

# A Computer Game- Assisted Repetitive Task Practice based Upper Extremity Therapy Program for Children with Spastic Unilateral Cerebral Palsy: A Single Case Study

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## Abstract

A case study is to provide evidence of the feasibility, acceptance, and benefits of a computer game-assisted repetitive task practice platform (G-RTP) in Upper extremity (UE) motor function of a child with Cerebral Palsy (CP).

**Method:** 4 year old left spastic CP was provided an individualized game-assisted therapy of 16 weeks. Outcome measures included PDMS-2, QUEST, computerized assessment of a broad range of object manipulation tasks.

**Results:** Findings demonstrated the feasibility and acceptability of the G-RTP program for use by children with UE motor impairment

**Conclusion:** The findings are positive and support a future definitive RCT needed to prove the efficacy and applicability.

**Keywords:** Repetitive Task Practice, Cerebral Palsy, Game Based Exercises

## Introduction

Canada and India face a growing population of children with neurodevelopmental disorders (NDD) <sup>1</sup>. CP is the most common neurodevelopmental disorders (NDD) occurring in 2 to 4 of every 1000 live births in North America and India, respectively<sup>2</sup>. Children with CP often present with upper extremity sensory-motor impairments that hamper the physical and functional abilities that are necessary for daily activities of living and participation in social events such as in school, play

and leisure activities in various environments. These impairments will result in reduced pace of development, cause future complications, and will require remedial training<sup>3,4</sup>. The ability to perform functional tasks with the Upper Extremity (UE) is an important predictor of success in daily activities and participation in school, play/leisure, and social activities<sup>5</sup>.

Therapy programs designed to improve UE motor and visual-spatial processing skills in children must strive to maximize neurodevelopmental capacities and prevent secondary impairments<sup>6-8</sup>. The effectiveness of these programs is proportional to the intensity and amount of training and the task-specificity of the exercise regime, for example, constraint-induced movement therapy (CIMT) <sup>9-11</sup>. There is growing evidence to support the idea of activity-dependent central nervous system (CNS) plasticity<sup>12</sup>. Simulating close-to-normal movements and repetition is taking shape<sup>12,13</sup>. However,

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it is difficult to engage these children in therapy for long periods and sustain motivation during intense repetitive task practice. Thus, there is a need for innovative, cost-effective approaches that motivate children with CP to complete long-term neuro-rehabilitation programs to improve neurodevelopmental outcomes. For improving adherence to therapy and for determining motor and functional outcomes in children with CP<sup>14</sup>. An emerging, promising therapy approach is to incorporate “fun” computer games with a range of interactive cognitive challenges help children to positively engage in activities. Studies have provided evidence of the benefits of video games in rehabilitation training<sup>15,16</sup>

For this purpose, we have developed a low-cost computer-aided, game-assisted repetitive task practice rehabilitation platform (G-RTP)<sup>17-19</sup>.

### Case Description

4 year old child with Lt spastic hemiplegia, having increased tone in upper extremity, grade one on the Modified Ashworth Scale (MAS)<sup>20</sup>, level 1 on the Gross Motor Functional Classification Scale (GMFCS)<sup>21</sup>, level 2 on the Manual ability classification system (MACS)<sup>22</sup> and scored 26 on the Mini Mental State Examination (MMSE)<sup>23</sup>.

Ethical clearance for this case study was obtained from Sri Dharmasthala Manjunatheshwara College of Medical Science & Hospital and the parent provided informed consent. Assessment tools were used for pre-to post-intervention and follow up assessment.

1. Peabody Developmental Motor Scale Version 2 (PDMS- 2)<sup>24,26</sup>
2. The Quality of Upper Extremity Skills Test (QUEST).
3. The child was also assessed using a computer-based assessment tool to quantify object manipulation skills<sup>17,18</sup>.

An inertia-based mouse was attached to five test objects presented in Figure 2. The objects were chosen with different physical properties.

As shown in Figure 1B the assessment game displays a moving target game object. The target objects appear at random locations at the top of the display and moves to the bottom in two seconds and then disappear. One game event is defined as the time between target

appearance and its disappearance. The game paddle at the bottom of the display is slaved to the object motion. The child was seated at a table with adjustable height. Each test object was placed on the table at a comfortable distance from the child. A 50 cm computer monitor was placed 1.5 meters in front of the participant at eye level, which displayed the computer game. The child used each of the five mouse equipped objects to move the game paddle and catch the moving target objects. The assessment game software logged the coordinates of the game paddle and target objects at a sampling frequency of 100Hz for the off-line analysis described below.

Figure C presents overlay plots of all game movement responses in each direction for one game trial. Each game was played for 60 seconds, (each game event was two seconds). Therefore, 30 game movement responses were obtained for analysis. Based on time indices of target appearance and disappearance, the software segments all 30 game movement trajectories for each 60-second game trial (15/direction). Figure D presents the trajectory of a typical game movement response. For a detailed description of the game movement, indexing and segmentation see Lockery et al., (2011)<sup>18</sup>. Following are the performance measures

(a) Success Rate (SR): it is the percentage of the total number of Target Objects that were caught in one game trial

(b) Movement Variance (MV): For each game trial, there were 15 game movement responses in each direction. For each game movement trajectory, MATLAB (The Math Works, Natick, MA, version 2010a) was used to compute the outcome measures described above.

### Intervention

The child attended 16 weeks for 2-3 days per week of 45-60mins of session, consisted of stretching exercises, game-assisted exercises. Similar to the concept of “shaping” consistent with Constraint-Induced Movement Therapy (CIMT) principles, the G-RTP takes advantage of ergonomic properties of common objects to amplify limited and small amounts of voluntary movement and then allows opportunities for an appropriate switch to objects having more demanding movement requirements or functional demands. These “mouse-equipped” objects can be used for assessment and to practice many gross or fine motor skills.

In a manner similar to interval training, 6-8 objects were initially selected for specific therapy goals and were instrumented with the inertial mouse. Sensory-motor skill training of finger/wrist and elbow and shoulder motions, and of bimanual controls. The motion of the objects was used to play computer games in a manner identical to that of a standard optical computer mouse, game-assisted. Each object-manipulation exercise was used for 2-4 minutes.

## Results

Tables 1 and 2 (PDMS-2) and (QUEST). Based on the scores of PDMS-2, substantial improvements in grasp and visuomotor test scores following the 16 weeks intervention were observed. There was a 15% improvement in grasp (41% to 49%) and a 12.5% improvement in visuomotor ability (87% to 105%).

**Table 1. PDMS-2 raw test scores**

PDMS-2 ITEMS (MACS score 2)	BASELINE SCORES	POST INTERVENTION SCORES				
		4 weeks	8 weeks	12 week	16 week	28 weeks
GRASP (Maximum 52)	41	43	43	44	49	49
VISUOMOTOR (Maximum 144)	87	96	96	99	105	105

Based on the scores of QUEST. There was a 47.26% improvement in grasp (40.74 to 88) and a 22.96% improvement in the total average score (69.04 to 92).

**Table 2. QUEST scores**

QUEST ITEMS	BASELINE SCORES	POST INTERVENTION SCORES				
		4 weeks	8 weeks	12 week	16 week	28 weeks
DISSOCIATED MOVEMENTS (Maximum 100)	78.12	82.81	85.92	85.92	80	100
GRASP (Maximum 100)	40.74	44.44	51.84	51.84	88	88
WEIGHT BEARING (Maximum 100)	74	100	100	100	100	100
PROTECTIVE EXTENSION (Maximum 100)	83.32	83.32	83.32	83.32	100	100
TOTAL average SCORE (Maximum100)	69.04	77.64	80.27	80.27	92	97

As shown in table 3, the CUE assessment scores showed substantial improvements in success rate and movement variance. Success rate improved ranging from 25% to 50% increase for all five tasks from pre to post intervention scores (16 weeks). These improvements were maintained for two out of five objects during the

follow up period with the scores ranging from 87% to 89%. The success rate scores were maintained to a lesser extent in case of the soccer ball, ring and tennis ball manipulation tasks with the scores ranging from 27% to 90%. Movement variance decreased for four of

the five tasks ranging from 9% to 47% for pre to post intervention scores (16 weeks). These improvements were maintained during the follow up period with the scores ranging from 30% to 49%.

Figure 2 shows representative plots of game movement responses of the five test object manipulation tasks that were used for pre-, post intervention (16 weeks) and follow up assessments (28 weeks). Compared to the pre-intervention plots, the number of valid traces are higher in post intervention and follow up assessment plots. Pre intervention game plots showed small amplitude movements with no interaction with the target.

The pre-intervention plots present jerky movement responses with irregular trajectories moving in the opposite direction on-screen than the target. Compared to the pre-intervention, post-intervention plots show less movement variance with high amplitude trajectories that depict left sided (upwards) and right sided (downwards) movements. As a result of less number of movement errors during the post-intervention performances, the success rates are higher and were maintained during the follow up assessment. These improvements are maintained till the follow up assessment.

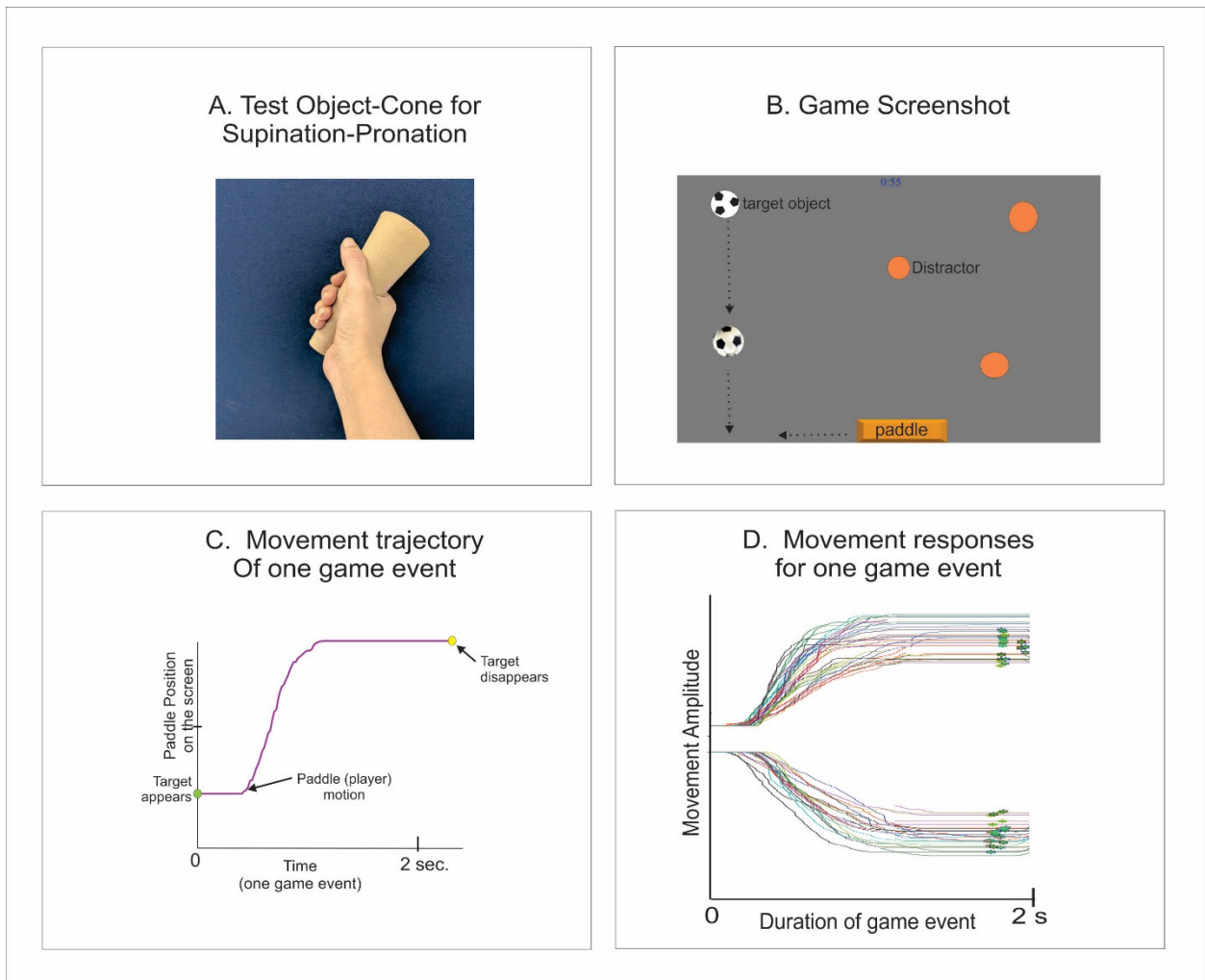


Figure 1

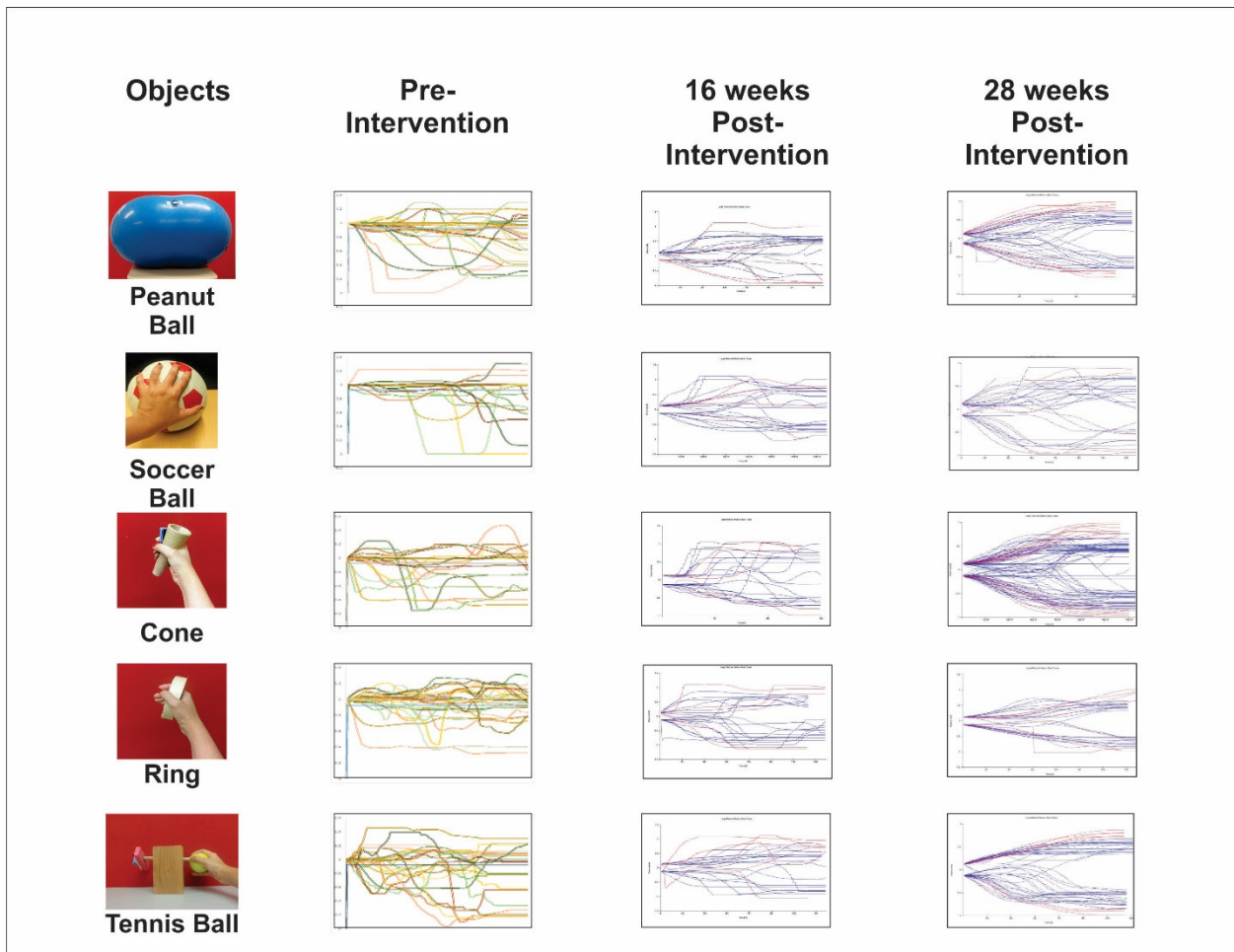


Figure 2

Table 3 Game Performance Outcome

Outcome Measures	Assessment time	Peanut Ball	Soccer Ball	Cone	Ring	Tennis Ball
	0 weeks	20	75	33.3333	0	50
<b>Success Rate</b>	16 weeks	66.66	100	50	42.8	100
	28 weeks	88.88	90	87.50	28.57	40.00
	0 weeks	55.5658	38.395	36.6807	44.6107	46.2837
<b>Movement</b>	16 weeks	46.7965	n/a	54.5773	18.3739	n/a
<b>Variance</b>	28 weeks	29.4965	47.8074	29.6765	48.5628	45.7173

The child’s mother was interviewed at the end of 28 weeks using a semi-structured interview. In her opinion she said,

“My child found it fun-filled and the objects used in therapy will help in my child’s hand and finger movements. Mainly, definitely, I like the program

because there are changes in (the child’s) hand, improvements in that hand.”- Mother of the child.

### Discussion

Emerging game-assisted rehabilitation technologies have the potential to improve child participation in

repetitive task practice and therefore facilitate functional recovery. Results of this pilot study demonstrated the feasibility and acceptability of the G-RTP program for use by children with motor impairment of the upper extremity due to CP. The present preliminary results did show substantial improvements in the PDMS-2, QUEST, and in performance metrics of a broad range of goal-directed object manipulation tasks. Buttoning and unbuttoning task was not achieved which is more fine aspects to develop. These changes can be attributed towards the repetitive practice and object manipulation tasks. These tasks were focused on finger and wrist movements and practicing object manipulation because the child had poor control in fine motor tasks using hand and fingers as compared to gross movements at proximal joints. Other scores showed significant improvements in PDMS-2 scores. Based on CUE assessment tool success rate scores, the child showed improvements from pre to post intervention in all five objects. The movement variance reduced from pre to post intervention in four out of five tasks. At pre-intervention, many of the responses were of very low amplitude so they were deemed invalid. Since the movement variance is computed from only a few valid responses, the variation is low whereas, during the post intervention tasks, there is a higher number of valid responses.

One main limitation of this approach is that it requires an IB computer mouse, a computer, and a source of common/modern computer games. It also requires the client to have a basic knowledge of computer operation. There are a number of fine motor skills that cannot be performed with the game-assisted repetitive task practice approach using the IB mouse, such as, writing, doing up buttons, tying shoelaces, cutting food. Another limitation is that the IB mouse detects angular motion; therefore, it is not possible to practice tasks that require only linear motion.

### Conclusion

A future definitive RCT needed to prove the efficacy and applicability of G-TRP for young children with Cerebral Palsy.

**Conflict of Interest :** None

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