2018

Is Video Game-Based Therapy Effective in Increasing the Physical Abilities of Children Diagnosed with Cerebral Palsy?

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A SELECTIVE EVIDENCE BASED MEDICINE REVIEW

In Partial Fulfillment of the Requirements For

The Degree of Master of Science

In

Health Sciences – Physician Assistant

Department of Physician Assistant Studies
Philadelphia College of Osteopathic Medicine
Philadelphia, Pennsylvania

December 15, 2017

ABSTRACT

OBJECTIVE: The objective of this selective EBM review is to determine whether or not video game-based therapy is effective in increasing the physical abilities of children diagnosed with cerebral palsy.

STUDY DESIGN: Systematic review of three English language randomized controlled trials (RCTs), all published after 2006.

DATA SOURCES: Two cross-over RCTs and one single-blind RCT, which analyzed video game-based therapy in children diagnosed with cerebral palsy. All studies were found using PubMed.

OUTCOME MEASURED: Each of the articles analyzed the effects of video game-based therapy on physical abilities, which were assessed by upper limb function, stable balance, and coordination. These outcomes were measured by Quality of Upper Extremities Skills Test, rhythmic weight shift test, and a tracking test, respectively. Analysis of data was done utilizing Wilcoxon signed rank test, Friedman's analysis of variance, and two-way ANOVA. Significance was determined using p-values for all three studies.

RESULTS: One study found that therapy with the Xbox Kinect significantly improved upper limb function. One study found that therapy with the Nintendo Wii did not significantly improve balance. One study found that therapy with the Nintendo Wii did not significantly improve coordination.

CONCLUSIONS: Evidence is inconclusive. Xbox Kinect may be an alternative to usual therapy. Video game-based therapy may be a useful adjunctive therapy. Further studies should include larger sample sizes and controlled sessions with a therapist present.

KEY WORDS: cerebral palsy, child, video games

INTRODUCTION

Cerebral Palsy (CP) is a condition characterized by non-progressive, chronic impairment of muscle tone, strength, coordination, or movements.[1] It is caused by cerebral insult, resulting from abnormal development or damage to the cerebral cortex that occurs before, during, or shortly after birth. The most common causes of cerebral insult are cerebral dysgenesis and hypoxic-ischemic encephalopathy.[2] Cerebral dysgenesis may result from infections, fevers, trauma, genetic mutations, and other conditions that affect normal brain growth. [2] The normal stress of labor and delivery can cause poor oxygen supply to the brain without causing any lasting damage. However, if the poor oxygen supply persists for extended periods of time, it can destroy brain tissue, resulting in hypoxic-ischemic encephalopathy.[2]

CP is the leading cause of physical disability in childhood.[2] The global incidence of diagnosed cases of CP is currently about 1 in every 500 babies, and there are over 17 million people diagnosed with CP worldwide.[2] This number is only expected to continually increase. About 41% of children diagnosed with CP have limited abilities to crawl, walk, run or play.[2] This causes a significant impact on the physical, social, and developmental aspects of the childhood. It also causes a significant impact on the family and healthcare, as it is responsible for 2.229 billion dollars in direct medical costs and 9.241 billion dollars in direct non-medical costs.[3] The medical costs for children with CP are so large that they are about 10 times the medical costs for children without CP.[4] CP is also responsible for 12,456 outpatients and 278 hospital admissions annually in the United States alone.[5]

As noted above, patients diagnosed with CP use up a significant amount of hospital resources. This impact is only expected to increase as the number of patients diagnosed with CP increases. Many of these costs and hospital stays are due to ineffective treatment modalities. As

the primary point-of-care provider, it is important for the physician assistant (PA) to coordinate and prescribe the most effective treatment plan for their patients. A more effective therapy program for patients with CP will reduce their medical-related costs and allow them to lead productive lives.

The term "cerebral palsy" is a nonspecific term that describes the mechanism of developing the condition, so clinical findings may be variable between patients. Common symptoms seen in patients presenting with CP include spasticity, hyperreflexia, and ataxia.[1] Patients may also present with signs of mental retardation, seizures, microcephaly, and disorders of speech, vision, hearing, and sensory perception.[1] There currently is no known cure. Current treatment strategies typically include pharmacologic medications and physical, occupational, and speech therapies. Pharmacologic treatments are typically only utilized to treat spasticity and seizures, not to improve the condition.[1] Physical therapy is typically geared towards improving motor control to improve quality of life.[6] Common physical therapies prescribed for children with CP involve stretching, balance balls, and exercise machines.[7]

An important aspect of CP from a therapy treatment perspective is that limitations in the physical abilities of patients are not actually due to the loss of ability but due to the failure of acquiring the appropriate motor schemas caused by the cerebral insult.[8] Therefore, therapies should be geared towards helping patients develop these motor schemas to improve physical abilities. To drive neuroplastic changes to achieve these developments, intense, task-oriented and long-term training is necessary, which can often be boring and tedious for children.[8]

A new modality of interest in therapy for children with CP is video game-based therapy utilizing commercial video game systems, such as the Nintendo Wii and Xbox Kinect, in the patient's own home. A recent study reports that therapy using the Xbox Kinect is effective for

improving physical activities in adults with CP.[8] Video game therapies may provide a solution to keep children actively engaged and interested in their therapy, possibly resulting in faster and more positive outcomes. These therapies may also reduce the cost associated with CP, since video game systems are becoming cheaper and more accessible. Since the therapies can be performed in home, they may also reduce costs associated with paying for physical therapy sessions and traveling to and from appointments. The three studies to be discussed are recent investigations into the efficacy of using video game-based therapies on improving physical abilities of children with CP.

OBJECTIVE

The objective of this selective EBM review is to determine whether or not video game-based therapy is effective in increasing the physical abilities of children diagnosed with cerebral palsy.

METHODS

Three RCTs were analyzed in this systematic review that included male and female children between the ages of 4 and 17 years who had been diagnosed with CP and were currently participating in a physical therapy regimen. Articles were chosen that studied video game-based therapy as the intervention therapy. Ramstrand and Lygnegard[6] used a cross-sectional RCT to compare improvements in balance between Nintendo Wii therapy and no therapy, and outcomes were analyzed using Friedman's analysis of variance (ANOVA). Zoccolillo et al[8] used a cross-sectional RCT to compare improvements in upper limb function between Xbox Kinect therapy and a conventional therapy based on Bobath neurodevelopmental concepts, and outcomes were analyzed using the Wilcoxon signed rank test. Chiu and Lee[9] used a randomized, single-blind study to compare improvements in coordination between Nintendo Wii therapy and the

participant's usual therapy, and outcomes were analyzed using two-way ANOVA. All three of the studies determined significance using p-values.[6,8,9]

Each of the three studies was obtained by a search on the PubMed database done by the author of this review using the key words "cerebral palsy", "child", and "video games". All three were originally written and published in the English language and were published in peer-reviewed journals. Only articles published in 2006 or later were considered. Each of the studies included in this systematic review were published in 2012 or later. Articles were chosen based on the accessibility of the intervention and the relevance of the outcomes as they pertain to patient, as well as being in the scope of practice of a PA. Inclusion criteria for subjects of the studies included a clinical diagnosis of CP, under 18 years of age, and enough strength and coordination to utilize the video game systems. Participants were excluded if they were 18 years or older, had previously used a Nintendo Wii or Xbox Kinect system, or had severe cognitive, physical, or visual impairments that prevented correct use of the systems. A summary of the demographics of each study can be found in Table 1 below.

Table 1: Demographics & Characteristics of Included Studies

Study	Type	# of Pts	Age (years)	Inclusion Criteria	Exclusion Criteria	W/D	Interventions
Zoccolillo (2015)[8]	Cross-over randomized controlled trial	22	4-14	- Children with clinical diagnosis of CP - Level of GMFC between I and IV - Age between 4 and 14	- Incapacity to understand the instructions and to execute the task - Severe comorbidities - Incapacity to stand even with external support	9	2 one-hour sessions per week of video game-based therapy using Xbox with Kinect
Ramstrand (2012)[6]	Cross-over randomized controlled trial	18	8-17	- Diagnosis of CP - GMFCS score of I or II - Could walk unaided for 10 minutes	- Previously use of Nintendo Wii balance board	6	30 minute sessions per day for 5 days each week of video-game therapy using Nintendo Wii Fit for 5 weeks
Chiu (2014)[9]	Single-blind, randomized controlled trial	62	6-13	- Children diagnosed with CP before the age of 5 - Children between 6 and 13 - Had enough hand function to hold *Wii* remote	- Severe cognitive or visual problems that precluded them from participating	2	Home-based *Wii Sports Resort* training plus usual therapy 3 times a week for six weeks

OUTCOMES MEASURED

The outcomes measured in each of the three studies were improvements in physical abilities. Physical ability is considered a patient-oriented outcome (POEM) because it significantly and directly impacts a patient's quality of life. Physical abilities are especially important to pediatric populations because walking, running, and jumping play an integral role in healthy childhood social and emotional development.[10] Additionally, improvements could also

decrease the medical costs associated with the diagnosis of CP. Increased ambulation and mobility decreases the risk of aspiration, pneumonia, and other infections, leading to fewer medical office visits and hospitalizations.[1] Improved mobility could also lead to these patients gaining employment and earning income to become independent and offset their medical costs.

Ramstrand and Lygnegard investigated the effects of the Nintendo Wii on physical abilities by measuring improvements in stable balance.[6] Stable balance was objectively measured using the modified sensory organization test (mSOT) on a PRO Balance Master system in four conditions: stable support with eyes open, stable support with eyes closed, unstable support with eyes open and unstable support with eyes closed. The researchers analyzed the data from the mSOT by calculating the velocity of the center of the pressure (CoP). An improvement in stable balance, and thus physical ability, was seen with a statistically significant reduction from baseline of the mean CoP, using Friedman's ANOVA to analyze the data between pre- and post-interventions.[6] This study also investigated the effects on reactive balance and rhythmic weight shift, but these were not examined in this review.

Zoccolillo et. al investigated the effects of the Xbox with Kinect system on physical abilities by measuring improvements in quality of upper limb functions.[8] Quality of upper limb functions was objectively measured using the Quality of Upper Extremities Skills Test (QUEST). An improvement in upper limb function, and thus physical ability, was observed as an increase in QUEST scores. The Wilcoxon signed rank test was used for comparing the data across the testing occasions. Secondary outcomes assessed in this study included hand abilities and visual-motor integration, but these were not examined in this review.

Chiu, Ada, and Lee investigated the effects of the Nintendo Wii system on physical abilities by measuring improvements in coordination.[9] Coordination was objectively measured

using a tracking task. This task required each participant to flex and extend the elbow and the index finger to follow a moving target on a computer screen, and data was reported as a ratio between the target and the response, with a perfect score reported as 1.00. Improvements in coordination, and thus physical ability, were observed as increased ratios. Significant differences between testing groups were determined using two-way ANOVA. Other outcomes assessed in this study were grip strength, objective hand function, and caregivers' perception of hand function, but these were not examined in this review.

RESULTS

Each of the three studies analyzed in this review were RCTs that investigated the effects of video game-based therapy on physical abilities in children under the age of 18 diagnosed with CP. The data obtained and reported by each of these studies was continuous and could not be converted to dichotomous data. Test statistics that were utilized and reported between all three included Friedman's ANOVA, two-way ANOVA, Wilcoxon signed rank test, and p-values.

Ramstrand and Lygnegard[6] performed a cross-sectional study that compared improvements in balance between a five-week program of therapy using the Nintendo Wii to a control group, in which participants did no therapy program for five weeks. This study was composed of eight males and ten females, but six participants failed to complete all testing sessions. Four of these subjects did not complete the recommended duration of therapy. Each participant was testing under four different standing conditions: stable support with eyes open, stable support with eyes closed, unstable support with eyes open, and unstable support with eyes closed. Testing was done using the mSOT and results were calculated as the averages of the mean velocities of the CoP. The data was analyzed between therapeutic conditions, or video game-therapy compared to no therapy, with Friedman's ANOVA and p-value set to less than

0.05 to determine significance. There was no significant difference determined from the data collected between the therapeutic conditions on the mean velocity of CoP for any of the four standing conditions. The analyzed data from this study is reported in Table 2 below.

Table 2: Mean velocity of the CoP in the mSOT at baseline and five weeks post-therapy

Mean Velocity of the CoP (cm/s)				F_r	P
	Baseline	**5 Weeks of Wii**	**5 Weeks of No Wii**		
Stable support, eyes open	2.34	2.21	2.17	4.17	0.12
Stable support, eyes closed	2.70	2.59	2.59	1.16	0.56
Unstable support, eyes open	3.90	3.38	3.86	2.67	0.26
Unstable support, eyes closed	5.70	6.16	7.51	1.50	0.47

Zoccolillo et. al[8] performed a cross-sectional study that compared improvements in upper hand functions between an eight-week program of sixteen 30 minute sessions twice a week of therapy using the Xbox Kinect to program of identical timing that utilized conventional treatment. This study began with 22 children, but nine children failed to complete all the testing sessions. Only one of these children dropped out due to study-related factors. The children were tested using QUEST assessments to measure the quality of their upper limb functions. QUEST evaluates upper limb dissociated movements, grasp function, protective upper limb extension, and weight bearing. Data was analyzed using the Wilcoxon signed rank test to compare the mean changes from baseline between intervention groups, with significance determined at an alpha level below 0.05. There was a significant improvement in scores in the children participating in video game therapy but not in children using conventional therapy. Analyzed data from this study is found in Table 3 below.

Table 3: Changes in mean QUEST Scores from Baseline at 8 Weeks

	QUEST Score		***P***
	Pre-Intervention	**Post-Intervention**	
Video Game Therapy	76±21	81±20	0.003
Conventional Therapy	74±20	77±19	0.056

Chiu, Ada, and Lee[9] performed a randomized, single-blind study that compared a six-week program of therapy using the Nintendo Wii to six weeks of the patient's usual therapy program. The study began with 62 participants, and only 5 participants did not complete all testing sessions. The participants were evaluated on coordination using a tracking test on a computer screen and were tested at baseline, after six weeks of intervention, and after 12 weeks of intervention. Coordination was tested and reported at two joints, the elbow and the index finger. Data was reported as a ratio from 0 to 1.00, where 1.00 is a perfect score. The data between intervention groups was analyzed using two-way ANOVA, with a p-value of less than 0.05 determining statistical significance. There was no significant improvement in coordination of the video game group compared to the usual therapy at 6 and twelve weeks for either joint tested. Analyzed data from this study is found in Table 3 below.

Table 4: Change in tracking ratios between intervention groups from baseline at 6 and 12 weeks (video game therapy minus usual therapy)

Differences Between Groups			**95% CI**	***P***
Elbow	Week 6 from Baseline	0.04	-0.03 to 0.11	0.30
	Week 12 from Baseline	0.05	-0.02 to 0.12	0.15
Finger	Week 6 from Baseline	-0.01	-0.07 to 0.05	0.54
	Week 12 from Baseline	0.00	-0.06 to 0.06	0.92

DISCUSSION

Cerebral Palsy is the most common cause of physical disability in children and often leads to limitations in abilities to crawl, walk, run, and play.[2] Currents therapies are aimed

towards helping patients develop appropriate motor schemas through intense and long-term training.[8] Video game-based therapies using systems such as the Nintendo Wii or Xbox Kinect have been proposed as an alternative to conventional therapies to keep the child's interest during these long-term treatments and to reduce costs associated with therapy.

One study found statistically significant improvements in physical abilities when using video game-based therapies, and two studies found no statistically significant improvements. Zoccolillo et al[8] found a statistically significant improvement in upper limb functions in children using an Xbox Kinect therapy program but no significant improvement in those using conventional therapies. This study lost nine of its 22 participants before completion, but none of these were lost due to lack of interest.[8] Ramstrand and Lygnegard[6] showed no significant difference in improved balance in children using the Nintendo Wii compared to the control group. This study also lost four of its 18 participants because of failure to complete all the training sessions due to lack of interest.[6] Chiu and Lee[9] also found no statistically significant improvement in coordination between using the Nintendo Wii and using the usual therapy. This study only lost five out of its 62 participants, none of which were due to lack of interest.[9]

All three studies limited enrollment to children under the age of 18 with a clinical diagnosis of CP who did not have mental or physical limitations that prevented them from completing the therapy sessions. Ramstrand and Lygnegard[6] and Zoccolillo et al[8] both were also limited by small sample sizes, but both compensated for this by performing cross-sectional studies. Both these studies were also limited by poor retention rates, with dropout rates of 33.3%[6] and 40.9%[8], respectively. The study by Chiu, Ada, and Lee[9] was limited by the single-blind design because the participants and therapists could not be blinded to the intervention.

Another important factor to consider that affects each of these studies is that the diagnosis of cerebral palsy, by nature, is a heterogenous diagnosis that encompasses a variety of etiologies and symptoms. Patients may have a variety of mental, physical, and neurologic abnormalities, all of which may be affected differently by these therapies. The variance among symptoms may be a source of the inconclusive evidence obtained from these studies.

As with most treatments, there are both positives and negatives to video game-based therapies. An important positive aspect is that most children seem to enjoy the therapy session, as evidenced by the small number of drop-outs due to lack of interest. Additionally, these systems are relatively inexpensive, readily available to most families, and allow therapy to occur in the patients' own homes. One major negative aspect of these therapies is that since they are performed at home, they are not monitored by a therapist, so the parent or child is responsible for ensuring the therapies are completed correctly.

CONCLUSION

This systematic review of three RCTs shows that the effects of video game-based therapies compared to control groups are inconclusive in improving physical abilities in children with CP. Zoccolillo et al[8] suggests that therapy with an Xbox Kinect may be a reasonable alternative to conventional therapies, but it is limited by a small sample size so further investigation is required. The studies by Zoccolillo et al[8] and Chiu, Ada, and Lee[9] suggest that video game-based therapies may be an appropriate addition to usual therapies, due to the children's enjoyment and low cost. All three studies were limited by control of adherence to the video game treatment plan. Further studies should utilize larger sample sizes and therapist-monitored therapy sessions to control this source of variance.

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