EFFECT OF VIRTUAL REALITY ON SELECTIVE MOTOR CONTROL AND UPPER LIMB FUNCTIONS IN CHILDREN WITH HEMIPARESIS: A PILOT STUDY

Ahmed E. Fayed1, Amira M Abd-elmonem2, Hoda A. Eltalawy3

1Specialist physical therapist at national institute of neuromotor system, Cairo, Egypt, Pt_hayatcenter@yahoo.com, https://orcid.org/0000-0002-2957-1128
2Assistant professor of Physical therapy for pediatrics, faculty of Physical therapy, Cairo University, Dramira.salim2020@gmail.com, https://orcid.org/0000-0002-5877-8339
3Professor of Pediatrics Physical Therapy and Pediatrics Occupational Therapy, Faculty of Physical Therapy, Cairo University, Egypt, https://orcid.org/0000-0003-2187-3890

ABSTRACT

Background: Several factors prohibit functional performance in children with hemiparesis as spasticity, weakness and contractures. However, selective motor control is considered as the main contributor to motor impairments in children with CP.

Purpose: To study the effect of virtual reality on selective motor control and upper limb functions in children with hemiparesis.

Methods: Twenty children with hemiparesis from both genders (7-12 years) were randomly assigned into two groups (control and study) 10 children in each group. The study group received virtual reality program and control group received occupational therapy program. In both groups treatment was conducted for 60 minutes a day, three times a week for 8 weeks.

Results: There were improvements in selective motor control in the study group more than the control group and also improvement in upper limb coordination in study group compared to control group with no difference between groups in hand grip strength by 8 weeks.

Conclusion: Virtual reality may be more effective than occupational therapy in improving selective motor control and upper limb function in children with hemiparesis.

Key words: Cerebral palsy; Motor control; Upper extremity; Wii game.

I. INTRODUCTION

Cerebral palsy (CP) is a category of chronic movement disorders that first manifested in early childhood 1, with an occurrence of 1.5–3 per 1000 live births 2. Children with CP often experience neurological symptoms including dystonia, ataxia, athetosis and particularly spasticity. 3

Hemiplegic CP children are characterized by muscle weakness on one side of the body, delay in developmental milestones, and mainly upper limb involvement that has a significant impact on global function, fine motor control, personal care with the affection of selective motor control (SMC). 4 In the longer term, spasticity can lead to muscle fibrosis with fixed contractures. 5

Selective motor control is the ability to isolate a muscle or combination of muscles to produce a particular movement. 6 In children with CP, spasticity that directly caused impairment of SMC as movement patterns governed by flexor or extensor synergies that obstruct functional movements is affected. 7
Virtual reality (VR) refers to a computer-generated simulation in which a person can interact within an artificial three-dimensional environment using electronic devices, such as special goggles with a screen or gloves fitted with sensors. In this simulated artificial environment, the user is able to have a realistic-feeling experience through being a part of the game or the action.

The effect of VR in SMC is not mentioned clearly in previous studies and there is controversy between studies about the effect of using VR in UL rehabilitation. For this controversy and the unclear effect of VR on SMC we conducted this study. Therefore, the rational of this study was to investigate the effect of VR on SMC, upper limb coordination and hand grip strength in children with hemiparesis.

II. METHOD

Study design and ethical considerations

A pilot controlled clinical trial study was carried out from December 2020 to February 2021. The study was approved by the local ethics committees of Faculty of Physical Therapy, Cairo University, Egypt (P.T.REC/012/002486). The Study protocol is registered online on Clinical Trials.gov (NCT04679779). A signed written consent form was obtained from children’s parents/legal guardian before starting the study.

Participants

Twenty volunteer children (11 boys and 9 girls) aged from 7-12 years participated in this study. They were recruited from physical therapy department of National Institute of Neuro Motor System according to the following criteria (1) diagnosed as hemiparetic CP obtained from medical records (2) scored 1 to 1+ according to Modified Ashworth Scale (MAS) (3) scored I or II grade on Gross Motor Function Classification System (GMFCS) and (4) scored I–II on the Manual Ability Classification System (MACS). Children were excluded if they had (1) surgery in their upper extremities within the past 12 months; (2) significant visual auditory problems; (3) mental retardation (4) structural or fixed soft tissue deformities in the affected upper extremity or (5) received previously virtual reality training for upper limbs.

Intervention

- The study group received Wii training program for 30 min (using Wii Nintendo Revolution (pre-release), seventh generation, made in china) in addition to conventional physical therapy program for balance and lower limb training for 30 min (5 minutes for each game), three times a week for 8 weeks. The training included six Wii games: (1) tennis; (2) boxing; (3) bowling; (4) basketball, (5) Frisbee and (6) Golf with different levels of difficulties. These games were selected to enhance smooth full range of upper extremity movements with visual and auditory feedback as well as sensory feedback from the vibration of the remote. The researcher demonstrated the aim and requirements of the game for each child before stating the training schedule.

The control group received a designed occupational therapy program for 30 min including exercises for facilitating of basic hand skills included reaching, carrying, grasping, releasing, in-hand manipulation, and bilateral hand use, in addition to the same conventional physical therapy program for balance and lower limb training for 30 min. The dose of training was 60 minutes, three times a week for 8 weeks.

Outcome measures

Primary outcomes measure:
- Selective voluntary motor control of upper extremity

The Test of Arm Selective Control (TSMC); a valid and reliable tool used to assess movement of shoulder, elbow, forearm, wrist, finger and thumb by using simple tools for grasp items from sitting positions. The average administration time was 16 minutes to complete the test for total 8 movements. Each joint is scored as a 0 (absent), 1 (impaired), or 2 (normal). For a limb score, the scores are added with the maximum score per side is 16 with higher score indicates better performance.

Secondary outcome measures:
- Handgrip strength
(Baseline Pneumatic Squeeze Dynamometer, 30 psi, made in China).

Hand dynamometer is an hand-held device for objectively quantifying muscle strength.\textsuperscript{16} Its a valid and reliable tool \textsuperscript{17}; which used to assess hand grip strength by measures the maximum isometric contraction of the hand muscles and reported it in kilogram by proper grasp of the dynamometer from sitting positions .\textsuperscript{18}

For application: child sitting in rested position in chair with suitable height and back rest, arm beside the body, shoulder in extension, elbow in 90 degree flexion and child grasping device with wrist in neutral position.\textsuperscript{19} Repeat the test for 3 times and note the mean measure \textsuperscript{20}

**Upper limb coordination:**

It was measured using the short form of Bruinink-Oseretsky Test for motor proficiency (BOT-2).\textsuperscript{21} BOT-2 which is a measure of fine and gross motor skills of children and youth, 4 through 21 years of age.\textsuperscript{21} It is a valid and reliable tool \textsuperscript{22} which consists of four composites with eight subtests, including fine manual control, manual coordination, body coordination, strength and agility.\textsuperscript{23} In the current study the subset 7 was used to assess the upper limb coordination.\textsuperscript{24}

**Statistical analysis**

Data were screened, for normality assumption test and homogeneity of variance. Normality test of data using Shapiro-Wilk test. The statistical analysis was conducted by using statistical SPSS Package program version 25 for Windows (SPSS, Inc., Chicago, IL). Numerical data are expressed as mean and standard deviation by Chi-square test. Wilcoxon signed ranks test to compare between pre- and post-treatment within study group and control group. Mann-Whitney U test to compare between study group and control group.

**III. RESULTS**

Demographic data: In the current study, a total of 20 patients participated and they were randomly distributed into 2 groups (10 for each group). The results showed no significant differences in demographic data for age (P=0.404), weight (P=0.658), height (P=0.760), Body mass index (BMI) (P=0.978), and gender (P=0.614), the MACS (P=0.254), and MAS (P=0.614) between study group and control group (Table 10).

<table>
<thead>
<tr>
<th>Items</th>
<th>Study group (n=10)</th>
<th>Control group (n=10)</th>
<th>P-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age (year)</td>
<td>X±SD</td>
<td>X±SD</td>
<td></td>
</tr>
<tr>
<td>Weight (kg)</td>
<td>9.73 ±2.04</td>
<td>9.01 ±1.68</td>
<td>0.404</td>
</tr>
<tr>
<td>Height (cm)</td>
<td>28.18 ±5.79</td>
<td>29.48 ±7.06</td>
<td>0.658</td>
</tr>
<tr>
<td>BMI (kg/m\textsuperscript{2})</td>
<td>113.33 ±7.36</td>
<td>114.25 ±5.75</td>
<td>0.760</td>
</tr>
<tr>
<td></td>
<td>21.94 ±6.23</td>
<td>22.58 ±4.77</td>
<td>0.978</td>
</tr>
<tr>
<td>n (%)</td>
<td>Gender (Boys : Girls)</td>
<td>5 (50.00%) : 5 (50.00%)</td>
<td>6 (60.00%) : 4 (40.00%)</td>
</tr>
<tr>
<td>MAC</td>
<td>6 (60.00%) : 4 (40.00%)</td>
<td>7 (70.00%) : 3 (30.00%)</td>
<td>0.254</td>
</tr>
<tr>
<td>Modified Ashworth</td>
<td>5 (50.00%) : 5 (50.00%)</td>
<td>6 (60.00%) : 4 (40.00%)</td>
<td>0.614</td>
</tr>
</tbody>
</table>

P-value: probability value P-value>0.05: non-significant X: mean SD: standard deviation

The statistical analysis within each group revealed there were significantly increased in handgrip strength (P=0.012) (Table 2). Selective motor control (P=0.011), and upper limb coordination (P=0.011) at post-treatment compared to pre-treatment within study group. In control group, no significant difference (P=0.340) in handgrip strength between study group and control group, while there were significantly increased in selective motor control (P=0.015) and upper limb coordination (P=0.008) at post-treatment compared to pre-treatment (Table 2).
No significant difference at post-treatment of handgrip strength (P=0.834), while there were significant differences in selective motor control (P=0.015), and upper limb coordination (P=0.019) between study group and control (Table 2).

Table 2: Comparison of all measured outcome variables within and between two groups.

<table>
<thead>
<tr>
<th>Variables</th>
<th>Items</th>
<th>Study group (n=10)</th>
<th>Control group (n=10)</th>
<th>P-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hand grip</td>
<td>Pre-treatment</td>
<td>2.00 ±1.34</td>
<td>2.58 ±1.70</td>
<td>0.462</td>
</tr>
<tr>
<td></td>
<td>Post-treatment</td>
<td>2.49 ±1.53</td>
<td>2.64 ±1.89</td>
<td>0.834</td>
</tr>
<tr>
<td></td>
<td>Mean difference</td>
<td>0.49</td>
<td>0.06</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Improvement %</td>
<td>24.50%</td>
<td>2.33%</td>
<td></td>
</tr>
<tr>
<td></td>
<td>P-value</td>
<td>0.012*</td>
<td>0.340</td>
<td></td>
</tr>
<tr>
<td>TSMC</td>
<td>Pre-treatment</td>
<td>10.75±1.67</td>
<td>10.75 ±2.12</td>
<td>0.380</td>
</tr>
<tr>
<td></td>
<td>Post-treatment</td>
<td>14.63±1.18</td>
<td>12.00 ±2.50</td>
<td>0.014*</td>
</tr>
<tr>
<td></td>
<td>Mean difference</td>
<td>3.88</td>
<td>1.25</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Improvement %</td>
<td>36.09%</td>
<td>11.63%</td>
<td></td>
</tr>
<tr>
<td></td>
<td>P-value</td>
<td>0.011*</td>
<td>0.015*</td>
<td></td>
</tr>
<tr>
<td>Bots</td>
<td>Pre-treatment</td>
<td>26.63 ±5.44</td>
<td>29.00 ±8.78</td>
<td>0.245</td>
</tr>
<tr>
<td></td>
<td>Post-treatment</td>
<td>32.25 ±5.72</td>
<td>31.00 ±8.50</td>
<td>0.019*</td>
</tr>
<tr>
<td></td>
<td>Mean difference</td>
<td>5.62</td>
<td>2.00</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Improvement %</td>
<td>21.10%</td>
<td>6.90%</td>
<td></td>
</tr>
<tr>
<td></td>
<td>P-value</td>
<td>0.011*</td>
<td>0.008*</td>
<td></td>
</tr>
</tbody>
</table>

Data are expressed as mean ±standard deviation  
P-value: probability value  
* Significant (P<0.05)

IV. DISCUSSION

Aim of this study was to identify the effect of virtual reality on selective motor control and upper limb coordination and strength in children with hemiparesis.

The age range of 7 to 12 years was selected because it was thought to be the most appropriate age for using Wii games, as children are old enough to understand the games and follow therapist instructions.25

This pilot study found that CP children with hemiparesis who completed an 8-week upper-limb Wii training programme saw a significant improvement in both selective motor control and coordination of upper limb compared with who carried out a designed occupational therapy program with no significance improvement noticed in hand grip strength between both groups.

Improvement in both SMC and upper limb coordination CP children may occur as a result of one of the following factors:

First, child motivation as it makes treatment more interesting and brings patients more enthusiasm, and the sports favored by the patients in daily life can be used as a training program in a virtual reality system.26

Secondary, brain reoganization that cause spontaneous recovery through learning and practise 27 that related to the frequent trying of children to reach higher game scores in an easily and interesting environment of repetition of training that causes improvements in the brain's neural organisation and aids in the acquisition of motor and functional skills. 28

Thirdly, visual input mechanism that more than just playing or practising, virtual reality has emerged as a new technology that allows for increased intensity of training while offering sensory input.29
Finally, intense proprioception rehabilitation that caused by the VR field through use of spiral diagonal movement patterns that can stimulate the joint and muscle proprioceptor so the responsiveness of muscles can be enhanced and the recovery of neuromuscular and motor function can be stimulated. 30

Non significance improvement of hand grip strength may come in agree with this theory that to gain more strength you should put more tension in muscle and make your sets longer that the amount of time a muscle is kept under tension during an exercise is referred to as time under tension (TUT). 31 While in Wii training the main focus in the way of how doing the movement and how quality of it with no tension increase so no increase in TUT and no increase in hand grip strength. 32

Limitations

The main limitation of our study was working during the lock down period of corona virus that affect the sample size of patient and small frequency of research sessions.

V. CONCLUSION:

This study offer that Wii training may be an interesting training modality for improving upper limb selective motor control and coordination in children with hemiparetic CP.

Declaration of interest

The authors report no declaration of interest

Funding

None.

REFERENCES


31 Newmire DE, Willoughby DS. Partial compared with full range of motion resistance training for muscle hypertrophy: A brief review and an identification of potential mechanisms. The Journal of Strength & Conditioning Research. 2018 Sep 1;32(9):2652-64.