any cochlear implants. Moreover, they had not participated in any exergame balance training program nor had they used any Wii Fit balance exergame prior research. Formation of the sample included purposive (judgmental) sampling due to the small size of the population (Cohen & Manion, 1994).

For the purposes of the research the sample was split into two equal-sized groups (of 3 boys and 2 girls each): an Exergame Group (EG) that participated in the exergame-based intervention program, and a Traditional Group (TG) that participated in the traditional adapted exercise intervention program. Five parents -one for each student of the EG- and five instructors of the EG students working at the school -a mathematics teacher, a science teacher, a psychologist, a speech therapist and a social worker- also participated in the research. All participants gave their informed consent prior to their voluntary participation in the study.

Intervention programs

Both programs (for the EG and the TG) took place in the school, during the regular PE classes, with identical time duration. In specific, both programs lasted 5 weeks each one, and each comprised 2 sessions per week. In both programs, for each participant, each session lasted about 15 minutes. Thus, both groups underwent a total time of about 150 minutes exercise intervention. Both programs were taught by the same PE teacher.

The TG program consisted of the following balance exercises:

- Walking 'tiptoes-heel' on the walking line for 2 min and 30 sec [Bruininks-Osetelsky Test of Motor Proficiency BOTME (Bruininks, 1978)]
- Balance on one foot on the ground, alternating right and left leg, the bent leg touching the knee of the other leg, for 1 min and 30 sec on each leg and an interval of 10 sec between sets [Berg Balance Scale (Berg, Wood-Dauphinee, Williams & Maki 1992)]
- Inflated flat balance disk 1: balance on one leg on the soft surface of the disk, alternating right and left leg, the bent leg touching the knee of the other leg, for 1 min and 30 sec on each leg and an interval of 10 sec between sets (Malliou et al., 2004; Gioftsidou, Malliou, Pafis, Beneka, Godolias & Maganaris, 2006; Willardson, 2007)
- Inflated flat balance disk 2: balance on one leg on the soft surface of the disk, alternating right and left leg, the bent leg touching the knee of the other leg and the hands touching the waist, for 1 min and 30 sec on each leg and an interval of 10 sec between sets (Malliou et al., 2004; Gioftsidou et al., 2006; Willardson, 2007)
- Inflated flat balance disk 3: balance on one leg on the soft surface of the disk, alternating right and left leg, the bent leg touching the knee of the other leg and the student trying to catch a ball thrown to him/her in different directions while maintaining his/her balance, for 1 min and 30 sec on each leg and an interval of 10 sec between sets (Malliou et al., 2004; Gioftsidou et al., 2006; Willardson, 2007)

The EG program consisted of balance exercises conducted through various balance exergames in Nintendo Wii Fit Plus using the Wii Balance Board. Those exercises had similar characteristics as the TG exercises, had also been used in prior studies on balance training in children (e.g. Abdel Rahman, 2010) and adults (e.g. Deutsch, Robbins, Morrison & Bowlby, 2009; Sugarman, Burstin, Weisel-Eichler & Brown, 2009) and were as follows:

- 'Soccer Heading' exercise
- 'Ski Jump' exercise
- 'Ski Slalom' exercise
- 'Snowboard Slalom' exercise
- 'Table Tilt' exercise
- 'Tightrope Walk' exercise
- 'Bubble Balance' exercise
- 'Penguin Slide' exercise
- 'Lotus Focus (Zazen)' stability and meditation exercise
- 'Yoga' exercises ('Standing Knee Pose' and 'Yoga Tree Pose')

Instruments

The research elicited both quantitative and qualitative data. Collection of pre and post quantitative data assessing students' balance ability, prior and after application of the intervention programs, included the use of the Flamingo Balance Test (FBT) applied to all students of the sample. Qualitative post data were gathered through interviews of the EG students, as well as their parents and instructors, regarding the exergame-based intervention program. Specifically, semi-structured interviews were conducted in an attempt to gain insight in students' views and experiences concerning their participation in the exergames (e.g. enjoyment, motivation, perceived usefulness, efficacy and ease of use), as well as in their parents' and instructors' views on the exergame-based intervention program. Prior conduction of interviews, three interview guides -comprising questions that would serve as a base for the discussions- were constructed (one for each category of interviewee, that is, student, parent and instructor).

The guide for the student interviews consisted of questions, through which students expressed their perceptions concerning: a) whether the balance training through the exergames was helpful or not, b) any advantages or disadvantages of this method compared to traditional balance training exercises, c) whether they managed to understand what they had to do in order to succeed in the exergames or not, d) how they managed -or not- to correct themselves during gameplay, e) whether they believed that the exergames were safe, enjoyable and easy to use or not, f) whether they preferred exergames to static videogames or not, and g) whether they would like exergames to become a regular part of their PE curriculum or not. Students were also asked how they perceived receiving bonus points during gameplay.

The guide for the parent interviews comprised questions, through which parents were asked whether -or not-: a) their child engages in playing videogames outside school, b) they believe that their child's balance improved through the intervention program, c) their child had discussed with them regarding the intervention program, d) they believe that exergames constitute a safe and entertaining exercise mode for their child.

Finally, the instructor interview guide consisted of questions, through which instructors were asked whether -or not-: a) they believe that their students' balance improved through the intervention program, b) their students had discussed with them concerning the intervention program, c) they believe that exergames -like those used during the intervention program- can be used for balance training purposes.

Procedure

Official permission to conduct the research was asked and obtained from the Greek Ministry of Education. According to the conditions of the permission: a) before the beginning of the research, the school administration and the instructors of the school were informed regarding the research procedures, b) they consented that the research be conducted, c) the students participated in the research, after they and their parents had been informed regarding the research procedures and had been explained that participation was not compulsory and that all data regarding participants would be analyzed anonymously. The criteria for inclusion in the research were: being 17 to 19 years old, having severe hearing loss exceeding 70 db, not bearing any cochlear implants and not having other accompanying disabilities (apart from deafness). The students that fulfilled the criteria and wanted to participate in the research constituted the sample of the study.

Prior intervention, the height and weight of all 10 students of the sample were measured and all 10 students underwent the FBT pre-measurement. Next, the students were split into two equal groups (EG and TG) of 5 students each (3 boys and 2 girls), taking into account students' pre-test FBT scores in an attempt to ensure that the two groups did not differ in terms of initial balance ability.

Following, there was a brief period of students' familiarization with the procedures of the prospective interventions. In particular, two familiarization sessions with the exercises and the instrumentation of the respective intervention were conducted for each group (15-17 minutes per participant). To maximize communication, the students were also taught (in sign language) new words and concepts relevant to the terminology of the interventions.

Next, each group participated in its respective intervention program and after completion the students of both groups underwent again the FBT as post-measurement. In addition, the students of the EG, their parents and instructors were interviewed. During all the afore-mentioned stages of the research, a sign language interpreter facilitated the communication with students. All measurements took place within school environment.

The FBT is one of the 9 tests that form the Eurofit Physical Fitness Test Battery, a set of tests conceived by the Council of Europe (Eurofit, 1992) for assessing the physical abilities (e.g. speed, endurance, balance) of adolescents aged 17 to 19 years. In this study, the equipment used for the FBT was a timer and a metallic beam 50 cm in length, 5 cm in height and 3 cm in width. During the test, the beam was stabilized on each end and its surface was not slippery. In both groups, each student stood on the beam on his/her dominant foot (without shoes) and tried to maintain balance holding the trainer's hand. While trying to do so, the other foot was bent to the height of the knee near the student's buttocks and was held by the student's same-side hand (i.e. flamingo pose). The actual test began when the student let the trainer's hand. In that instant, the trainer started timing and stopped the timer every time the student lost his/her balance for any reason. In this case, the process and timing started from the beginning repeating the procedure. In case of more than 15 falls in the first 30 seconds, the test terminated and the student's score was calculated as zero. Otherwise, the student's score was the total number of falls or losses of balance that the student had in 60 seconds (Eurofit, 1992).

All interviews were recorded. Interview transcription was conducted immediately after the interviews in order to ensure that the transcripts were as complete as possible and that they contained the verbal statements of the interviewees as well as the researchers' observations regarding the non-verbal communication with the interviewees.

Data analysis

Due to the specificity of the research and the small size of the sample, non-parametric tests were used (Pallant, 2001). In particular, Mann-Whitney U tests were performed for the initial comparison of demographic and somatometric data [age, height, weight, body mass index (BMI)] between the EG and the TG. Such tests were also used for the comparison of FBT pre-test scores between groups and the comparison of FBT post-test scores between groups. Wilcoxon matched-pairs signed ranks tests were performed for the comparison of FBT scores between pre-test and post-test measurements, within the whole sample and within groups. The level of statistical significance for all analyses was set at 0.05.

The interview transcripts were initially examined with a view to identifying recurrent major themes in the interviewees' discourse. Then the transcripts were re-examined and those major themes together with new themes that emerged were grouped into categories.

Results

In what follows the results of the analyses of the quantitative data of the research are presented first, followed by the results of the analyses of the qualitative data.

Quantitative data

Table 1 and Table 2 show students' demographic and somatometric data (which were measured prior intervention) as well as students' pre-test and post-test FBT scores for the EG (Table 1) and the TG (Table 2).

Table 1. Demographic/somatometric data and pre-test/post-test FBT scores for the EG (N=5).

Student	Gender	Age (years)	Height (m)	Weight (Kg)	BMI (Kg/m^2)	FBT pre-test	FBT post-test
1	Boy	19	1.73	100.3	33.5	7	7
2	Boy	19	1.64	61.0	22.7	9	9
3	Boy	19	1.75	95.1	31.1	11	10
4	Girl	17	1.72	55.6	18.8	6	5
5	Girl	18	1.58	62.4	25.0	7	7

Table 2. Demographic/somatometric data and pre-test/post-test FBT scores for the TG (N=5).

Student	Gender	Age (years)	Height (m)	Weight (Kg)	BMI (Kg/m^2)	FBT pre-test	FBT post-test
1	Boy	19	1.68	66.8	23.7	9	8
2	Boy	19	1.87	67.0	19.2	9	8
3	Boy	18	1.72	64.6	21.8	10	10
4	Girl	18	1.49	40.7	18.3	9	8
5	Girl	18	1.61	54.5	21.0	8	6

Table 3 presents descriptive statistics of students' demographic/somatometric data as well as the results of the Mann-Whitney U tests that compared those data between the EG and the TG, showing that the two groups did not differ significantly prior intervention.

Table 3. Descriptive statistics of students' demographic/somatometric data and results of their comparison between the EG (N=5) and the TG (N=5).

	EG			**TG**			**Mann-Whitney U**
Variable	**Median**	**Minimum**	**Maximum**	**Median**	**Minimum**	**Maximum**	**p**
Age (years)	19	17	19	18	18	19	0.817
Height (m)	1.72	1.58	1.75	1.68	1.49	1.72	0.675
Weight (Kg)	62.4	55.6	100.3	64.6	40.7	67.0	0.465
BMI (Kg/m^2)	25.0	18.8	33.5	21.0	18.3	23.7	0.117

Table 4 shows descriptive statistics of the students' pre-test and post-test FBT scores as well as the results of the Mann-Whitney U tests that compared FBT scores between the two groups (EG and TG) and the results of the Wilcoxon matched-pairs signed ranks tests that compared FBT scores within each of the groups.

Table 4. Descriptive statistics of students' pre-test and post-test FBT scores and results of their comparison between the EG (N=5) and the TG (N=5), and within each group.

	EG			**TG**			**Mann-Whitney U**
Variable	**Median**	**Minimum**	**Maximum**	**Median**	**Minimum**	**Maximum**	**p**
FBT pre-test	7	6	11	9	8	10	0.280
FBT post-test	7	5	10	8	6	10	0.670
Wilcoxon (p)	0.157			0.059			

As seen in Table 4, the results of the Mann-Whitney U tests indicate that the two groups did not differ significantly in pre- and post- measurements in terms of their balance ability. Furthermore, the results of the Wilcoxon matched-pairs signed ranks tests show that within each of the groups, there was no statistically significant difference in balance ability between pre- and post-measurements. As seen in Table 1 and Table 2, four students maintained their performance in the FBT, whereas the remaining six students improved their performance from the pre-test to the post-test. Four out of those 6 students belonged to the TG and two students belonged to the EG. Thus, there was an improvement in students' balance ability after intervention, which, however, did not reach statistical significance.

Finally, it should be noted that in the sample as a whole (all 10 students), a Wilcoxon matched-pairs signed ranks test that was conducted to compare the students' pre-test and post-test FBT scores showed a statistically significant difference from the pre-test to the post-test ($p=0.02$), indicating that physical exercise can improve the balance ability of adolescents with deafness.

Qualitative data

Six thematic categories emerged from students' discourse regarding exergame use: a) training benefits, b) advantages or disadvantages of training, c) student reinforcement through the provision of clear goals and rewards, d) feedback to the student, e) safety and ease of use, f) enjoyment, acceptance and preference to static videogames, as follows:

Training benefits: All 5 students of the EG answered that the exergame-based intervention program indeed helped them. However, the perceived benefits of the program varied among students. More specifically, 3 students (2 boys and one girl) felt that their balance, stability and body posture improved. For instance a boy mentioned *"It helped me a lot in controlling my movement and I felt fantastic participating in this program"*. A girl stated that she felt improving her orientation, whereas the other boy of the EG mainly focused on his pleasure and energy during gameplay and did not mention any concrete perceived benefits.

Advantages or disadvantages of training: Most students (4 out of 5) of the EG maintained that exergame training has more advantages compared to traditional balance training exercises. Those students mentioned that exergame training was more enjoyable and interesting, and less boring and tiring than regular exercises. As a girl mentioned: *"I believe that it has nothing to do with traditional exercises. The advantages are more. Classical exercises are boring whereas this way of experiential participation in exercise is more fun… learning through a pleasant experience"*. Another advantage mentioned by a boy was the direct and comprehensible correction of the student by the exergame environment. A disadvantage mentioned by another boy -with big shoe pads- was the small surface size of the Wii Balance Board. Only one student of the EG (a girl) stated that traditional exercises were better because they are more "lively" and can be performed outdoors instead of in front of a TV screen.

Student reinforcement through the provision of clear goals and rewards: All EG students answered that exergames goals were clear and easily comprehensible. Three of the students mentioned that in this new situation they had initially faced small difficulties in understanding what they had to do within the games only in the first session. All students stated that the image on the TV screen helped them a lot by providing them with concrete instructions on what they had to do as to stabilize their movements and improve their balance. As stated, the existence of clear goals had also *"helped my concentration. So that my attention was not disrupted and I could succeed my target"*. Furthermore, receiving bonus points during gameplay was very motivating for most students, who answered that this system of awards gave them enthusiasm and encouraged them to continue and try harder within the exergame environment. For instance, a boy stated *"Really, the stars that I was gaining and the points gave me the power to continue to try and to win in the effort that I was making"*.

Feedback to the student: Most EG students answered that the exergames provided control and self-correction possibilities, and they have appreciated the fact that during gameplay they could monitor their performance on the TV screen and, consequently, correct a false movement. For instance, a boy mentioned: *"You had to do exactly the same as on the screen. It also corrected you and with the results and the experience that you gained, you could improve your performance… I could see how my feet were positioned on the platform and whether I was on the correct position. There was that yellow circle that was appearing and you could instantly understand if you were right or wrong… I could avoid wrong movements with my feet and I could see feedback improving myself"*.

Safety and ease of use: All EG students answered that the exergames were safe and easy to use. A student pointed out that, however, they required attention and concentration.

Enjoyment, acceptance and preference to static videogames: Most EG students (4 out of 5) answered that the intervention program improved their balance in a way that is motivational. For instance, a girl mentioned that *"it gives energy and promotes confidence"*, whereas a boy stated *"It gave me great pleasure, I wanted more and more. I wanted to reach a higher level of exertion and to participate even more"*. Two of the students pointed out exergame balance training as absolutely suitable for people with deafness. For instance a girl mentioned *"I see that many deaf people have balance problems and difficulties in attaining balance. I hope this training is applied sometime in the future so that those people can gain stability, which is important"*. All students stated that exergames were more effective and enjoyable than static videogames since they mobilize the whole body and offer exercise that is fun. Also, *"they are not tiring for the eyes and are a pleasure for the whole body"*. Finally, most students (4 out of the 5) answered that they would like exergame balance training to become a regular part of the PE curriculum at school, whereas only one student (a girl) answered that she prefers traditional physical exercise.

Three thematic categories emerged from parents' discourse: a) improvement in balance ability, b) students' impressions, c) appeal, safety and preference, as follows:

Improvement in balance ability: On the contrary to students' perceptions, most parents (4 out of the 5) answered that they did not notice any improvement in their child's balance ability. Only one parent noted an improvement, which he attributed to the exergame intervention program *("Before, he fell many times in a minute, now he falls less. Obviously, this was after that Wii")*, based on what his child had said to him.

Students' impressions: All 5 students had talked to their parents regarding their participation in the exergame intervention program. From their children's discourse, parents formed the perception that it was something enjoyable and helpful for their children. As the mother of a girl noted: *"She told us that she did balance exercises with an electronic device and that she liked it a lot"*.

Appeal, safety and preference: Most parents stated that exergame training is a safe and appealing mode of exercise for their children. As they mentioned, their children spend many hours playing static videogames, which is something that they do not approve. They would prefer that their children played exergames instead of static videogames because they consider the former more useful than the latter. As the father of a boy stated: *"I would clearly prefer this instead of seeing him seated in front of the computer playing videogames for hours and hours … I wish he accepts that we play exergames together … it is exercise of the body and the mind as well"*.

Finally, three thematic categories also emerged from instructors' discourse: a) improvement in balance ability, b) students' impressions, and c) acceptance and utility:

Improvement in balance ability: All 5 instructors had the impression that their students' balance improved after the exergame intervention. For instance, an instructor noted: *"I don't know whether it can improve balance or not, but I think that it had a positive impact on students' balance"*.

Students' impressions: The instructors mentioned that the EG students seemed excited about their participation in the exergame-based intervention program and compared their performances in the exergames teasing and challenging one another. As noted, *"Sometimes, I heard them talk about those games and they seemed excited. They compared their game scores and exchanged opinions"*.

Acceptance and perceived utility: All instructors said that exergame balance training is an interesting, innovative and alternative mode of balance training, which combines training and entertainment. For instance, an instructor stated *"Those games are something original and smart, a different way to do sport and to improve in balance, and students can practice in their homes too"*.

Discussion

This study involved two groups of adolescent students with deafness and compared two balance training programs -one for the Exergame Group (EG) utilizing Wii Fit balance exergames with the Wii Balance Board and one for the Traditional exercise Group (TG) consisting of traditional balance exercises and equipment- as to their effectiveness to improve students' balance ability. Furthermore, the study investigated EG students' views and experiences regarding the balance exergames (e.g. enjoyment, motivation, perceived usefulness, efficacy, ease of use) as well as their parents' and instructors' views on this mode of balance training.

As derived from the results of quantitative analyses, both programs yielded an improvement in students' balance ability, although this improvement did not reach statistical significance. Furthermore, there was no statistically significant difference between the two programs (EG and TG) in terms of effectiveness. These findings seem to partially disagree with the findings of other studies in children and adolescents with disability, which have shown a significant improvement in participants' balance ability after an exergame-based intervention (Abdel Rahman, 2010; Shih et al., 2010; Mombarg et al., 2013; Tarakci et al., 2013; Jelsma et al., 2014; Atasavun Uysal & Baltaci, 2016; Gatica-Rojas et al., 2016; Jelsma et al., 2016; Tarakci et al., 2016). They also contrast the outcomes of certain prior studies which have shown that exergame-based balance training was more effective than traditional exercise balance training in children with disabilities (e.g. Abdel Rahman, 2010; Shih et al., 2010) and they agree with the outcome of another study which has not reported a statistically significant difference in effectiveness between exergame-based and traditional balance training in healthy adults (Vernadakis et al., 2012). Perhaps, in the present study, a longer duration of the program could help students to better familiarize themselves with the new mode of exercise (i.e. exergaming) and could give them time to adapt and achieve a better performance.

As for the qualitative results of the study, the exergame-based balance training program was well-accepted by the students, who perceived the program as beneficial for their balance and also as more interesting, motivational and enjoyable compared to a traditional balance training program. The students appreciated the opportunities for self-control, self-correction, pursuit of goals and receipt of awards offered by the exergames' training environment, and perceived these games as safe and easy to use. Furthermore, they expressed their desire for balance exergames to become part of their regular PE curriculum and showed their preference of such games compared to static videogames. Those findings seem to confirm the notion that exergames can spur motivation for exercise (Yang et al., 2008; Papastergiou, 2009; Whitehead et al., 2010; Staiano et al., 2013; Vernadakis et al., 2014) especially through goals, rewards and the feedback provided to the user regarding correctness of performance (Whitehead et al., 2010; Vernadakis, Papastergiou, Zetou & Antoniou, 2015).

The findings also agree with the conclusions of other research studies that examined exergame-based balance training in adults (e.g. Sugarman et al., 2009; Young, Ferguson, Brault & Craig, 2010; Meldrum, Glennon, Herdman, Murray & McConn-Walsh, 2012) and children (e.g. Jelsma et al., 2014) showing that participants enjoyed the experience and were satisfied by it. It should also be noted that, contrary to the –reasonable- reservations expressed by Anderson, Annett and Bischof (2010), that exergames that have not been specifically designed for specific disorders may be too difficult to play with or may not provide the appropriate, specialized feedback needed to their users, in this study the students perceived exergames as helpful and easy to play and comprehend. Students' expressed desire to use exergames during PE classes in school seems to agree with the assertion that such games can reinforce the scholastic PE curricula (Vander Schee & Boyles, 2010). Parents' and instructors' views were also positive overall. Specifically, both parents and instructors of the EG students perceived this mode of balance training as being innovative, safe, useful and motivational for their children and students. However, the parents did not report noticeable improvement in their children's balance following application of the exergame-based program.

This study had certain limitations, which should be mentioned. First, the results apply to adolescents with deafness aged 17 to 19 years having severe hearing loss exceeding 70 db, not bearing any cochlear implants and not having other accompanying disabilities, and cannot be generalized to other populations. Second, the sample was small. However, given the small size and the specificity of the population studied as well as the very limited number of special schools for the population studied, obtaining a greater sample was extremely difficult. Third, findings concern the specific exergames used (Nintendo Wii Fit Plus balance exergames). The results may have been different, if other exergames were used.

The study opens up interesting future research perspectives. Specifically, it is interesting to investigate (ideally using larger samples) how an exergame-based balance training program could be better designed and incorporated into the PE curriculum so as to produce significant and long in duration improvements of balance skills for students with deafness. The issue of integrating balance exergames into PE school curriculum for students with deafness seems to be particularly crucial. This study showed that such games are well-accepted by such students. Thus, an inclusion of exergames in the everyday school life of students with deafness may perhaps increase their motor abilities as well as their interest towards PE classes and motivation towards exercise, and eventually further motivate students with deafness to adopt an active way of living that will include activity and sports.

Conclusions

The main conclusion drawn from this study is that balance exergames constitute a feasible, safe, easy-to-use and motivational mode of balance training for adolescents with deafness, which is well accepted both by students and their parents and instructors as a means for balance training in school settings. Quite clearly, this finding is likely to favor the adherence of adolescents with deafness in exergame-based balance training programs. Nevertheless, the findings of this study also indicate that the effectiveness of this mode of balance training needs to be further investigated in the future. Hopefully, the present study can provide useful guidance regarding future research efforts that will further investigate the effectiveness of innovative training methods -based on information and communication technology tools- for young people with deafness.

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