The Journal of Physical Therapy Science

S P T S

Original Article

Effects of Wii Fit® balance game training on the balance ability of students with intellectual disabilities

Tai-Yen Hsu, PhD[1]

[1] Department of Physical Education, National Taichung University of Education: No. 140 Min-Sheng Rd., Taichung City 403, Taiwan

Abstract. [Purpose] The aim of this study was to assess the effects of 8 weeks of Wii Fit balance game training on the balance abilities of students with intellectual disabilities. [Subjects and Methods] Twenty-four students with intellectual disabilities were selected and randomly divided into Wii Fit balance game training, physical education, and sedentary activity groups. The Wii Fit balance game training group received two 40-minute Wii Fit balance game training sessions per week for a total of 8 weeks. Kruskal-Wallis one-way analysis of variance and the Wilcoxon signed rank test were used to compare differences. [Results] After eight weeks of training, the Wii Fit balance game training group showed significant differences between the pre- and post-training parameters, including the duration of standing on one leg with the eyes closed, average anteroposterior movement speed, swing area per unit time, and speed strength index. The physical education group showed significant differences between the pre- and post-training speed strength index values. The sedentary activity group did not show any significant differences between the pre- and post-training parameters. [Conclusion] Wii Fit balance game training can improve static balance and lower extremity muscle strength in students with intellectual disabilities.
Key words: Students with intellectual disability, Virtual reality, Balance ability

(This article was submitted Dec. 18, 2015, and was accepted Jan. 19, 2016)

INTRODUCTION

Although the main characteristic of people with intellectual disabilities is impairment of intellectual ability, some studies have also noted significantly poorer motor nerve systems, sensory integration, motor development, and sport performance compared with the normal population. Thus, people with intellectual disabilities have a higher chance of falling[1, 2]. The main factor leading to falls among this population is the lack of ability to control balance[3]. Because of long-term overprotection by their caregivers or previous frustrations with achieving physical abilities, people with intellectual disabilities often have unsuccessful physical experiences, which hinders motor development. In this context, regular exercise can increase not only balance abilities but also cardiovascular fitness, muscular fitness, and flexibility. Regular exercise can also reduce the risk of development of many chronic diseases in people with intellectual disabilities.

Recently, rapid technological development has produced many virtual reality game systems, such as the Wii developed by Nintendo in 2006 and the Kinect for Xbox 360 introduced in 2010. Virtual reality utilizes computer simulations to produce a three-dimensional virtual world and provides users with real world-like simulations involving vision, hearing, and movement[4]. Virtual reality games have been widely used in medicine and rehabilitation for stroke patients, cerebral palsy patients, psychiatric patients, and the elderly[5–7]. The application of virtual reality has many advantages, including the absence of restrictions in the implementation environment, fixed training content, reduced costs, improved motivation, safe training, and life-like experiences with demanding or unfamiliar sports[4]. However, virtual reality training has rarely been used in

Corresponding author. Tai-Yen Hsu (E-mail: hsu@mail.ntcu.edu.tw)

education. This study investigated the capacity of Wii Fit balance games to improve the balance abilities of students with intellectual disabilities and utilized this type of training to potentially improve these abilities in this particular population, thereby decreasing the chance of future occupational injuries once the students enter employment and reducing their risks in daily life due to poor balance.

SUBJECTS AND METHODS

Purposive sampling was applied to select 24 students with intellectual disabilities. All the parents or guardians agreed to the participation of their children by signing a statement of informed consent. The study was approved by the Ethics Committee of the National Taichung University of Education and was conducted in accordance with the Declaration of Helsinki. The students were randomly divided into Wii Fit balance game training, physical education, and sedentary activity groups, with 8 students in each group. The Wii Fit balance game training group received two 40-minute Wii Fit balance game training sessions per week for a total of 8 weeks. The physical education group underwent a general physical education course that involved jogging and jumping rope. The sedentary activity group experienced 8 weeks of sedentary activity. Characteristics of the subjects are listed in Table 1. There were no significant differences in height, weight, or the degree of mental retardation among the three groups (p>0.05).

This study consisted of three experiments. The first experiment measured static balance by having the subject stand on one leg with his/her eyes closed; the reliability and validity of this method of measurement have been reported to be 0.87 and 0.864, respectively[8, 9]. The second experiment measured dynamic balance using the Timed Up and Go test; the reliability and validity of this method of measurement have been reported to be 0.87 and 0.864, respectively[10, 11]. The third experiment measured lower limb muscle strength (speed strength index during rapid standing).

The static balance measurement in this study required the subjects to stand barefoot on a force plate (Kistler model 9286AA, 100 Hz) with their hands on their hips and their body in an upright posture. Upon hearing the start signal, the subjects closed their eyes, lifted the nondominant leg, and then returned the leg to the force plate upon loss of balance. After completing one round of measurement, which lasted for as long as the subject stood on one leg with their eyes closed, the subjects were asked to sit on an experimental chair that was placed on a path containing a force plate with their feet naturally resting on the force plate. Upon hearing the start signal, the subjects immediately stood up, walked to a yellow line nine meters in front of their position, and returned to sit on the experimental chair. Dynamic balance and lower extremity muscle strength were simultaneously measured at the moment when the subject stood up to walk.

Many studies focusing on specific groups have used median values of experimental data for data analysis[12–14]. In the present study, the subjects were measured 3 times before (pre-training data) and after (post-training data) training, and the median values of the three tests were used for analysis and comparison. The independent variables were the different intervention methods, and the dependent variables included the dynamic and static balance parameters and the speed strength index. Kruskal-Wallis single-factor analysis of variance was used to compare the homogeneity of the subjects in the Wii Fit balance game training, sedentary activity, and physical education groups, and the Wilcoxon signed rank test was used to compare differences between the pre- and post-training parameters of subjects within each of the groups. The significance level was set at α=0.05.

RESULTS

The pre-training static and dynamic balance and lower extremity muscle strength data were compared using nonparametric Kruskal-Wallis single-factor analysis of variance, and the results are shown in Table 2. There were no significant differences in the three variables (p>0.05), suggesting that the subjects in the three groups showed similar pre-training values.

Table 3 shows the pre- and post-training parameters, including static balance, dynamic balance ability, and lower extremity muscle strength, for each group. In the Wii Fit balance game training group, the static balance parameter showed a significant increase of 7.7 seconds for the duration of standing on one leg with the eyes closed (p=0.012). The pre- and

Table 1. Characteristics of the subjects

Group	Age (years) (mean ± SD)	Height (cm) (mean ± SD)	Weight (kg) (mean ± SD)	Degree of mental retardation
Wii Fit balance games training group				
(N=8)	17.5 ± 0.7	164.2 ± 10.9	56.8 ± 21.4	Mild
Sedentary activity group				
(N=8)	17.8 ± 0.8	164.0 ± 7.5	62.2 ± 17.4	Mild
Physical education group				
(N=8)	17.4 ± 0.5	160.3 ± 8.4	66.5 ± 16.2	Mild

post-training anteroposterior movement speeds were 16.3 cm per second and 11.7 cm per second, respectively. The post-training anteroposterior movement speed was significantly reduced by 4.6 cm per second compared with the pre-training speed, which suggests that the training significantly reduced this parameter (p=0.036). The pre- and post-training swing area per second values were 0.7 cm^2 and 0.2 cm^2, respectively, representing a significant decrease of 0.5 cm^2 in this parameter (p=0.012). Regarding dynamic balance ability, the pre-training value for the Timed Up and Go test was 15.9 seconds. After eight weeks of training, this time improved to 14.8 seconds, representing a reduction of 1.1 seconds. Thus, the subjects in the Wii Fit balance game training group were faster in the Timed Up and Go test, although the difference was not significant (p=0.069). For lower extremity muscle strength, the pre- and post-training speed strength index values were 3.0 times the body weight per second and 3.5 times the body weight per second, respectively, representing a significant increase of 0.5 times the body weight per second among subjects in the Wii Fit balance game training group (p=0.017).

The physical education group did not show any significant differences between the pre- and post-training parameters, with the exception of the speed strength index (p=0.017), and the sedentary activity group did not show any significant differences between the pre- and post-training parameters.

DISCUSSION

Because previous studies reported that short balance training programs (4 or 5.5 weeks) did not lead to significant effects on the ability to control posture and balance[15], this study was designed to include 8 weeks of training. Pre-training data were collected in the week prior to training, and post-training data were collected during the 8th week of training.

Longer durations of standing on one leg with the eyes closed indicate an improved ability to maintain and control body posture. The duration of standing on one leg with the eyes closed significantly improved in the Wii Fit balance game training group after eight weeks of training. The physical education group also showed an improved standing time, although the difference was not significant. After eight weeks of sedentary activity, the sedentary activity group showed a reduced duration of standing on one leg with the eyes closed, although the difference was not significant. These findings are consistent with those of Kuo et al.[16], who provided Wii Fit training to children with special needs. Both studies found that Wii Fit balance games could be used to increase the duration of standing on one leg with the eyes closed. Many researchers and clinicians have begun to use the speed of the foot center of pressure to assess changes in the foot center of pressure. The average speed of movement of the foot center of pressure is related to muscle contraction and stretching changes, with a smaller average speed indicating a better ability to control posture and balance[17, 18]. The Wii Fit balance training group showed a significant improvement in anteroposterior movement speed, indicating that training enhanced the ability of these subjects to control

Table 2. Pre-training parameters of each group

Items	Wii Fit balance game training group (Md ± QD)	Physical education group (Md ± QD)	Sedentary activity group (Md ± QD)
Duration of standing on one leg with the eyes closed (sec)	2.3 ± 0.7	1.5 ± 0.6	2.9 ± 2.4
Timed Up and Go (sec)	15.9 ± 2.2	17.2 ± 1.7	17.2 ± 0.6
Speed strength index (weight times/sec)	3.0 ± 0.3	2.8 ± 0.3	2.6 ± 0.3

Md: median; QD: interquartile range

Table 3. Pre- and post- training parameters of each group (Md ± QD)

Items	Wii Fit balance game training group		Physical education group		Sedentary activity group	
	Before	After	Before	After	Before	After
Duration of standing on one leg with the eyes closed (sec)	2.3 ± 0.7	10.0 ± 8.6*	1.5 ± 0.6	2.0 ± 1.6	2.9 ± 2.4	2.3 ± 0.3
Average mediolateral moving speed (cm/sec)	9.4 ± 2.3	7.8 ± 1.7	9.4 ± 2.3	8.2 ± 1.8	7.5 ± 2.2	8.3 ± 1.6
Average anteroposterior moving speed (cm/sec)	16.3 ± 4.6	11.7 ± 3.4*	10.6 ± 1.6	13.3 ± 3.8	11.7 ± 2.6	11.7 ± 3.5
Swing area per second (cm^2/sec)	0.7 ± 0.6	0.2 ± 0.05*	1.2 ± 0.8	0.6 ± 0.5	0.3 ± 0.3	0.6 ± 0.2
Timed Up and Go (sec)	15.9 ± 2.2	14.8 ± 1.0	17.2 ± 1.7	18.0 ± 1.1	17.2 ± 0.6	18.3 ± 1.0
Speed strength index (weight times/sec)	3.0 ± 0.3	3.5 ± 0.4*	2.8 ± 0.3	3.5 ± 0.5*	2.6 ± 0.3	2.7 ± 0.4

* Significant differences between the pre- and post-training data (p<0.05).
Md: median; QD: interquartile range

body posture. After eight weeks of physical education, the physical education group showed improvements in anteroposterior and mediolateral movement speeds, although the differences were not significant. This result may be related to the design of the physical education activities. The sedentary activity group showed an increase in mediolateral movement speed, indicating increased foot pressure center offset and increased body sway, but the difference was not significant. The foot center of pressure swing area is related to visual function, proprioception, and center of gravity[15, 18]. Smaller foot center of pressure swing area values indicate greater posture stability[19, 20]. In this study, all three groups showed a reduced swing area per second, but the difference between the pre- and post-training values was significant in only the Wii Fit balance game training group. This result indicated that the subjects in the Wii Fit balance game training group showed a significant improvement in posture stability after eight weeks of training.

A shorter Timed Up and Go test time indicates that a subject can complete the actions of getting up from the chair, walking some distance, returning to the chair, and sitting still in a shorter time and that the subject has better dynamic balance ability. Although the differences in the pre- and post-training values for the Timed Up and Go test were not significant, the Wii Fit balance game training group showed a reduction of 1.1 seconds, the physical education group showed a reduction of 0.8 seconds, and the sedentary activity group showed an increase of 1.1 seconds. The characteristics of virtual reality games enable them to attract students with short attention spans. Students with intellectual disabilities, who were often ignored in physical education in the past, showed considerable interest in participating in Wii Fit balance game training. After eight weeks of Wii Fit balance game training, the subjects in this group exhibited a significant improvement in static balance but no significant progress in dynamic balance ability. One explanation may be related to the design of the Wii Fit balance games. Among the Wii Fit balance games, Soccer Heading, Ski Slalom, Table Tilt, Snowboard Slalom, Balance Bubble and Penguin Slide are all static balance training games, whereas Tightrope Walk and Ski Jump are dynamic balance ability training games. It is possible that the higher number of static balance training games led to significant progress in static, but not dynamic, balance ability.

Lower extremity muscle strength is very important for daily life and the career adaptation of people with intellectual disabilities. Frey et al.[21] indicated that people with mild mental disabilities could effectively improve their muscle strength after exercise and training. In the present study, both the Wii Fit balance game training and physical education groups showed significant improvements in muscle strength, suggesting that both types of training can enhance lower extremity muscle strength. In contrast, the sedentary activity group did not show a significant improvement. Balance ability has been reported to be closely related to lower limb muscle strength[22]. However, the present study found that the physical education group significantly improved lower limb muscle strength but not dynamic and static balance abilities. Whether the lack of significant progress in balance ability in these subjects was due to influences of the sensory system, central nervous system, or other factors requires further investigation.

In conclusion, Wii Fit balance game training can improve the static balance ability and lower extremity muscle strength in students with intellectual disabilities. Additionally, Wii Fit is fun for the whole family, is not restricted by time or space, and is safe. It is recommend that Wii Fit training systems be provided to the families of students with poor balance to enable these students to undergo Wii Fit balance training in the home environment to enhance the efficacy of future learning.

ACKNOWLEDGEMENT

REFERENCES

1) Chen JL: Comparison of balance control between mental retardation and normal students. J Phys Educ Sports, 2006, 17: 29–42.

2) Shumway-Cook A, Woollacott MH: Dynamics of postural control in the child with Down syndrome. Phys Ther, 1985, 65: 1315–1322. [Medline]

3) Haley SM: Postural reactions in infants with Down syndrome. Relationship to motor milestone development and age. Phys Ther, 1986, 66: 17–22. [Medline]

4) Tzu-Chun Y: An Extended TAM with the Users' Behavior of the Interactive Virtual Reality Games: Case of Nintendo Wii. Taichung: National Taichung University of Science and Technology, 2008.

5) Sugarman H, Weisel-Eichler A: Use of the Wii Fit system for the treatment of balance problems in the elderly: a feasibility study. Virtual Rehabilitation International Conference, 2009, 111–116.

6) Tarakci D, Ozdincler AR, Tarakci E, et al.: Wii-based balance therapy to improve balance function of children with cerebral palsy: a pilot study. J Phys Ther Sci, 2013, 25: 1123–1127. [Medline] [CrossRef]

7) Yatar GI, Yildirim SA: Wii Fit balance training or progressive balance training in patients with chronic stroke: a randomised controlled trial. J Phys Ther Sci, 2015, 27: 1145–1151. [Medline] [CrossRef]

8) Miller DK: Measurement by the Physical Educator: Why and how. New York: McGraw-Hill, 2003.

9) Fan Chiang YM: Validating Four Static Balance Tests by a Force Platform System. Unpublished master's thesis, National Taiwan Normal University, 2001.

10) Chen HY: Reliability and minimal detectable change of single- and dual-tasking timed Up & Go tests. Chung Shan Med J, 2013, 24: 9–17.

11) Weng CS, Tian Z, Li M, et al.: The value of the timed "up and go" test at the evaluation of functional mobility in stoke patients. Chin J Rehabil Theory Pract,

2004, 10: 733–735.

12) Chia-Chi H: Early Trunk Exercises Enhance Recovery of Stroke. Unpublished master's thesis, National Yang-Ming University, 2004.

13) Jiaqing C, Chunxiang L, Lijun C, et al.: The effects of rehabilitation exercises in community-dwelling elderly with osteoarthritis and stroke: a pilot study. Taiwan Rehabil Med, 2010, 38: 97–105.

14) Taguchi N, Higaki Y, Inoue S, et al.: Effects of a 12-month multicomponent exercise program on physical performance, daily physical activity, and quality of life in very elderly people with minor disabilities: an intervention study. J Epidemiol, 2010, 20: 21–29. [Medline] [CrossRef]

15) Verhagen E, Bobbert M, Inklaar M, et al.: The effect of a balance training programme on centre of pressure excursion in one-leg stance. Clin Biomech (Bristol, Avon), 2005, 20: 1094–1100. [Medline] [CrossRef]

16) Wei-Chi K: The Effect of Six-Week Wii Fit® Game of Balance Training on the Balance Ability of Children with Hearing Impairment. Unpublished master's thesis, National Taichung University of Education, 2011.

17) Asseman F, Caron O, Crémieux J: Is there a transfer of postural ability from specific to unspecific postures in elite gymnasts? Neurosci Lett, 2004, 358: 83–86. [Medline] [CrossRef]

18) Paillard T, Noé F, Rivière T, et al.: Postural performance and strategy in the unipedal stance of soccer players at different levels of competition. J Athl Train, 2006, 41: 172–176. [Medline]

19) Hlavackova P, Fristios J, Cuisinier R, et al.: Effects of mirror feedback on upright stance control in elderly transfemoral amputees. Arch Phys Med Rehabil, 2009, 90: 1960–1963. [Medline] [CrossRef]

20) Morioka S, Hiyamizu M, Yagi F: The effects of an attentional demand tasks on standing posture control. J Physiol Anthropol Appl Human Sci, 2005, 24: 215–219. [Medline] [CrossRef]

21) Frey GC, McCubbin JA, Hannigan-Downs S, et al.: Physical fitness of trained runners with and without mild mental retardation. Adapt Phys Activ Q, 1999, 16: 126–137.

22) Nitz JC, Kuys S, Isles R, et al.: Is the Wii Fit a new-generation tool for improving balance, health and well-being? A pilot study. Climacteric, 2010, 13: 487–491. [Medline] [CrossRef]