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Original Research Article

EFFECT OF VIRTUAL REALITY VERSUS TRADITIONAL PHYSICAL THERAPY ON FUNCTIONAL BALANCE IN CHILDREN WITH DOWN SYNDROME: A RANDOMIZED COMPARATIVE STUDY

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ABSTRACT

Background: Children with Down syndrome (DS) have difficulties with equilibrium, balance, and protective responses leading to delay in postural control and locomotion. Improvement in balance can produce greater stability while performing activities of daily living or work related tasks. Virtual reality (VR) allows individuals to experience activities and events similar to those they might encounter in real life. It can be used clinically to improve strength, range of motion, coordination, attention span, balance and posture. However, the absolute effects of VR as a single treatment to improve balance are not yet investigated.

The purpose: of this study was to compare the effectiveness of virtual reality using Wii games versus traditional physical therapy in enhancing functional balance in children with DS.

Materials and methods: Twenty six children with Down syndrome from both sexes participated in this study. Their ages ranged from 6-9 years and randomly distributed into two groups. Group (A) received traditional physical therapy and Group (B) received Wii balance program. Treatment sessions were 30 minutes, 3 times per week for 8 weeks. The primary outcome measures were pediatric balance test, the timed up and go test, and the five-times-sit-to-stand test.

Results: All measured outcomes were significantly improved in both groups from pre to post-intervention. Children in group (B) showed significant improvements as compared with those of group (A).

Conclusion: Wii games based balance training has the potential to improve the functional balance in children with Down syndrome and it can be used as an alternative modality whenever conventional physical therapy is not feasible.

KEY WORDS: Down Syndrome, Virtual- Reality, Traditional physical therapy , Wii games, Functional Balance.

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INTRODUCTION

Control of whole body balance has substantial impact on the ability to perform everyday life competences [1]. Improvement in balance can produce greater stability while performing activities of daily living or work related tasks thus decreasing the occurrence of accidents or falls resulting in less injury [2]. Furthermore, poor balance can seriously limit performance and ultimately decreases quality of live [3]. Being highly reliable, the root mean square and velocity of the center of pressure (COP) displacement have been widely used in the literature to evaluate postural balance [4-6].

Down syndrome (DS), which is the most commonly occurring chromosomal anomaly, results in a large number of phenotypes including learning difficulties, cardiac defects and distinguishing facial features [7]. The syndrome has the incidence of 1 in every 800 live births and is one of the leading causes of intellectual disabilities [8]. It is known that children with DS often show muscle hypotonia, decreased strength, ligamentous laxity and difficulty initiating movement, all of which are thought to contribute to delays in motor development [9]. Palasiano et al. [10] reported that gross motor function might improve in children with DS as they grow, and that they require more time to learn movements as movement complexity increases. Moreover, postural instability in these children is recognized to be a consequence of their inherent musculoskeletal characteristics of lax ligament and reduced passive stiffness around motion joints [11].

Balance is maintained as a result of the interaction of three systems: the visual, the vestibular, and the sensorimotor systems. Ayres [12] clarified that a common feature in children with DS is the failure to integrate sensory information into adaptive responses that include making judgments about the environment, responding to the surrounding challenges with success and accomplishing the required task. The consequent deficits in static standing balance, has been considered as a partial explanation for the common functional balance problems in this population. Their condition generally leads them to be more inactive which contributes to an even worse postural control [13,11].

Traditional physical therapy approaches for movement difficulties and balance deficiencies in children with disabilities are repetitive and offer very little to keep a young mind focused during extended treatment sessions. Besides, children with DS tend to show difficulty in repeated practice of functional activities because of the nature of their movement limitations and cognitive impairments in addition to the lack of variability in the intervention context [14]. Therefore, the integration of video gaming technologies in the field of rehabilitation has been increasing in the recent years.

Virtual reality (VR) is a computer technology providing artificial sensory feedback so as to allow children to experience activities and events similar to those they might encounter in real life. Virtual reality-based therapy (VRBT) is one of the most promising recent developments in rehabilitation technology in which can be used clinically to improve strength, range of motion, coordination, attention span, problem solving, decision making, balance and posture [15]. The practice of these activities may be promising as it may increase the child's motivation during therapy, and can be used as part of the child's home therapy programs.

The Nintendo's Wii is a low-cost commercial VR system which changed the way video games were viewed because it actively involved the gamer in the playing of the game [16]. Wii has become a popular form of therapy for children with disabilities, supported by a growing body of evidence substantiating its effectiveness with this population. In their recent literature review, Wang and Reid [17] identified 21 studies that investigated the effectiveness of VR systems including Nintendo's Wii in pediatric rehabilitation including children with cerebral palsy, autism and attention deficit hyperactivity disorder (ADHD).

Most of the studies have used VR as an adjunctive treatment which did not allow evaluation of the absolute effect of intervention. In particular, collection of postural data in quite standing with eye opened and with eye closed was the primary concern to assess static balance. Therefore, the purpose of this study is to compare the effectiveness of virtual reality using wii games versus traditional physical therapy in enhancing functional balance in children with DS.

MATERIALS AND METHODS

Participants: The study was conducted on twenty six children with Down syndrome (18 boys and 8 girls) after approval of the local ethical authority. Children were identified from pediatric rehabilitation centers and physical therapy outpatient clinics.

The inclusion criteria were: children with a diagnosis of DS, as determined by a specialized physician, who aged between 6-9 years, able to stand and walk alone, able to understand simple instructions and their IQ level range at least

between 50-70%. The IQ level using Stanford binet intelligence scale was determined by a clinical psychologist. The exclusion criteria were: coexisting medical conditions as autism, cerebral palsy, loss of vision and hearing. Also children with previous history of neurological disorders such as traumatic brain injury, muscular dystrophies, and epilepsy were excluded [18]. Parents or children guardian were contacted to explain the study procedures and request consent. Children were divided randomly in to two matching groups, Group (A) received traditional physical therapy and Group (B) received Wii balance program. Treatment sessions were 30 minutes, 3 times per week for 8 weeks.

Randomization: To ensure that both groups contained approximately equal numbers of males and females, all participants with DS were stratified by sex before being randomly assigned into either group. Randomization process was performed using closed envelopes containing cards labeled with either group A or B. Finally, each child was asked to draw a closed envelope that contained the label of one of the two groups.

Outcome measures: All data were collected at the beginning and after the training program by the principal investigator who is a licensed physical therapist and pediatric certified clinical specialist with 10 years of experience working with this population. The investigator was blinded to group allocation and was not involved in the intervention. The primary outcome measures were pediatric balance test, the timed up and go test, and the five-times-sit-to-stand test.

Pediatric Balance Scale (PBS): Pediatric balance scale is a modified version of the Berg Balance Scale, and is used to assess balance for young children with mild to moderate disabilities. The relative and absolute reliability of PBS has been previously established [19]. The following materials were used to asses balance: adjustable height bench, chair with back support and arm rest, stop watch, masking tape-1 inch wide, a step stool 6 inches in height, chalkboard eraser, yardstick and a small level. It is a standardized test for children older than 4 years.

The timed up and go test: The children was seated in a chair with armrests and instructed to get up from the chair, walk to a point 3m away, turn around, walk back to the chair, and sit. Each participant performed two trials and the results of the two trials were averaged. This test is a valid and reliable measure of balance in typically developing children and children with disabilities [20, 21].

Five-times-sit-to-stand test: The five-times-sit-to-stand test was used to measure ability to perform transitional movements. The test is a valid and reliable measure of balance [22].

Participants were asked to 'stand up and sit down five times as quickly as they can' with their arms folded across their chests. The total time taken to complete the test was recorded using a stopwatch.

Intervention

Group A: children received traditional physical therapy that was provided by the certified physical therapists in the clinical setting for 30 min in a form of throwing and catching balls/bean-bags outside of their base of support, reaching for objects while standing or sitting on stable or unstable surfaces, walk up and down stairs, balance beam walk, single leg stance and kicking activities [23]. Treatment provided for this group was individualized based on functional limitations and abilities of each child.

Group B: Children in this group participated in the Wii training using Nintendo Wii Sports and Nintendo Wii Fit. Three Wii games (Figure. 1) were practiced for 10 minutes each as follow: football heading game which improves movements of trunk and extremities in large spectrum of balance perturbations that vary in both amplitude and location of destabilizing force. Second is the Ski Slalom game which elicits lower limbs balance strategy and improve loading of the lower extremities, and finally the Table Tilt game elicits control over the whole body through dynamic balance on a virtual balance board. Each training session was supervised by a therapist from one of the clinical sites.

Data analysis: For the statistical analysis, the Kolmogorov-Smirnov test demonstrated normal data distribution. Thus, parametric tests were performed and the data were expressed as mean and standard deviation values. At

baseline, differences in age and gender between the two groups were analyzed. Two-way repeated-measures analysis of variance for repeated measures on the time factor was used to compare the difference between groups (Group A and Group B) and timing (pre-intervention and post-intervention) for each studied outcome. The alpha level of statistical significance was set at $P < 0.05$. Statistical Package for the Social Sciences Version 19.0 (IBM Corporation, New York, NY, USA) was used for the analysis.

Soccer heading game (A), Ski Slalom game (B) and Table tilt game(C).

RESULTS

Twenty six children participated in this study. Their mean age was 7.07± 0.67 years, weight 23.3± 5.93 kg, and height 113.6± 10.27. There were 18 (69.2%) boys and 8 (30.8%) girls. Children demographics data are presented in Table 1. No significant differences were found at baseline between groups demographics (age, weight, height, and gender) or any of the variables measured. All measured outcomes were significantly improved in both groups from pre to post-intervention. The raw data for the groups are shown in Table 2. Between groups comparison following the intervention indicated that the VR training group showed significant improvements in pediatric balance scale ($P = 0.046$), the timed up and go test ($P = 0.043$) and five-times-sit-to-stand test ($P = 0.027$) as compared with the traditional physical therapy group.

Table 1: Demographic characteristics (mean ± standard deviation) of the participants.

	Group A n=13	Group B n=13	P value
Age (year)	7.40± 1.27	7.18 ± 1.85	0.363
Height (cm)	113.8 ±5.15	115.5 ± 4.06	0.127
Weight (kg)	22.75 ± 4.38	20.30 ± 5.70	0.282

Table 2: Outcome measures at pre-intervention and post-intervention for the group A and group B.

Variables	Group A n=13		Group B n=13		
	pre	post	Pre	post	Mean difference (post intervention) P value
Pediatric balance scale (M±SD)	47.35 ± 3.8	52.15 ± 4. 7	48.2 ± 4.6	57.75 ± 2.6	5.6 (0.046)*
The timed up and go test (sec) (M±SD)	10.65 ±1.7	8.95 ± 1.4	10.21 ± 2.0	7.01 ± 1.8	1.9 (0.043)*
The five times sit to stand test (sec) (M±SD)	16.56 ± 2.3	14.62 ± 3.2	15.6 ± 2.6	11.2 ± 2.9	3.4 (0.027)*

M; mean, SD; standard deviation, * Significant at $P < 0.05$

DISCUSSION

The use of VR training in the form of Wii games has become a popular form of therapy for children with disabilities, supported by a growing body of evidence which confirm its efficacy with this specific population [24]. The current study was conducted to compare the effects of traditional physical therapy with those gained by VR training using Wii games in enhancing functional balance in children with DS.

Comparison between the baseline and post intervention data showed that both modalities are effective in improving all balance outcome measures. These findings could be attributed to the nature of the selected sample comprising children with mild cognitive impairments and no coexisting medical conditions. Moreover, group A received a well structured physical therapy program which included reaching, weight shifting, single leg bearing, and challenging base of support activities. All of these balance exercises were conducted by a certified physiotherapist who is specialized in pediatric rehabilitation. Similar results were reported by Park [25] who found that ellipse area of COP decreased significantly after wobble board training in adolescents with DS. The post intervention improvement in group B concur with the findings of other studies which determined that VR training using video games is a useful rehabilitation tool for children with disabilities [17,18,24,26]. Snider et al. [27] stated that VR has potential benefits for children with neurological disorders and could positively affect the brain reorganization/plasticity, motor capacity, visual-perceptual skills, social participation and personal factors.

In contrast to our findings, Ramstrand and Lygnegård [28] suggested that the use of Nintendo

Wii fit training balance board and Wii Fit software for a minimum of thirty minutes per day in the patient own home, over a five weeks period, is not effective as a balance training tool for children with hemiplegic or diplegic cerebral palsy (CP). However, the former authors have used VR as an unsupervised home exercise program in a small sample of children with marked physical limitations. These factors might explain the non significant differences which were observed between testing occasions for any of the balance measures investigated in their study.

Regarding the comparison between the post intervention data of both groups, the children in group B out-performed the children in group A significantly. This comparison reveals that VR in the form of Wii games is superior to traditional physical therapy training in improving functional balance in children with DS. This is partially due to the fact that during balance training repetition of individual exercises is important for the recovery of neural connections and brain plasticity [29]. Virtual reality training (VRT) allows children to interact with a virtual environment while they perform a specific therapeutic exercise. It is enjoyable and may motivate patients to do more repetitions of their exercises [30], contributing to increased intensity.

The three Nintendo Wii games used in this study were repeated an average of 150 times during each VRT session. Over 24 treatment sessions, each movement is performed up to almost 3600 times, thereby providing a high intensity of movement repetition. Consequently it is expected that neural recovery could be enhanced using VRT exercises which is additionally characterized by being feasible and safe [24]. No adverse effects or musculoskeletal injuries were reported during the extended course of treatment. Definitely, this kind of highly motivating intense training could not be achieved using traditional physical therapy training which might be boring for this specific population of young children.

Generally, balance in response to postural perturbation is influenced more by the visual system than by the vestibular and somatosensory systems. Vision receives accurate cues and assists motor function by integrating of information about the positions of the head in space and objects in the external environment [31]. Children with DS have problems with motor responses elicited by received information rather than cognition of visual information. Additionally, head position caused by scoliosis and the cervical reflex have negative impacts on both the central and peripheral nervous systems. A probable explanation of functional balance improvement after VR training over the traditional rehabilitation program is its ability to improve the head orientation and to maintain constant focus through visual attraction which is needed during dynamic balance exercises. The use of the Wii games involves augmented forms of sensory feedback that allow detection of posture and balance disturbances and corrections, thus allowing the participant to use both timely feedback control and feed-forward preparatory control required during different balance challenges.

These results came in disagreement with Jelsma et al. [32] who concluded that Nintendo three weeks of Wii Fit training should not be used in place of conventional physical therapy to improve balance and gross motor functions in children with spastic hemiplegic cerebral palsy. This could be attributed to the small sample size, short treatment course, and different sample inclusion criteria in their study.

The current study has some limitations; the first one is the lack of control for physical activities of the children outside the clinical with no unified home exercise program. Second, the physical therapists who supervised the training programs were not blinded to the purpose of the study. Finally, children selected for the study suffered mild degree of cognitive impairments and physical disability making it difficult to generalize these results for children with higher degrees of impairments or disabilities.

CONCLUSION

The current study supports the use of Wii games not only as a safe and potentially effective adjunctive therapeutic tool to augment the rehabilitation of young children with DS but also as an alternative modality whenever conventional physical therapy is not feasible. This new

concept would help clinicians to design a high intense home exercise program with a variety of games and controlled level of difficulty to target children with diverse impairments and functional disabilities using a low cost commercially available gaming system.

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Conflicts of interest: None

REFERENCES

[1]. Figura, F.,Cama,G.,Capranica,L.,Guidetti,L.,& Pulejo, C. Assessment of static balance in children. The Journal of Sports Medicine and Physical Fitness 1991;31(2):235–242.

[2]. Seagraves, F., M. Horvat, C. Franklin, & K. Jones. Effects of a school based program on physical function and work productivity in individuals with mental retardation. Clinical Kinesiology 2004;58(2):18-29.

[3]. Baker C.P., Newstead,A.H., Mossberg,K.A., & Nicodemus,C.L. Reliability of static standing balance in nondisabled children :Comparison of two methods of measurement. Pediatric Rehabilitation1998;2(1):15–20.

[4]. Wrisley, D.M., &Whitney,S.L. The effect of foot position on the modified clinical test of sensory interaction and balance. Archives of Physical Medicine and Rehabilitation 2004;85(2):335–338.

[5]. Winter, D. Biomechanics and motor control of human movement (4th ed.). Hoboken, NJ: John Wiley & Sons, Inc.; 2009.

[6]. Wang, H, Long, I, Liu, M. Relationships between task-oriented postural control and motor ability in children and adolescents with Down syndrome. Research in Developmental Disabilities 2012;33(6):1792–1798.

[7]. E.Lana-Elola, S.D. Watson-Scales, E.M. Fisher, V.L. Tybulewicz. Down syndrome: searching for the genetic culprits, Dis Model Mech 2011;4(5):586-595.

[8]. B.L. Handena, A.D. Cohena, U. Channamalappaa, P. Bulovab, S.A. Cannonc, W.I. Cohenc, C. A. Mathisd, J.C. Priced, W.E. Klunka. Imaging brain amyloid in nondemented young adults with Down syndrome using Pittsburgh compound B, Alzheimer's & Dementia 2012;8(6):496-501.

[9]. Shields N, Taylor NF, Dodd KJ. Effects of a community-based progressive resistance training program on muscle performance and physical function in adults with Down syndrome: a randomized controlled trial. Arch Phys Med Rehabil. 2008;89(7):1215–20.

[10]. R.J. Palisano, S.D. Walter, D.J. Russell, P.L. Rosenbaum, M. Gemus, B.E. Galuppi, L. Cunningham. Gross motor function of children with down syndrome: creation of motor growth curves, Arch Phys Med Rehabil 2001;82(4):494-500.

[11]. Galli, M., Rigoldi, C., Mainardi, L., Tenore, N., Onorati, P., & Albertini, G. Postural control in patients with Down syndrome. Disability and Rehabilitation 2008;30(17):1274–1278.

[12]. Ayres, A. J. Sensory integration and the child (2nd ed.). Los Angeles: Western Psychological Services; 2004.

[13]. Cabeza-Ruiz, R., Garcia-Masso,X., Centeno-Prada,R.A., Beas-Jimenez, J.D., Colado,J.C., & Gonzalez,L.M. Time and frequency analysis of the static balance in young adults with Down syndrome. Gait and Posture 2011;33(1):23-28.

[14]. Wuang, Y. P., Wang, C. C., Huang, M. H., & Su, C. Y. Prospective study of the effect of sensory integration, neuron-developmental treatment, and perceptual motor therapy on sensorimotor performance in children with mild mental retardation. American Journal of Occupational Therapy 2009;63(4):441–452.

[15]. Snider, L., Majnemer A. and Darsaklis V. Virtual reality as a therapeutic modality. Dev Neurorehabil. 2010;13(2):120-128.

[16]. Shinkle, E. Video games, emotion and the six senses. Media Culture Society 2008;30(6):907-915.

[17]. Wang M, Reid D. Virtual reality in pediatric neurorehabilitation: attention deficit hyperactivity disorder, autism and cerebral palsy. Neuroepi demiology 2011;36(1):2–18.

[18]. Wuang Y, Chiang C, Su C, Wang C. Effectiveness of virtual reality using Wii gaming technology in children with Down syndrome. Research in Developmental Disabilities 2011;32(1):312–321.

[19]. Franjoine MR, Gunther JS, Taylor MJ: Pediatric balance scale: a modified version of the berg balance scale for the school age child with mild to moderate motor impairment. Pediatr Phys Ther, 2003;15(2):114-128.

[20]. Posiadlo D, Richardson S. The timed 'up & go': a test of basic functional mobility for frail elderly persons. J Am Geriatr Soc 1991;39(2):142–148.

[21]. William EN, Caroll SG, Reddihough DS, Phillips BA, GaleaMP. Investigation of the timed 'up & go' test in children. Dev Med Child Neurol,2005;47(8):518–24

[22]. Whitney SL, Wrisley DM, Marchetti GF, Gee MA, Redfern MS, Furman JM. Clinical measurement of sit-to-stand performance in people with balance disorders: validity of data for the five-times-sit-to-stand test. Phys Ther 2005;85(10):1034–45.

[23]. Tatla, S. K., Radomski, A., Cheung, J., Maron, M., Jarus, T. Wii-habilitation as balance therapy for children with acquired brain injury. Developmental Neurorehabilitation 2012;17(1):1-15.

[24]. Salem Y, Gropack S, Coffin D, Ellen M. Godwin E. Effectiveness of a low-cost virtual reality system for children with developmental delay: a prelimi

nary randomised single-blind controlled trial. Phys Ther. 2012;98(3):189–195.

[25]. Park TJ. The effects of wobble board training on the eyes open and closed static balance ability of adolescents with down syndrome. J Phys Ther Sci. 2014 Apr;26(4):625-7.

[26]. You SH, Jang SH, Kim YH, Kwon YH, Barrow I, Hallett M. Cortical reorganization induced by virtual reality therapy in a child with hemiparetic cerebral palsy. Dev Med Child Neurol 2005;47(9):628–35.

[27]. Snider, L., Majnemer A. and Darsaklis V. Virtual reality as a therapeutic modality. Dev Neurorehabil. 2010;13(2):120-128.

[28]. Ramstrand N, Lygnegård F.: Can balance in children with cerebral palsy improve through use of an activity promoting computer game? Technol Health Care, 2012;20(6):501–510.

[29]. Teasell R, Bayona N, Salter K, Hellings C, Bitensky J. Progress in clinical neurosciences: stroke recovery and rehabilitation. Can J Neurol Sci. 2006;33(4):357-64.

[30]. Thornton M, Marshall S, McComas J, Finestone H, McCormick A, Sveistrup H. Benefits of activity and virtual reality based balance exercise programmes for adults with traumatic brain injury: Perceptions of participants and their caregivers. Brain Injury. 2005;19(12):989-1000.

[31]. Nashner L, Berthoz A: Visual contribution to rapid motor responses during postural control. Brain Res, 1978;150(2):403–407.

[32]. Jelsma J, Pronk M, Ferguson G, et al. : The effect of the Nintendo Wii Fit on balance control and gross motor function of children with spastic hemiplegic cerebral palsy. Dev Neurorehabil, 2013;16(1):27–37.

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