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Potential of the Nintendo Wii™ as a rehabilitation tool for children with cerebral palsy in a developing country: a pilot study

C. Gordon, S. Roopchand-Martin *, A. Gregg

Section of Physical Therapy, University of the West Indies, Kingston, Jamaica

Abstract

Objectives To explore the possibility of using the Nintendo Wii™ as a rehabilitation tool for children with cerebral palsy (CP) in a developing country, and determine whether there is potential for an impact on their gross motor function.
Design Pilot study with a pre–post-test design.
Setting Sir John Golding Rehabilitation Center, Jamaica, West Indies.
Participants Seven children, aged 6 to 12 years, with dyskinetic CP were recruited for the study. One child dropped out at week 4.
Intervention Training with the Nintendo Wii was conducted twice weekly for 6 weeks. The games used were Wii Sports Boxing, Baseball and Tennis.
Main outcome measures Percentage attendance over the 6-week period, percentage of sessions for which the full duration of training was completed, and changes in gross motor function using the Gross Motor Function Measure (GMFM).
Results All six participants who completed the study had 100% attendance, and all were able to complete the full 45 minutes of training at every session. Those who were wheelchair bound participated in two games, whilst those who were ambulant played three games. The mean GMFM score increased from 62.83 [standard deviation (SD) 24.86] to 70.17 (SD 23.67).
Conclusion The Nintendo Wii has the potential for use as a rehabilitation tool in the management of children with CP. Clinical trials should be conducted in this area to determine whether this could be an effective tool for improving gross motor function.

Keywords: Virtual reality; Nintendo Wii; Cerebral palsy; Gross motor function

Introduction

Cerebral palsy (CP) is one of the three most common lifelong developmental disabilities, with prevalence rates ranging from 1.5 to 3 per 1000 live births [1–3]. During the management of children with CP, therapists are constantly being challenged to find a balance between activities that are engaging but also effective. Treatment techniques showing good results have been those that are grounded on motor learning theories, where the main focus is intense practice of functional activities [4–8].

The integration of virtual reality into neurorehabilitation is an approach to therapy that is currently being explored in both adults and children with promising results. It has been shown that neurons in the adult human brain increase their firing rates when the individual observes movements being performed by another person [9–11]. Activation of this mirror-neuron system can induce cortical re-organisation and possibly contribute to functional recovery.

Studies using systems ranging from full to partial immersion have reported improvements in both upper and lower extremity function in patients following stroke and children with CP [12–24]. Furthermore, case studies investigating cortical re-organisation in a patient following chronic stroke and a child with hemiparetic CP have shown evidence of neuroplastic changes associated with enhanced functional skills when training was undertaken in a virtual environment [23,24].

Simple virtual reality gaming systems such as the Nintendo Wii™ are affordable, and many physical therapy departments in third world countries, as well as individual

* Correspondence: Section of Physical Therapy, University of the West Indies, P.O. Box 126, Mona P.O. Kingston 7, Jamaica. Tel.: +876 927 2235; fax: +876 702 2023.
E-mail address: sharmella3@hotmail.com (S. Roopchand-Martin).

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therapists, may find that it is well within their budgets. The Nintendo Wii could potentially be a treatment option for physical therapists who have to work in very constrained spaces and with limited equipment to keep the children engaged in the rehabilitation process.

The objectives of this pilot study were to explore the possibility of: (1) using the Nintendo Wii for the rehabilitation of children with CP in a setting with multiple distractions; (2) children with both good and limited grasp function being able to play the selected games; and (3) both wheelchair-dependent and ambulant children being able to train with the gaming system. Additional objectives were to determine: (4) the acceptability of this form of training among children with CP; and (5) whether training with the Nintendo Wii had the potential to impact gross motor function.

Methods

Study design

A pilot pre–post-test study was conducted to explore the potential of using the Nintendo Wii as a rehabilitation tool for children with dyskinetic CP in a developing country. Approval to conduct the research was given by the University of the West Indies Ethics Committee (Mona Campus).

Participants

Participants were recruited from three treatment centres located in the parish of St. Andrew, Jamaica. Children between the ages of 6 and 12 years who had adequate cognitive function to understand the requirements for interaction with the gaming system, and had visible shoulder and elbow movement were included. Any children involved in an exercise/rehabilitation programme or diagnosed with any other medical problem that could affect their ability to participate in the training were excluded from the study.

Procedure

Prospective candidates were identified, the study was explained to the parents/caregivers and informed consent was obtained. All participants were assessed using the Gross Motor Function Measure (GMFM) prior to the start of training, and two familiarisation sessions were scheduled for each participant to interact with the system. This was followed by a 6-week training programme, at the end of which the children were re-assessed by the same evaluators. Assessments were conducted by two therapists who had been trained in and had significant experience with use of the GMFM. Both assessors were aware that the study involved the use of the Nintendo Wii, but no study details were provided. The two assessors selected were the only physical therapists in Kingston with experience of using the GMFM when the study was being conducted. Both were also involved in part-time lecturing at the School of Physical Therapy, and therefore it would have been impossible to blind the assessors.

Training

The training sessions took place in the afternoons after the children's regular school day. They were conducted by a final-year physical therapy student under the supervision of a qualified therapist. Participants were trained 2 days/week, on set days, for 6 weeks, with each session lasting 45 minutes. Participants who were wheelchair dependent were trained in unsupported sitting on a stool, whilst those who were ambulant were trained in standing. In both situations, a gait belt was placed around their waist to prevent falls. In addition, the student therapist stood behind the participant during training to guard against a fall. Mats were placed on the floor around the participant as an additional safety measure. For those who had a weak or non-functional grasp, a crepe bandage was used to secure the Wii Remote™ in the hand.

All participants started with Wii Sports Boxing, and a different game was assigned once they were winning 90% of the matches played in each session. Progression was made from Boxing to Baseball and then Tennis. No form of manual facilitation or guidance was provided. The training sessions were conducted in an open space (48 square feet), and other patients were being treated in the surrounding area.

Virtual reality system

The Nintendo Wii gaming console with the Wii Sports Resort disc was used for training. Images were projected to a screen using a Dell DP projector (Model 3300MP). For Wii Sports Baseball and Tennis, the bat and racket accessory were attached to the Wii Remote.

Outcomes

Objective 1 was assessed based on the percentage of sessions for which the children were able to remain engaged with the game for the full 45 minutes. Objectives 2 and 3 were assessed based on the number of games completed by those with impaired hand function or who were wheelchair dependent compared with those who had good hand function or were ambulant. Percentage attendance over the 6-week period and the percentage of sessions completed was used to assess the acceptability of the intervention (Objective 4). The GMFM was used to assess potential changes in gross motor function (Objective 5).

The GMFM-88 is a standard observational instrument for measuring change in gross motor function in children. It has excellent test–retest, inter-rater and intra-rater reliability (intra-class correlation coefficient 0.88 to 0.99), and can be used across a broad range of ages and functional abilities [25,26]. The instrument assesses movement performance in different positions. Individual tasks are scored on a four-point scale, and dimension scores are calculated as a percentage

Table 1
Subjects' characteristics.

Subject	Age (years)	Gender	Category of cerebral palsy	Impaired grip	No. games played	Mobility[a]
1	11	Male	Diplegia	No	2	Wheelchair
2	12	Male	Quadriplegia	Yes	2	Ambulant
3	10	Female	Diplegia	No	3	Ambulant
4	9	Female	Diplegia	No	3	Ambulant
5	9	Male	Hemiplegia	Yes	2	Wheelchair
6	11	Male	Hemiplegia	Yes	2	Wheelchair
7	12	Female	Quadriplegia	Yes	2	Wheelchair

[a] Children were ambulant with an assistive device.

of the maximum possible score obtainable on each dimension, with the highest possible percentage being 100. The five dimensions are then averaged to give the total GMFM score. The minimal clinically meaningful change on the scale is considered to be 1% [26,27].

Data analysis

The mean and standard deviation for scores on each section of the GMFM were determined. Mean pre-test and post-test scores for all dimensions were computed.

Results

Seven children were recruited for the study with a mean age of 10.6 years. Participant 2 dropped out at Week 4 of the 6-week study period due to a loss of interest by the parent. Data from this participant were not analysed. The participants' characteristics are shown in Table 1. Three of the six participants who completed the study had impaired grip function, and four were wheelchair dependent.

All six participants who completed the study had 100% attendance for the entire 6-week period. They remained focused and engaged with the games for the full 45-minute duration at all sessions. Both the wheelchair-dependent and ambulant participants were able to play for the full 45 minutes with no adverse events, and the same was noted for those with normal and impaired grip function.

The three participants who had impaired grip function were only able to play two of the three games (Wii Sports Boxing and Baseball). The same was also seen for one participant who had no grip impairment but was wheelchair dependent. The two subjects who were ambulant with an assistive device and had no grip impairment were able to play Wii Sports Boxing, Baseball and Tennis.

The mean pre- and post-test scores for the six dimensions of the GMFM and the total instrument score for each participant are shown in Table A (see supplementary online material). All changes were noted to be above the minimal clinically important difference for the scale (1%). The mean change in the total GMFM score was 7%. It was noted that the mean post-test scores for all sections were higher than the mean pre-test scores. The largest change was seen in Section B (sitting) with a mean change of 12% (SD 13.94). The smallest change was seen in Section A (lying and rolling) with a mean change of 2% (SD 3.34).

Discussion

Results of the study indicate that the Nintendo Wii has potential to be a viable option for use in the rehabilitation of children with CP in developing countries. The Nintendo Wii was developed for able-bodied individuals and requires that the participant holds the remote in the hand while playing. It was noted in this study, however, that by simply securing the remote and nunchuck in the hands of those with limited grasp, using a crepe bandage, they were able to engage fully in Wii Sports Boxing and Baseball. All of the children attempted to play Wii Sports Tennis in addition to Boxing and Baseball; however, only the two ambulant children were able to progress to this game for training. It is possible that the children's perception of the degree of movement required to play Wii Sports Tennis successfully could have hindered their efforts. Their hands were engaged with the remote, and they may have perceived themselves as being unable to move the wheelchair to go after the ball whilst holding the Wii Remote.

It was noted that even with the constrained space and multiple distractions, the children remained fully engaged in the activity. The fact that they attended all sessions was viewed as an indication that this form of training was acceptable to them, and they were motivated to continue training. For the children in this study, the ability to play the games could have led to an enhanced feeling of self-efficacy which may have contributed to their motivation to continue the training programme. It has been reported elsewhere that children with CP felt that they could do more things like their peers when they were engaged in virtual reality training [12].

There was an overall change in participants' performance on the GMFM following the 6-week training period. The domain that showed the least change was lying and rolling. Most of the participants were already close to the maximal score on this domain at the start of the treatment, which would explain the minimal change that was observed. Participants 5, 6 and 7 had the greatest change in the sitting domain scores. These three children had the lowest scores on this domain at the start of treatment, and their entire training programme

was conducted in sitting. The large improvement in their performance on this domain was therefore not surprising.

All participants showed improvement in the crawling and kneeling domain scores. Although the children were in the seated position during training, they were not restrained in the chair. As they became engaged in the programme, they were seen to be attempting to push themselves off the chair into a standing position. The continued effort to stand could have resulted in some strengthening of the hip, knee and trunk extensors, and core stability may have improved as they worked on maintaining their balance while playing. This could explain the observed improvements. The changes in standing were minimal for most participants; however, participant 4 showed a large increase in her score at the end of training. This may have been primarily due to an increased sense of confidence in her abilities, which she obtained from training in the standing position.

Due to the small number of subjects in this study and the lack of a comparative group, it is difficult to say whether the changes observed in gross motor function were due to the training programme, a learning effect or natural changes. However, these results indicate that there may be some potential for training with the Nintendo Wii to have an impact on gross motor function, and research studies should be conducted to explore this hypothesis.

Limitations

A pilot study of this nature does not allow for any concrete conclusions to be made, and clinical trials are required in this area of research. The within-group change noted in the GMFM scores in this study exceeded the minimal clinically important difference. It is expected that there would be a moderate effect between groups with a randomised clinical trial comparing the use of the Nintendo Wii with traditional therapy. A sample size of 64 participants per group would be required to detect this effect [28].

Conclusions

This pilot study indicates that the Nintendo Wii has potential to be a viable tool for use in the rehabilitation of children with CP in developing countries. With minor modifications, children with limited hand function and those who are wheelchair dependent can engage in training on the Nintendo Wii. Clinical trials should be conducted to investigate the effect of this form of training on gross motor function in children with CP.

Ethical approval: The University of the West Indies, Mona Campus, Faculty of Medical Sciences Ethics Committee.

Conflict of interest|: None declared.

Appendix A. Supplementary data

Supplementary data associated with this article can be found, in the online version, at http://dx.doi.org/10.1016/j.physio.2012.05.011.

References

[1] Sankar C, Mundkur N. Cerebral palsy – definition, classification, etiology and early diagnosis. Ind J Pediatr 2005;72:865–8.
[2] Cans C. Surveillance of cerebral palsy in Europe: a collaboration of cerebral palsy surveys and registers. Dev Med Child Neurol 2000;42:816–24.
[3] Winter S, Autry A, Boyle C, Yeargin-Allsopp M. Trends in the prevalence of cerebral palsy in a population-based study. Pediatrics 2002;110:1220–5.
[4] Garvey MA, Giannetti ML, Alter KE, Lum PS. Cerebral palsy: new approaches to therapy. Curr Neurol Neurosci Rep 2007;7:147–55.
[5] Charles JR, Wolf SL, Schneider JA, Gordon AM. Efficacy of a child-friendly form of constraint-induced therapy in hemiplegic cerebral palsy: a randomized control trial. Dev Med Child Neurol 2006;48:635–42.
[6] Eliasson AC, Krumlinde-Sundholm L, Shaw K, Wang C. Effects of constraint-induced movement therapy in young children with hemiplegic cerebral palsy: an adapted model. Dev Med Child Neurol 2005;47:266–75.
[7] Ahl LE, Johansson E, Granat T, Carlberg EB. Functional therapy for children with cerebral palsy: an ecological approach. Dev Med Child Neurol 2005;47:613–9.
[8] Gordon AM, Schneider JA, Chinnan A, Charles JR. Efficacy of hand-arm bimanual intensive therapy (HABIT) in children with hemiplegic cerebral palsy: a randomized control trial. Dev Med Child Neurol 2007;49:830–8.
[9] Rizzolatti G, Fabbri-Destro M, Cattaneo L. Mirror neurons and their clinical relevance. Nat Clin Pract Neurol 2009;5:24–34.
[10] Iacoboni M, Mazziotta JC. Mirror neuron system: basic findings and clinical applications. Ann Neurol 2007;62:213–8.
[11] Pomeroy VM, Clark CA, Miller SG, Baron JC, Markus HS, Tallis RC. The potential for utilizing the mirror neurone system to enhance recovery of the severely affected upper limb early after stroke: a review and hypothesis. Neurorehabil Neural Repair 2005;19:4–13.
[12] Reid D, Campbell K. The use of virtual reality with children with cerebral palsy: a pilot randomized trial. Ther Recreat J 2006;40:255–68.
[13] Braynton C, Bossé J, Brien M, McLean J, McCormick A, Sveistrup H. Feasibility, motivation and selective motor control: virtual reality compared to conventional home exercises in children with cerebral palsy. Cyberpsychol Behav 2006;9:123–8.
[14] Akhutina T, Foreman N, Krichevets A, Matik L, Narhi V, Pylaeva N, *et al.* Improving spatial functioning in children with cerebral palsy using computerized and traditional game tasks. Disabil Rehabil 2003;25:1361–71.
[15] Chen YP, Kang LJ, Chuang TY, Doong JL, Lee SJ, Tsai MW, *et al.* Use of virtual reality to improve upper-extremity control in children with cerebral palsy: a single-participant design. Phys Ther 2007;87:1441–57.
[16] Deutsch JE, Borbely M, Filler J, Huhn K, Guarrera-Bowlby P. Use of a low-cost, commercially available gaming console (Wii) for rehabilitation of an adolescent with cerebral palsy. Phys Ther 2008;88:1196–207.
[17] Viau A, Feldman AG, McFayden BJ, Levin M. Reaching in reality and virtual reality: a comparison of movement kinematics in healthy participants and in adults with hemiparesis. J Neuroeng Rehabil 2004;1:11.
[18] Joo LY, Yin TS, Xu D, Thia E, Chai PF, Kuah CWK, *et al.* A feasibility study using interactive commercial off-the-shelf computer gaming

in upper limb rehabilitation in patients after stroke. J Rehabil Med 2010;42:437–41.
[19] Saposnik G, Mamdani M, Baylety M, Thorpe KE, Hall J, Cohen LG, *et al.* Effectiveness of virtual reality exercises in stroke rehabilitation (EVREST): rationale, design and protocol of a pilot randomized clinical trial assessing the Wii gaming system. Int J Stroke 2010;5:47–51.
[20] Saposnik G, Teasell R, Mamdani M, Hall J, Mcilroy W, Cheung D, *et al.* Effectiveness of virtual reality using Wii gaming technology in stroke rehabilitation. Stroke 2010;41:1477–85.
[21] Sveistrup H. Motor rehabilitation using virtual reality. J Neuroeng Rehabil 2004;1:10.
[22] Weiss PL, Kizony R, Feintuch U, Katz N. Virtual reality in rehabilitation. In: Selzer M, Clarke S, Cohen L, Duncan P, Gage F, editors. Textbook of neural repair and rehabilitation. Cambridge: Cambridge University Press; 2004. p. 182–97.
[23] You SH, Jang SH, Kim YH, Hallett M, Ahn SH, Kwon H, *et al.* Virtual reality-induced cortical reorganization and associated locomotor recovery in chronic stroke: an experimenter-blind randomized study. Stroke 2005;36:1166–71.
[24] You SH, Jang SH, Kim YH, Kwon H, Barrow I, Hallett M. Cortical reorganization induced by virtual reality in a child with hemiparetic cerebral palsy. Dev Med Child Neurol 2005;47:628–35.
[25] Damiano D, Gilgannom M, Abel M. Responsiveness and uniqueness of the paediatric outcomes data collection instrument compared to the gross motor function measure for measuring orthopaedic and neurosurgical outcomes in cerebral palsy. J Pediatr Orthop 2005;25:641–5.
[26] Russell D, Rosenbaum PL, Avery LM, Lane M. Gross motor function measure (GMFM-66 & GMFM-88) user's manual. London: McKeith Press; 2002.
[27] Wang H, Yang Y. Evaluating the responsiveness of 2 versions of the Gross Motor Function Measure for children with cerebral palsy. Arch Phys Med Rehabil 2006;87:51–6.
[28] Cohen J. Statistical power analysis for the behavioral sciences. New Jersey: Lawrence Erlbaum Associates Inc.; 2009.