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Effectiveness of gamification to improve eye-hand coordination in children with cerebral palsy: an interventional study

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Abstract

Background: Gamification is the use of game elements to engage and invoke desired behavior in users. Children with cerebral palsy (CP) have compromised eye hand coordination and gamification may be one of the advanced therapeutics to improve the sensory motor coordination.

Objectives: To evaluate the effectiveness of gamification to improve eye – hand coordination and to find the impact of gamification on cognition improvement.

Methodology: 30 Children with CP were selected based on their ability to clear the first stage of bubble shooting and hill climb racing car games, Gross motor functional classifications (GMFCS) grade between 1 to 4, Mini Mental State Examination Scale (MMSE) score greater than 9, Manual Ability Classification System (MACS) grade between 2 to 4. Children were assessed pre- and post-performance with outcome measures such as Alternate Hand Wall Toss Test (AHWTT), Encephal Smartphone Stroop Test Application (ESSTA), and MMSE.

Result: Outcome measures AHWTT, ESSTA, MMSE were assessed every week for 4 weeks of duration of Gamification and statistically analyzed with repeated measure ANOVA where Wilk's lambda test saw highly significant as compared to p= 0.01 for ESSTA. Competitive gaming to achieve higher scores or stages with constant feedback ease sensory motor association. Bubble shooting games have vertical eye movement which gets hastened via pyramidal system and hill climb racing car games have horizontal eye movement via extrapyramidal system.

Conclusion: Gamification improves eye hand coordination along with cognition in children with cerebral palsy must be taken into consideration for neurodevelopmental training.

Key words: Gamification, Eye -Hand coordination, Cerebral palsy

INTRODUCTION

Gamification is one of the facilitation tools to hasten Neurodevelopmental development among children with cerebral palsy. Movement facilitation stays the major area of interest for every researcher. Appropriate sensory stimulation has a significant role in achieving motor output in Neurodevelopmental techniques (NDT). Eye-hand coordination movement is the skill whereby visual information from the eyes and motor information from the hands are efficiently applied to work together as an essential part of self-help activities, play, perception, and schoolwork. Coordination is the ability to execute smooth, correct, controlled movements. Coordinated movements are characterized by proper speed, distance, direction, timing, and muscular tension. Cerebral palsy is the most common motor disability in childhood. Its Prevalence range in India is from 1.5 to 4 per 1000 live births or children []). Preterm birth is a major risk factor for cerebral palsy. (2) Preterm born children have 6.4% chances of coordination disorder and very preterm born have 18.3% chances of coordination disorder.80% of children with Cerebral palsy have some abnormal neurological findings with the white matter being the most common. [2,4] White matter subserves coordination. [3] Information and communication technology has an increasing influence on the way we interact, learn, and live. The gamification where sensory-motor integration occurs at multiple levels & synchronization of sensory (visual) and motor (hands) stays essential components in the entire process. Regardless of the involvement of hemisphere eye-hand coordination is affected. If any damage in the hemisphere i.e., right hemisphere damage then the difficulty in the role of processing, difficulty in visual feedback and movement if the left hemisphere is damaged motor programming and timing & sequencing affected. Despite body area affected or brain involvement all the cerebral palsy children have eye-hand coordination affected. [5]

Gamification supplies a wide customize range from beginner level to more superior level which enables to supply a competitive level for children. The vestibular system manages balance and coordination. During gamification frequent movement occurs between eyes due to the game element. Stimulation from the brain reaches the midbrain –pons-medulla-semicircular canal. The semicircular canal is a part of the vestibular system. Continuous feed-forward and feed backward improve pathways between vestibulo-ocular reflex pathways. [5] Gamification is insightful when face to face rehabilitation is not possible and in absence of costly motion specific tools.

Materials and methods:

Study design: This study was an interventional study, an online mode where participants can take part in their comfortable environment. The study duration was one month starting from 6th January 2021 to 28th February 2021 was approved by the ethical committee of School of Physiotherapy, RK University, and Recognized by Central drug standard control organization and trial registered under clinical trials registry –INDIA. Telephonic verbal consent was taken from parents.

Data Collection

A flyer was distributed among special educators, special schools, and physiotherapists for voluntary participation in the study.39 parents agree to take part among them 7 are excluded because of not fulfilling inclusion criteria .32 children with cerebral palsy who have difficulty in eye-hand coordination were taken between the ages 10-16 years.

The participant was taken based on the following criteria:1) Children and parents who are willing to take part in the study.

2) Children with cerebral palsy who can play bubble shooting games (Bubble shooter 13.0.5 version) and hill climb racing games (finger soft 1.48.1 version) and clear first level.

3) Gross motor functional classifications (GMFCS) level between 1to 3[6].

4) Manual ability classification system between (MACS) level ii to IV [7].

5) Participants who complete 32 sessions or more than that out of 40 Sessions in a 4 week. Exclusion criteria.

4) Children with severe cognitive impairment who score Mini-mental state examination less than 9.

Intervention

39 Parents responded to a flyer, their children were assessed and among them, 32 children were selected who fully fill inclusion and exclusion criteria. Pre & Post Assessment was done for the following outcome measure

1. Alternate hand wall toss test

2. Encephal smartphone Stroop app test 3. Minimental state examination for children was taken.

Video games were played by children for 20 minutes a day for 5 Days a week for 4 weeks by mobile/computer/laptop According to the American Academy of Pediatrics.

Total 12 sessions were supervised by video conferences 28 sessions were non-supervised. One session is 10 minutes. A total of 2 games were chosen for vertical and horizontal eye movement. Bubble shooting game for vertical eye movement in which Aim was match and smash all the balls of the same color.

This is one of the best shooter games that are simple and easy to learn at more than 1500 + levels. **Hill climb racing game – horizontal eye movement** Face the challenges of unique hill climbing environments with many different cars.

Bubble shooting game

hill climb racing game

Detailed description of outcome measure

Outcome measures taken were for eye-hand coordination and cognition.

1) Alternate –hand wall toss test 2) Encephal smartphone Stroop app test 3) Mini Mental state examination scale.

Alternate hand wall toss test

The alternate hand wall toss is a test of upper limb coordination which consists of standing one meter away from a wall and tossing a tennis ball with one hand against the wall in an underarm maneuver and then catching it with the opposite hand. The ball was then thrown back against the wall with the hand that caught it, and then, it was caught again with the first throwing hand. The test continued for 30 seconds, and we normally distributed data. Pre- and post-change significantly conformed by paired t-test. Repeated measure analysis was done to see weekly changes for four weeks.

recorded the number of successful catches. [8,9]

Encephal smartphone Stroop app test

Stroop Test is a test of a user's mental speed. A series of runs will be presented to evaluate the user's response rate in finding the color of printed text. Lesser seconds suggest good eye-hand coordination. [10]

Mini Mental state examination scale Mini Mental state examination scale is a scale of cognition.it includes orientation, attention and concentration, registration & sensory perception, recall, language (name body parts, command, repeat sentence, reading, writing, and copy design. (11)

Sample size calculation

Considering the pilot study, a small sample size 30 has been taken for the study. (12)

Statistical analysis

Demographic and baseline data were examined for normality using the skewness and kurtosis, normally distributed bell-shaped histogram and Shapiro wilk test which suggest normal distribution of data. Pre- and post-change significantly conformed by paired t-test. Repeated measure analysis was done to see weekly changes for four weeks.

Encephal smartphone Stroop app test

Result:

Out of 32 children (20 boys) participated in the study, 2 children (1 boy) dropped out due to parents' observation about misuse of mobile phones.

	Grade 1	Grade 2	Grade 3	Grade 4
GMFCS grade	8	11	10	1
MACS grade	not included	12	10	8

Table: 1 Demographic details of children as per the different grades of GMFCS and MACS

- **AHWTT, ESSTA, MMSE outcomes mean value and standard deviation prove in table 2**

Outcome measure	Value and description	Pre means	Post means	P value
AHWTT	Numbers of catches in 30 seconds	7.93±1.76	10.00±2.00	0.00
ESSTA	Seconds to complete one round of the test	30.46±1.126	27.96±0.955	0.00
MMSE	Score	20±1.086	23.33±1.090	0.00

Table: 2: Pre and Post mean difference changes in outcomes

Table suggests pre-mean and post-mean of outcome measures and it suggests significant improvement (P=0.00) in AHWTT, ESSTA, and MMSE.

Outcome measures	Repeated measure analysis from Day 1 with 8th, 15th, 21st and 28th day				
	Day 1	Day 8	Day15	Day21	Day 28
AHWTT		1.00	0.65	0.11	0.00
ESSTA		1.00	0.10	0.02	0.01
MMSE		0.00	0.00	0.00	0.00

- **Repeated measure analysis was done to know significant improvement every week. Which is proved in table 3.**

Table: 3: Repeated measure analysis of variance of outcomes

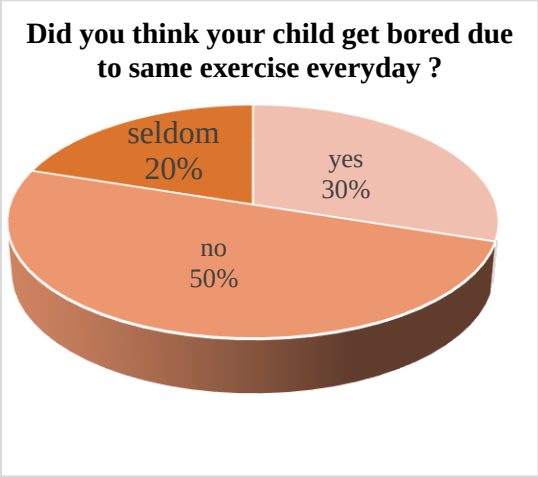
Significant improvement was noted in the alternate hand wall toss test from day21 Significant improvement was noted in the Encephal smartphone Stroop app test from day 15 onward. Significant improvement was noted in the Mini mental state examination scale after day 7. (Table 3)

Discussion

The current study assesses the effectiveness of gamification to improve eye-hand coordination in children with cerebral palsy. In the alternate hand wall toss test, the child throws a ball in the underarm manual and must catch with other hands. Child must move hand and eye in context to the ball. In this procedure gaze and vertical eye movement are needed. By playing a bubble shooting game vertical eye movement improves and leads to a better score in the alternate hand wall toss test. By playing vertical eye movement game rostral intestinal medial longitudinal fasciculus activated which are in pons. Pons is a connection between cerebellum and cerebrum so by playing video game activation of cerebellum and cerebrum occurs which manage balance and coordination. [9] Vertical eye movement directly correlates with the pyramidal system. As in hill climb, racing game movement involves horizontal eye movement. When doing horizontal eye movement neurons activated are para pontine reticular formation which is a part of the reticular formation system that makes a reticulospinal tract. The reticulospinal tract is a part of **Extrapyramidal tract pathway** which manages keeping coordination. [10] Gamification is based on **implicit learning** where a child fails and

learns it leads to more automaticity which improves eye-hand coordination. Mini Mental state examination scale has components like recall, attention, copy a design, reading sentence, writing which requires cognition and eye-hand coordination [12]. Mini Mental state examination scale suggests improvement in a score as a child has to focus on games and avoid external stimulation from the environment, so it improves concentration. During video games, if a child is unable to clear the stage, they still are which hurdles are difficult and memorize it, by that process memory improves. [8,10]. Gamification also works on augmented feedback where knowledge of result and knowledge of performance are applicable which overtime develops muscle memory to perform the task independently. [4]

As its mention in graph 1 & 2 that 30% children get bored due to same exercise every day and 40% parents think that gamification is insightful this data must take into consideration for future research.



Graph 2

Conclusion:

Gamification is useful to improve eye-hand coordination along with improvement in cognition. In context to statistical significance and clinical reasoning, we do see that gamification is one of the effective tools to improve eye–hand coordination in children with cerebral palsy. The selection of computed games must remain an essential fragment of the study. Hand movements in association with vertical and horizontal tracking of eye movements must be taken into consideration to improve eye–hand coordination [13]. Moreover, improvement in cognition level by game-specific interest and concentration may add to physical and functional activities related to eye-hand coordination in children with cerebral palsy.

Limitation and future recommendation

Limitation The size of the screen to play the computed games was varied. Future recommendation: The choice of games must have inclusion of simulation and includes hand – arm and trunk movements with eye coordination.

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Ethical Approval: Ethics Committee (EC), School of Physiotherapy, RK University, Rajkot approved by The Central Drugs Standard Control Organization.

Clinical Trial Registry of India (CTRI) number: CTRI/2021/01/030268

Conflict of Interest: Nil

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