Comparison of a Traditional and a Video Game Based Balance Training Program

Annika Kliem & Josef Wiemeyer

Institute of Sports Science

Technische Universität Darmstadt

Abstract

The aim of the present study is to compare the efficiency of traditional and video game based balance training programs. 22 customers of a health care centre (age: *M* = 47.6 yrs; *SD* = 13.1) volunteered to participate in the experiment. They 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 five balance tests (SEBT, ball-handling, two video games, dynamic balance), 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.

Two-factor analyses of variance showed both general and differential improvements of the two groups for pre and post test measures. Both groups improved their balance performance in 4 of five tests. The traditional group showed a significantly greater improvement in two tests (SEBT: $F_{(1,20)} = 8.907$, $p = .007$, $\eta^2 = .308$; ball-handling: $F_{(1,20)} = 13.578$, $p = .001$, $\eta^2 = .404$), whereas the Wii group showed a significantly greater improvement in one test (Ski Slalom ($F_{(1,20)} = 5.101$, $p = .035$, $\eta^2 = .203$). Psychological questionnaires revealed neither significant pre-post effects nor differences between the groups for pre and post test measurements.

The results confirm that the Nintendo Wii Fit ™ may be a suitable medium of training balance in prevention and rehabilitation of adults. Specific effects of training are more pronounced than transfer between virtual and real performance.

BALANCE, VIDEO GAMES, NINTENDO Wii Fit ™, REHABILITATION, PREVENTION

Introduction

Body balance is a basic skill and a very important sensorimotor ability of human beings. Without the ability to keep balance a person could not stand, walk or sit upright without tools for more than a few seconds. Therefore, balance has a great importance in daily life (Wydra, 1993). Balance performance decreases continuously in life, starting from age 45 (Teipel, 1995). As a consequence, the risk of getting injured by falling is high in elder people. To avoid this, it is important to exercise balance performance. However, sometimes traditional training programs are not attractive to participants for several reasons (e.g., rote, mechanic movements and exposure to group training). In this regard, the new exergames offer attractive options for exercising, even for seniors (Parker, 2007). Thus, the goal of the present study was to compare a traditional and a video game based training program.

Exergames have been very successful in the recent years. Besides the fact that playing exergames can be funny, enjoyable, and entertaining, this activity can improve physical abilities in subjects of all ages. There is a number of studies concerning the relationship between digital games and overweight or energy expenditure, especially with regard to prevention of overweight and obesity (Bausch, Beran, Cahanes, & Krug, 2008; Boehm, Hartmann, & Boehm, 2008; Graves, Stratton, Ridgers, & Cableon, 2007; Hagger, Chatzisarantis, & Biddle, 2002; Lanningham-Foster, Jensen, Foster, Redmond, Walker, Heinz & Levine, 2006; Marshall, Biddle, Gorely, Cameron & Murdey,. 2004; Saelens & Epstein, 1998). Furthermore, there are studies and meta-analyses about the impact of Serious Games on a healthy lifestyle and health-related activities (Baranowski, Buday, Thompson. & Baranowski, 2008; Kato, Cole, Bradlyn & Pollock, 2008; Lager & Bremberg, 2005; Lieberman, 2001). A study by Brumels, Basius, Cortright, Oumedian, & Brent (2008) deals with the impact of video games on balance performance. Brumels et al. (2008) compared 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 (AMTI AccuSwayPLUS Balance Platform). 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, "Statistical evaluation of perceived difficulty and enjoyment of the programs obtained data showing the video based games to be perceived as less strenuous (DDR®, $p = 0.073$, Wii Fit™, $p = 0.014$) and more enjoyable (DDR®, $p = 0.007$, Wii Fit™, $p = 0.006$) than the traditional balance program" (Brumels et al., 2008, p. 26).

Besides the question how such exergames can be used in medicine, in sports science the question arises, whether transfer effects exist from the virtual game to real world, and vice versa, and how exergames can be used for learning and training. More specifically, the question is: How are, for example, the movements in Wii Sports ™ Bowling transferable to the real bowling or, referring to the present study, is it possible to transfer video game training of balance to real balance performance and vice versa?

The aim of this study is to determine whether there is a difference between a game-based and a traditional training program, and whether transfer effects can be found. In contrast to Brumels et al. (2008), who examined younger adults (*M* age = 19.56 years, *SD* = 1.69), in this study older patients attending rehabilitation and prevention were also included.

Methods

Participants

All participants were recruited from a health care centre, the Gesundheitszentrum Rehaktiv, Großostheim in Germany, which specializes in prevention and rehabilitation. Twenty-two participants, 5 men and 17 women between the ages of 18 and 67 years (*M* = 47.36 years, *SD* = 13.14) participated voluntarily.

All participants were regularly engaged in sports and were enrolled in a structured strength and cardiovascular training program before the study started.
Only two participants had experience with video games, whereas none had any experience with the Nintendo Wii Fit TM.

Study design

The study was performed based on an experimental two-factor design with repeated measures. Pre and post measurements were performed before and after the treatment. Dependent variables comprised the Star Excursion Balance Test (SEBT), a single-leg balance test on the Posturomed device (ball-handling), a dynamic balance test (DBT), published by Wydra (1993) and Boes (2001), and two game tests on the Wii Fit TM (Ski Slalom and Balance Bubble). Participants were randomly assigned to one of two treatment groups based on their pretest scores (Wii, *n* = 11 and traditional, *n* = 11). Both exercise groups participated in balance training exercises three days a week for three weeks. Each training session lasted about 10 to 12 minutes and included game-based or traditional balance exercises.
Table 1 shows the design of pretest and posttest measurements and questionnaires.

Table 3. Structure of the experimental study

	t1 (Pretest)		Treatment	t2 (Posttest)		
	Questionnaire	Balance Tests		Questionnaire	Balance Tests	Retest
Group 1: Wii	Mood State Self-efficacy	SEBT Ball-handling Ski Slalom Balance Bubble DBT	Treatment 1: Wii	Mood State Self-efficacy PAES Flow Subjective experience	SEBT Ball-handling Ski Slalom Balance Bubble DBT	Ball-handling Ski Slalom Balance Bubble
Group 2: Traditional	Mood State Self-efficacy	SEBT Ball-handling Ski Slalom Balance Bubble DBT	Treatment 2: Traditional	Mood State Self-efficacy PAES Flow Subjective experience	SEBT Ball-handling Ski Slalom Balance Bubble DBT	Ball-handling Ski Slalom Balance Bubble

Pre and Post Measurements

Tests

Before the tests started, the subjects were asked to take off their shoes. The order of the tests was as follows: SEBT, ball handling, Ski Slalom, Balance Bubble and finally DBT. The first two tests are static, non-game-based balance tests, the second two tests are also static, game-based balance tests on the Wii Fit TM and the final test is a dynamic balance test executed on a small beam. The tests were chosen to analyze two types of transfer: transfer between virtual and real movements, and transfer from exercised to non-exercised tests.
After the post measurement, a retest of ball-handling, Ski Slalom, and Balance Bubble has been performed for a test of reliability. The respective correlation coefficients were 0.880, 0.678, and 0.567, respectively.

SEBT

SEBT required the participant to balance on one leg in the centre of an eight-directional SEBT Star with their hands placed on their hips. Subjects reached out as far as they could with their free leg in each direction, starting with the anterior direction by gently touching the ground with their toe without shifting weight. After each tap they returned to the starting position and proceeded to the next direction. This exercise was continued in all eight directions in a clockwise manner. Because the achieved absolute width depends on the leg length (Gribble & Hertel, 2003), the individual distances were divided by the leg length of the respective subjects. The leg length was measured as the distance between the anterior superior iliac spine (ASIS) and the middle of the lateral malleolus.

Ball-handling

In the ball-handling test subjects balanced on one leg on the Posturomed, i.e., a therapeutic device associated with a mobile platform, and passed a small ball around their body with their hands. Standing on the right leg, the subject had to move the ball around first clockwise and then counter-clockwise. The procedure was repeated on the left leg. The number of turns in one direction was limited to eight. The participant was awarded one point per cycle. When a subject could not keep his or her balance and stepped down, only the circles already completed were counted. Therefore, a subject could achieve a maximum score of 32 points.

Ski Slalom

In this game the player took the role of a skier and raced against time. By leaning to the right or left, the skier controlled the direction of his movement. By leaning forward or backward, the player controlled her speed. As in the real sports the skier had to clear the gates as fast as possible. For the test the beginner level was chosen. By default of the Wii Fit ^{TM} system, seven seconds were added to the total time for each missed gate. The game was played three times in succession. The mean time of the three trials was calculated for further analysis.

Balance Bubble

The player was placed in a small soap bubble and had to float down a river. By leaning forward and backward the player controlled both forward and backward direction and speed of his movement. By leaning to the right and left, the player controlled the lateral direction. If the bubble touched the walls of the river, the bubble burst and the player fell down. In this game, the distance (unit: metres) was measured, which each player could reach without falling down. Each subject played the game three times. The mean time of the three trials was calculated for further analysis.

Dynamic balance (DBT)

The dynamic balance performance was tested using a variety of exercises of the balance test (‘Gleichgewichtstest’) published by Wydra (1993; see also Boes, 2001). Four exercises on a beam were selected (length of the beam: 300 cm; width: 10 cm; height: 15 cm above the ground).

The first task was to walk forward over the beam with eyes open and the hands resting on the hips, to turn around at the end and walk back to the starting point.

Second task: Walk backward with eyes open and the hands resting on the hips, to turn around at the end and walk backward to the beginning point.

Third task: Walk forward with eyes closed. Arms were allowed to be used for balance.

Fourth task: Walk backward with eyes closed. Arms were allowed to be used for balance.
If a participant completed the track without touching the ground he got two points. If he touched the ground once with one foot he got one point. If he fell off the beam or touched the ground two times or more he got zero points. The maximum score was eight points.

Questionnaires

Before the tests started, the participants were asked to complete a questionnaire. The pretest questionnaire consisted of 8 questions about the participants' mood state and 5 items concerning their self-efficacy. The subjects had to answer the following question: *How confident are you to accomplish the following tasks, without trying? One leg stand without falling over for 30 (45 / 60 / 75 / 90) seconds.* The subjects had to mark each of the five statements on a six-digit scale, ranging from 'very unsure' (1) to 'very sure' (6)
In the posttest condition, the items of the pre-questionnaires were applied again. Additional questions were asked regarding the completed treatments, i.e., about the pleasure of the treatment using the physical activity enjoyment scale (PAES) by Kendzierski and DeCarlo (1991). Regarding 'flow', questions were derived from the game flow model of Sweetser and Wyeth (2005). The questions referred to the dimensions of *concentration, challenge, skill, control, clear goal, feedback, immersion, and social interaction*. The questions concerning subjective experiences were adopted from Brumels et al. (2008, p. 29):
1) How difficult was your program?
2) How engaged were you during your program?
3) How enjoyable was your program?
Whereas Brumels et al. (2008) applied a 5-grade scale, a 6-grade scale was used in this study.

Interventions

Treatment of the Wii group

The treatment of the Wii Fit ™ exercise group (Wii group) consisted of playing games selected by the authors from the balance training exercises offered by the Nintendo Corporation. The Wii Fit ™ Balance Board was placed about two meters from the television in front of the screen. During each training session, the subjects were instructed to play the same three games on the balance board, each for about three minutes. The participants were allowed to choose their own difficulty level. Furthermore, they were asked not to perform any other balance exercises during the intervention period.
The training protocol consisted of *Ski Slalom*, *Table Tilt*, and *Tightrope Walk. Ski Slalom* is the same game used during the tests. In the game *Table Tilt* balls have to be guided into one or more holes of a virtual tabletop. By shifting the center of gravity the player tilts the table. In the game *Tightrope Walk,* the player simulates a walk on a tightrope. The player has to perform steps on the board to get from one end of the rope to the other and to keep balance. The rope is fixed between two skyscrapers. Here, the player's center of gravity must always be kept exactly in the middle, so that the tightrope walker does not lose his balance and fall down. While crossing the tightrope the player has to avoid a steel monster by jumping over the monster.

Treatment of the traditional group

The traditional training group (Trad group) received a treatment with four varying levels of balance exercises using specific training devices. The exercises are listed and described in Table 2.

Table 4. Treatment protocol of the traditional group

Name	Implementation	Frequency	Comment
Squat	Squats on the Aero-Step	3 series of 10 repetitions Breaks between the series: 30 s	Knee angle between 100° to 170° Slow execution Performed barefoot
Ball-handling	Single-leg stand on the Posturomed, while the hands moves a small ball around the body Clockwise and counter-clockwise	10 s per attempt 4 times on the right and 4 times on the left leg	The Posturomed can be adjusted in its difficulty by fixing the springs.
Rotary board	Both feet on the markers, trying to maintain the balance	Performing for two minutes with the aim not to fall down from the base	To ascend and under disturbance, the hands may be used for support.
Ball-cycling	Single-leg stand on the Sisselkissen, using the toes of the opposite foot to move a tennis ball around the Sisselkissen	Two trials on the right leg (two turns clockwise and two turns counter-clockwise) Two trials on the left leg (two turns clockwise and counter-clockwise)	Performed barefoot

Results

Data was analyzed using the Statistical Package for Social Sciences (SPSS), Version 17.0.

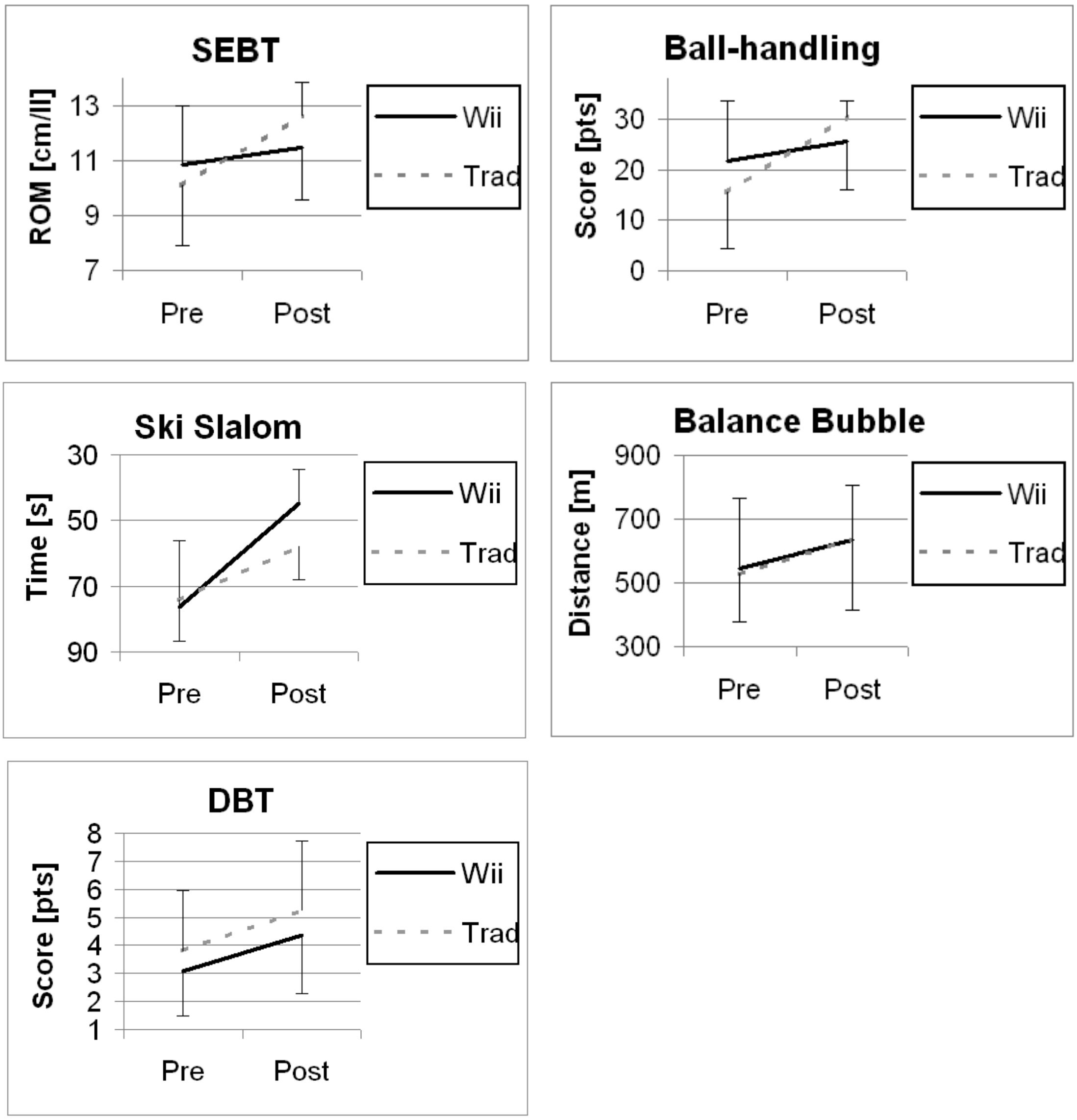
Performance tests

In Table 3 means and standard deviations of pretest and posttest measurements are illustrated (see also Figure 1).

Table 5. Descriptive Statistics of the five tests (t1 – pretest; t2 – posttest)

Test	Group	*M* (t1)	*SD* (t1)	*M* (t2)	*SD* (t2)
SEBT	Wii	10.88	2.11	11.47	1.91
[cm/leg length]	Trad	10.09	2.18	12.66	1.19
Ball-handling	Wii	21.82	11.85	25.64	9.68
[Points]	Trad	15.63	11.29	30.55	2.94
Ski Slalom	Wii	76.42	20.38	44.96	10.42
[Seconds]	Trad	74.34	12.26	57.91	10.02
Balance Bubble	Wii	543.70	220.70	635.88	170.70
[Metres]	Trad	527.94	148.88	640.42	224.89
Dynamic Balance	Wii	3.09	2.12	4.36	2.46
[Points]	Trad	3.82	1.60	5.27	2.08

Figure 1. Results of the five tests



The 2 × 2 ANOVAs with the factors group (Wii, traditional) and measure (pre, post) showed general improvements of the two groups for pre and post test measures in four of the five tests (Table 4; see also Figure 1): SEBT , ball-handling, Ski Slalom, and DBT. The improvement in the Balance Bubble test closely missed the 5% level. Interactions of group and measure indicating differential improvement were found in three tests) (Table 4: SEBT, ball-handling, and Ski Slalom.

Table 6. Results of 2 × 2 ANOVA for the five tests

Test		***df***	***F***	***p***	η^2
SEBT	**pre-post**	**1, 20**	**22.320**	**<.001**	**.527**
	pre-post × group	**1, 20**	**8.907**	**.007**	**.308**
	group effect	1, 20	.077	.785	.979
Ball-handling	**pre-post**	**1, 20**	**38.712**	**<.001**	**.659**
	pre-post × group	**1, 20**	**13.578**	**.001**	**.404**
	group effect	1, 20	.028	.869	.001
Ski Slalom	**pre-post**	**1, 20**	**51.848**	**<.001**	**.722**
	pre-post × group	**1, 20**	**5.101**	**.035**	**.203**
	group effect	1, 20	1.223	.282	.058
Balance Bubble	*pre-post*	*1, 20*	*4.020*	*.059*	*.167*
	pre-post × group	1, 20	.040	.844	.002
	group effect	1, 20	.007	.932	<.001
Dynamic Balance	**pre-post**	**1, 20**	**26.471**	**<.001**	**.570**
	pre-post × group	1, 20	.118	.735	.006
	group effect	1, 20	1.038	.320	.049

To confirm the results of the ANOVAs the Mann-Whitney U-test was calculated for pre-post differences (Delta). Significant results were found for Delta SEBT and Delta ball-handling (Table 5). In both tests, the traditional group showed a greater improvement. The groups also showed different performance gains in the Ski Slalom, where the Wii group could improve more than the traditional group. In Delta Balance Bubble and Delta dynamic Balance group differences were not significant. In the Balance Bubble test the Wii could improve a little bit more, while the traditional improved a little bit more in the dynamic Balance tests (Table 5).

Table 7. Results of the Mann-Whitney U-Test for the five tests

Test	Group	Mean Rank	*Z*	*p*
Delta SEBT	Wii Trad.	7.64 15.36	-2.791	.005
Delta Ball-handling	Wii Trad.	7.59 15.41	-2.833	.005
Delta Ski Slalom	Wii Trad.	14.55 8.45	-2.200	.028
Delta Bubble Balance	Wii Trad.	11.55 11.45	-.033	.974
Delta Dynamic Balance	Wii Trad.	11.05 11.95	-.341	.733

Questionnaires
Results for mood state and self-efficacy are illustrated in Tables 6 and 7, respectively.
2 × 2 ANOVAs showed neither significant general nor differential changes of the two groups for pre- and posttest measures.

Table 8. Descriptive statistics of the questionnaire mood state (t1 – pretest; t2 – posttest)

Mood state	Group	*M* (t1)	*SD* (t1)	*M* (t2)	*SD* (t2)
Arousal	Wii	4.73	0.82	4.77	0.68
	Trad.	5.00	1.64	5.00	1.43
Energy	Wii	4.36	0.87	4.68	0.81
	Trad.	5.27	0.65	5.00	1.18
Depression	Wii	5.36	0.45	5.55	0.57
	Trad.	5.64	0.64	5.50	0.89
Anger	Wii	5.27	0.79	5.55	0.69
	Trad.	5.73	0.65	5.73	0.90
Alertness	Wii	3.36	0.92	3.18	0.92
	Trad.	2.91	1.38	2.64	1.38

Table 9. Descriptive statistics of the questionnaire self-efficacy

	Group	*M* (t1)	*SD* (t1)	*M* (t2)	*SD* (t2)
Self-efficacy	Wii	4.05	1.28	4.04	.77
	Trad.	5.36	.56	5.38	.64

To measure a potential statistical difference between the two groups in terms of physical activity enjoyment, the Mann-Whitney U-test was used. The differences between the groups were not significant in any of the eleven items.
Furthermore, no significant differences between the traditional and the Wii group were found for flow experience. The item *feedback* closely missed the 5% level ($z(22)$=-1.827, p = .068).

Concerning the last part of the psychological questionnaire, the *subjective experiences* also did not show any significant differences between the two training groups (Table 8).

Table 10. Descriptive statistics and results of the Mann-Whitney U-test for subjective experiences

Item	Group	M	SD	Mean Rank	*Z*	*p*
Difficulty	Wii	3.45	1.13	12.09	-.443	.658
	Trad.	3.27	1.56	10.91		
Engagement	Wii	2.36	1.03	11.83	-.107	.865
	Trad.	2.36	1.36	11.27		
Enjoyment	Wii	2.09	1.14	11.55	-.350	.972
	Trad.	2.18	1.33	11.45		

Discussion

Regardless of the group, all subjects were able to improve their balance performance in four of five tests from pre- to posttest. Significant improvements for all subjects were confirmed for the tests SEBT, Ski Slalom, ball-handling and DBT, but not in the Balance Bubble test. This result cannot be clearly considered a general exercise effect, because no no-treatment control group was examined. Furthermore, in three tests the pre-post effect is specified by a significant group × measure interaction indicating differential effects of Wii and traditional training.

The significant group × measure interaction qualifies the results of Brumels et al. (2008). Whereas both groups improved significantly, the traditional group showed a greater improvement indicating a specific training effect.

In the ball-handling test the traditional group also achieved a significantly greater improvement from pretest to posttest. Again, this result can be considered a specific effect of exercise. It should be noted, however, that the maximum number of points to be achieved was 32 and the average of the traditional group in the posttest was 30.55 points. A ceiling effect occurred, with only three of the eleven subjects of this group not achieving a maximum score.

The Ski Slalom test showed a different result. Here, the Wii group achieved a significantly greater improvement from the pretest to the posttest measurement. This can also be considered a specific effect of game exercise.

The Balance Bubble and dynamic balance tests did not provide significant interactions failing to indicate statistical differences between the performance changes of the groups from pretest to posttest. In the dynamic balance test both groups improved. It is not clear whether this is a true transfer or a simple test repetition effect, because a no-treatment control group is missing.

Generally, the results of the study reveal that the Wii group improved performance more in the game-based tests, whereas the traditional group improved more in the traditional tests.

With regard to a transfer from virtual to real movement it is conceavable, that the Wii group achieved a sensorimotor transfer to the ball-handling, dynamic balance and SEBT test. This effect may be either just a repeated measures effect or a true transfer effect. Furthermore, data do not allow to decide whether this transfer is sensorimotor or cognitive. The cognitive strategies may not only be improved by the treatments but also by playing the game three times in the pretest condition due to the low complexity of the games. Apparently, cognitive strategies appear and evolve very quickly during the first attempts. In conclusion, it should be noted that the types and proportions of the transfer process could not be accurately determined. Adoption of a control group and experimental manipulation of cognitive and sensorimotor processes are to be performed to decide these questions. The same difficulty holds for the traditional group concerning transfer from traditional to game movements.

No part of the psychological questionnaire showed any significant difference, neither in the posttest nor in the pretest to posttest measures. Particularly notable is the non-existing increase in the self-efficacy, although all subjects were able to significantly improve their balance performance. Contrary to the results of Brumels et al. (2008), the two training groups experienced their treatments as similarly difficult, enjoyable and engaging. This difference may be due to the different ages of the subjects. Whereas Brumels et al. (2008) examined younger adults (range: 18 to 24 yrs; M = 19.56 yrs), this study examined older adults (range: 18 to 67 yrs; M = 47.37 yrs). Compared to the relative values of the Wii group of Brumels, the subjects of the present Wii group experienced lower enjoyment (35 vs. 88 per cent maximum), lower engagement (39 vs. 88 per cent maximum), and greater difficulty (58 vs. 32 per cent maximum). The differences in the traditional group are considerably smaller for enjoyment and engagement (enjoyment: 55 vs. 63 per cent; engagement: 36 vs. 43 per cent; difficulty: 39 vs. 67 per cent). Therefore, the lack of differences may be due to the fact that older adults may not be as motivated by playing digital games as younger adults do.

Conclusion

Provided a repeated gaming effect can be excluded by testing a no-treatment control group, game-based balance training with the Nintendo Wii Fit ™ may be suitable in prevention and rehabilitation of adults, although the overall efficacy of game-based training was not as high as that of a traditional training. In order to achieve equivalent or better effects, a more motivating and more variable game-based training program should be developed. While transfer effects of training are not clear, it is certain that specific effects of training are more pronounced than transfer between virtual and real performance.

References

Baranowski, T., Buday, R., Thompson, D. I., & Baranowski, J. (2008). Playing for real. Video games and stories for health-related behavior change. *American Journal of Preventive Medicine*, *34* (1), 74-82.

Bausch, L. M., Beran, J. N., Cahanes, S. J., & Krug, L. D. (2008). Physiological reponse while playing Nintendo wii sports. *Journal of undergrate kinesiology research*, *3* (2), 19-25. Retrieved March 2, 2009 from http://people.uwec.edu/dalleclc/KINSjournal/Spring%202008%20Manuscripts/bausch.beran.cahanes.krug.spring.2008.pdf

Boehm, H., Hartmann, M., & Boehm, B. (2008). Predictors of metabolic energy expenditure from body acceleration and mechanical energies in new generation active computer games. In Dagstuhl Seminar Proceedings 08372 - *Computer Science in Sport - Mission and Methods*. Retrieved April 24, 2009 from http://drops.dagstuhl.de/opus/volltexte/2008/1685

Boes, K. (Eds.) (2001). *Handbuch motorische Tests* [Handbook of motor tests] (2. edition.). Göttingen: Hogrefe.

Brumels, K. A., Basius, T., Cortright, T., Oumedian, D., & Brent, S. (2008). Comparison of Efficacy Between Traditional and Video Game Based Balance Programs. *Clinical Kinesiology, 62* (4), 26-31.

Graves, L., Stratton, G., Ridgers, N. D., & Cableon, N. T. (2007). Energy expenditure in adolescents playing new generation computer games. *British Medical Journal, 335*, 1282-1284. Retrieved March 4, 2009 from http://www.bmj.com/ cgi/content/full/335/7633/1282

Gribble, P. A. & Hertel, J. (2003). Considerations for normalizing measures of the Star Excursion Balance test. *Measurement in Physical Education and Exercise Science, 7* (2), 89-100.

Hagger, M. S., Chatzisarantis, M. L. D., & Biddle, S. J. H. (2002). A meta-analytic review of the theories of reasoned action and planned behavior in physical activity: Predictive validity and the contribution of additional variables. *Journal of Sport and Exercise Psychology, 24,* 3-32.

Kato, P. M., Cole, S. W., Bradlyn, A. S., & Pollock, B. H. (2008). A video game improves behavioral outcomes in adolescents and young adults with cancer: A randomized trial. *Pediatrics, 122* (2), 305-317.

Lager, A. & Bremberg, S. (2005). *Health effects of video and computer game playing. A systematic review.* Stockholm: Swedish National Institute of Public Health. Retrieved April, 10, 2009 from http://www.fhi.se/PageFiles/4170/ R200518_video_computer_game(1).pdf?epslanguage=en

Lanningham-Foster, L., Jensen, T. B., Foster, ,R. C., Redmond, A. B., Walker, B. A., Heinz, D., & Levine, J. A. (2006). Energy Expenditure for Sedentary Screen Time Compared With Active Screen Time for Children. *Pediatrics, 118* (6), 1831-1835.

Lieberman, D. A. (2001). Management of chronic pediatric diseases with interactive health games: Theory and research findings. *The Journal of Ambulatory Care Management, 24* (1), 26-38.

Kendzierski, D. & DeCarlo, K. J. (1991). Physical-activity enjoyment scale: 2 validation studies. *Journal of Sport & Exercise Psychology*, *13*, 50-65.

Marshall, S. J., Biddle, S. J. H., Gorely, T., Cameron, N., & Murdey, I. (2004). Relationships between media use, body fatness and physical activity in children and youth: a meta-analysis. *International Journal of Obesity, 28*, 1238-1246.

Parker, F. S. (2007). *Nursing Home Technology: Wii Video Game*. Retrieved January 13, 2010 from http://hospiceandnursinghomes.blogspot.com/2007/06/ nursing-home-technology-wii-video-games_06.html

Saelens, B. & Epstein, L. (1998). Behavioral engineering of activity choice in obese children. *International journal of obesity, 22*, 275-277.

Sweetser, P. & Wyeth, P. (2005). Game Flow: A Model for Evaluating Player Enjoyment in Games. *ACM Computers in Entertainment*, *3* (3). Retrieved January 13, 2010 at http://delivery.acm.org/10.1145/1080000/1077253/p3a-sweetser.pdf?key1=1077253&key2=2023119321&coll=GUIDE&dl=GUIDE&CFID=30058722&CFTOKEN=75596469

Teipel, D. (1995). *Studien zur Gleichgewichtsfähigkeit im Sport* [Balance ability studies in sport]. Köln: Strauß.

Wydra, G. (1993). Bedeutung, Diagnose und Therapie von Gleichgewichtsstörungen [Significance, diagnosis, and therapy of balance disorders]. *Motorik*, *16* (3), 100-107.