EFFECT OF VIRTUAL REALITY IN SPIDER CAGE ON GROSS MOTOR PERFORMANCE AND BALANCE IN CHILDREN WITH SPASTIC DIPLEGIA

Engi E. Sarhan[1], Amr Mohsen Abo Khatwa*[2], Mohamed Bedair Ibrahim[3], Abeer M. Salamah[4], Hajer M. Abdullatif[5], Sherif Moustafa Mahmoud Ramadan[6], Nesma EM. Barakat[7]

[1]Department of Physical Therapy for Neurology and its Surgery, Faculty of Physical Therapy, Kafrelsheikh University, Kafrelsheikh, Egypt; [2]Physiotherapist at Shubrakhit General Hospital, Al Buhayrah, Egypt; [3]Department of Physical Therapy for Paediatrics, Faculty of Physical Therapy, Kafrelsheikh, Egypt; [4]Department of Paediatrics, Faculty of Medicine, Kafrelsheikh University, Egypt; [5]Department of Physical Therapy for Neurology and Neurosurgery, Faculty of Physical Therapy, Sinai University, Kantara, Egypt; [6]Department of Basic Sciences, Faculty of Physical Therapy, Sinai University, ,Kantara, Egypt;[7]Department of Physical Therapy for Paediatrics,Faculty of Physical Therapy, Kafrelsheikh, Egypt

Abstract

Background: Cerebral palsy (CP) is a motor impairment syndrome that affects movement and posture. This study applied on children with spastic diaplegia to examine the effect of virtual reality in spider cage on gross motor performance and balance.

Purpose: This study aimed to detect the effect of virtual reality in spider cage on gross motor performance and balance in children with spastic diplegia.

Materials and methods: The study randomly assigned children with spastic diplegia to either the virtual reality training group (16 children, average age: 8.4 years) or the control group (16 children, average age: 8.47 years). The virtual reality training group used the virtual reality glasses system for virtual reality training in spider cage in addition of traditional physiotherapy exercises for three months and the control group did traditional physical therapy exercises included spider cage exercises for three months. The researchers measured the Pediatric Balance Scale, The Gross Motor Function Measurement-88 before and after the training sessions.

Results: there was a significant difference in Gross motor performance and balance posttreatment as compared with pretreatment in both groups (P < 0.001), there was a significant effect on Gross motor performance and balance in the virtual reality group in comparison with control group with P. value 0.02 and < 0.001.

Conclusions: Our study demonstrated that virtual reality training improves balance and gross motor skills in children with spastic diplegia.

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*Corresponding Author: Amr Mohsen Abo Khatwa, Physiotherapist at Shubrakhit General Hospital, Al Buhayrah, Egypt

Correo-e: ptrservices2022@gmail.com

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Introduction

Cerebral palsy (CP) is a motor impairment syndrome that affects movement and posture. It is caused by brain defects or lesions that occur in an immature brain before or during birth or within two years of birth (1).

It is accompanied by motor disorder; disturbances of sensation, cognition, perception, communication, and behaviour; and seizure disorder and affects overall development (2,3)

Accordingly, children with CP show reduced postural control when engaging in several activities such as sitting, standing, and walking and have limitations in performing the activities of daily living (4,5).

Therapeutic approaches for CP include neurodevelopmental treatment, Vojta therapy, sensory integration therapy, and conductive education. Specific therapeutic strategies for CP may differ, but they all aim to improve the independence of children with CP (6).

Considering that the rehabilitation period of patients with CP is observed in a prolonged period of time, it is important to induce the sustained participation of these patients, making sure that the therapeutic interventions are interesting and easily performed (7). For this we have used this treatment tools in our study.

Spider therapy is an intensive treatment approach which was originally developed in Poland. It involves suspending the child in the Centre of universal exercise unit by using a number of elastic bungee cords of different elasticity, these cords are attached to specific points on special belt around the child's waist, Froming a unique spider web around the child which provides them essential support (8).

In the past, traditional neuro physiological approaches and novel emerging rehabilitation strategies addressed the gross motor function and balance capacity of children with CP (9).

Virtual reality gaming Aug ments a desirable motor processing skills through task-driven training and also encourage problem–solving. With a higher concentration and engagement of goal-driven games, the virtual reality gaming might influence the cognitive-motor planning of children with CP (10).

Virtual reality increases the neuroplasticity and motor learning associated with active participation, motivation and active repetition (9,10).

VR games promotes a systematic practice of functional movements and multi-sensory feedback. Practice of the goal directed movements, audio-visual feedback and motivation are important components for motor gains. VR approach includes the main principles of the motor learning theories such as the repetition of functional tasks, the feedback mechanism and the patient's motivation. VRT has positive effects on postural control, balance, gross motor function and upper extremity functions in children with CP (11,12).

Recommended that the group therapy, goal-directed motor practice, strengthening exercises, treadmill training, balance and walking training were beneficial for functional mobility of children with CP. In recent times, technological advancement has gained momentum in developing strategies for limb recovery and balance capacity of the pediatric and adult population with brain dysfunction (13).

Inadequate postural control and balance reactions prevent the voluntary skills and independence in activities of daily living. Thus, balance training to improve general motor skills and level of independence in activities of daily living is one of the main goals of rehabilitation, CP cannot be cured, but several interventions focus on reducing the impairments and increasing the independence in daily life (14).

Material and Methods

Design of the study

The study was designed as a prospective, randomized, double blind, pre- post-test, controlled trial.

Area of treatment

Outpatient clinic of physical therapy, Kafrelsiekh University.

Period of treatment

Study started: April 1,2023

Study completed: July 1,2023

Number of groups

The study randomly assigned thirty-two children with spastic diplegia; they were randomly assigned into two equal groups.

Group (A): virtual reality training group (16 children, average age: 8.4 years)

Group (B): the control group (16 children, average age: 8.47 years).

Ethical committee number: P.T/PED/1/2023/29.

Clinical trial number: NCT05740020

Participants

A convenient sample of thirty-two subjects with spastic diplegic CP recruited by pediatricians or pediatric neurologists and referred to Pediatric Out-patient Clinic of Faculty of Physical Therapy, Kafr-Elsheikh University. They were enrolled and assessed for their eligibility to participate in this study. Their age ranged from 6 to 12 years and Children with spasticity grades ranged from 1 to 2+ according to Modified Ashworth scale (MAS). Children who can sit on the chair with good balance and recognize and follow verbal orders and commands included in both testing and training techniques. Subjects were excluded if Children having visual or auditory defects, Current hospitalization for urgent medical reasons, Severe mental retardation, Children with history of epileptic seizure or any diagnosed Cardiac or orthopedic disability that may hinder assessment methods and treatment or They had a permanent deformity (bony or soft tissue contractures).

This study was performed according to the Statement of the Declaration of Helsinki. Using G-power version 3.1.9.7 for windows and regarding t-test study, alpha level of 0.05, confidence interval 80% and effect size of 1.135 calculated from the previous study of Krishna et al. (20), the total sample size was 28 children (fourteen in each group), (Figure 1). We have increased the number to 30 children (Fifteen in each group) to avoid any drop out.

To avoid selection bias, the children were randomly allocated by simple random method via choosing one of two wrapped cards representing the two treatment groups, which are:

- **Group (A):** Received virtual reality in addition to the traditional exercise program in spider cage.
- **Group (B):** Received a traditional exercise program in a spider cage (Figure 1).

Randomization

A computer-generated randomized table was the method used to implement the randomization using the SPSS program (version 27 for Windows). Each participant had an identification number. These numbers were assigned into two groups equal in number (n=16). Sequentially numbered index cards were secured in opaque envelopes. A blinded researcher opened the sealed envelope and allocated the patients according to their groups (Figure 2).

Intervention

After a baseline measurement Group (A) received virtual reality in addition to the traditional exercise program including spider cage exercises. Group (B) received traditional exercise including spider cage exercise. All groups received the treatment three sessions per week for 12 weeks.

Treatment program in Group A, virtual reality program

In the virtual reality group, we used a virtual reality glasses the child was stand in the spider cage then we applied a virtual realty glass on his head included a smartphone to apply the treatment we start a virtual reality application and virtual reality games. we observed his performance and interaction with games and videos on the screen LCD display by using screen mirroring we also use a balance board and step exercise while playing we ask a child to interact with the game included smash game and racing while standing and control balance. Virtual reality exercises are designed to match child ability and Performance the exercise involved with movement of child head and interact with the game and video display.

In the scoring game children wear asked to control the car by controlling their head movement And try to move the car in the true direction of the game to reach the end of this level, in the airplane game we asked children to move the head slow to control the plane and avoid smashing, in the 360 degree video we asked children to focus on the video and we ask children to describe what they are watching,

The treatment duration was thirty minutes and repeated three times per week for 3 months.

The traditional exercise program (given to both groups)

In the control group, according to the functional level of each child, neurodevelopmental techniques were applied. This program included activities that aims to facilitate typical motor development and function and to prevent secondary impairments and improving tone, Approximation that aims to control spasticity and stimulate the joint mechanoreceptors, balance exercise, mobility training, spider suspension exercise and gait training exercises.

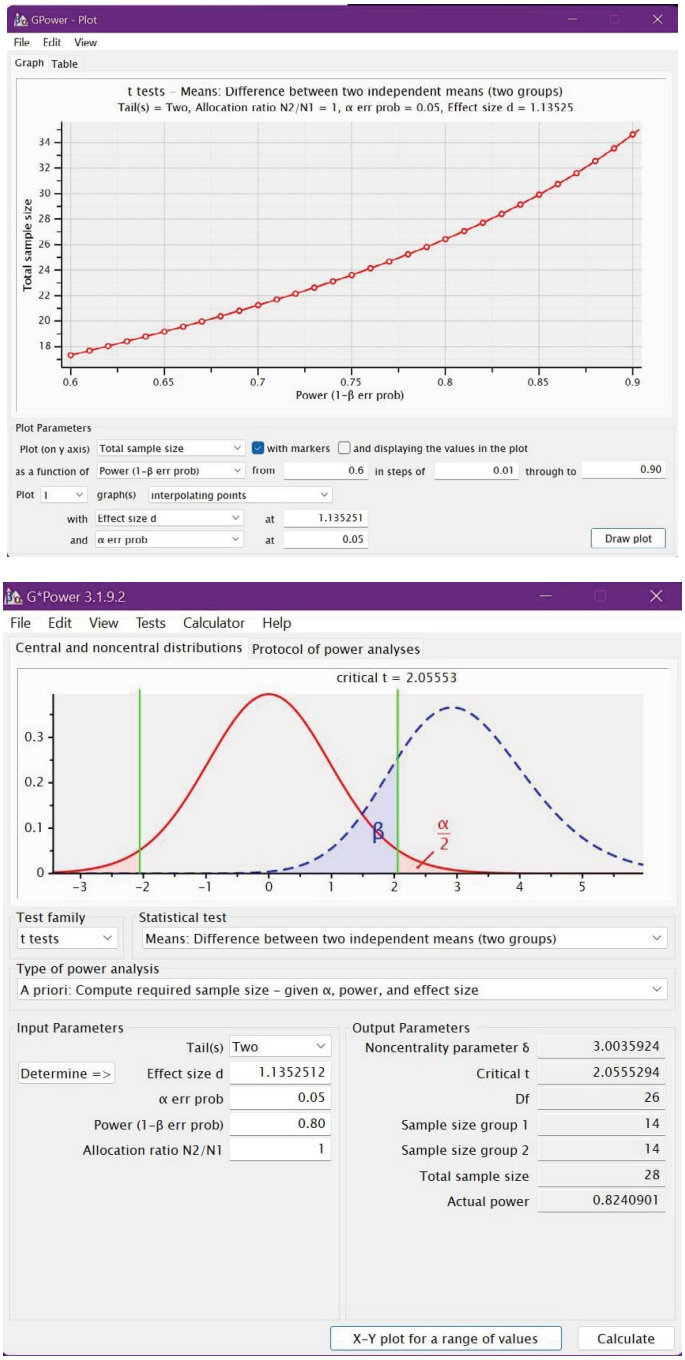

Figure 1. Sample size calculation in G-power software program.

Traditional physical therapy session consists of the following exercise: approximation, strengthening exercise, balance training program, gait training activities, stretching exercise, spider suspension exercise for 30 minutes, sitting on ball exercise, NDT program and using of all tests in gmfm as a treatment program exercise such as basic rolling and sitting and growling and working.

Advice

All participants were instructed to.

- Avoid distraction.
- Avoid rushing in movement.
- Always maintain balance and straightness.

Outcomes measurements

Evaluations were performed before and after training for both groups.

Gross Motor Function Measure 88 (GMFM-88)

The GMFM is used by a variety of rehabilitation specialists for clinical and research purposes to measure change over time, and the effectiveness of interventions to affect change (15).

The standardized measures provide objective information in an easy-to-understand format. As stated earlier, the GMFM has become the standard tool for measuring change in gross motor function over time for children with CP. Given its unique purpose, its wide use, and the amount of research that has been conducted using this outcome measure, examining the usefulness as related to intervention is important to measure change over time for children with CP. the Gross Motor Function Measure (GMFM) and its subsequent revision, has become the most common functional outcome measure used by rehabilitation specialists to measure gross motor functioning in children with CP and other neurologically based conditions, such as Down syndrome and traumatice brain injury (16).

This tool showed high validity at 0.91 when applied, the GMFM-88 was reported to be a useful method for measuring gross motor function in children with CP because of its high reliability, with inter-rater reliability of 0.77, test–retest reliability of 0.88, and intra-rater reliability of 0.68 (17).

Pediatric Balance Scale (PBS)

The PBS is a standardized tool for testing balance. this tool developed by modify ng the Berg Balance Scale to test the functional balance of the school-age population with mild-to-moderate motor impairment. The tool has been confirmed to be reliable in terms of both intra-rater reliability (intraclass correlation coefficient (ICC) = 0.99) and inter-rater reliability (ICC = 0.99). The items can be measured within 15 min and do not require the use of specialized equipment (18). PBS consists of 14 items that are scored from 0 points to 4 points with a maximum score of 56 points. The scale examines many of the functional activities such as sitting, standing, transfers and stepping (19).

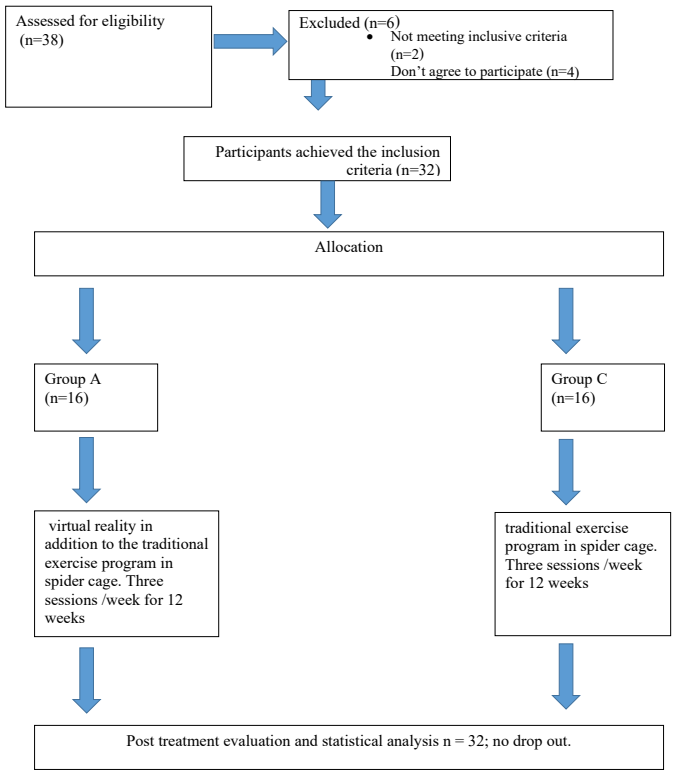

Figure 2. Flow char of the study.

Results

For normality test of data, Shapiro-Wilk test was performed. Descriptive statistics and Mann-Whitney test were conducted for comparison of age between the two groups.

Descriptive statistics and independent t test were conducted for comparison of pretreatment and post treatment measurements of Gross motor performance and balance between the two groups. A paired t test was conducted for comparison between Pretreatment and Post treatment measurements of Gross motor performance in group A only. The Wilcoxon test was conducted for comparison between Pretreatment and Post treatment measurements of balance in both groups and Gross motor performance in group B only. The arithmetic means as an average description of central tendency of the results. The standard deviation as a means of dispersion of the results. The level of significance for all statistical tests was set at P. value < 0.05. All statistical measures were performed through the statistical package for social studies (SPSS) version 27 for windows.

Between group comparison

Before the treatment, there was a non-significant difference in age, Gross motor performance and balance between the two groups with P. value of 0.98, 0.31 and 0.66 respectively, while after treatment, there was a significant difference in Gross motor performance and balance between the two groups with P. value 0.02 and < 0.001 respectively as showed in (Table 1), (Figure 3,4,5).

Within group comparison

- As showed in Table 1, figure 1&2, there was a significant difference Gross motor performance and balance posttreatment as compared with pretreatment in both groups (P < 0.001).
- Negative mean difference scores (95% confidence interval [CI]) on outcome measures indicate improvement.

Discussion

Our aim was to examine the effect of virtual reality on gross motor performance and balance of children with spastic diplegia. It was found that virtual reality and traditional exercises which are applied in similar durations have a positive effect on gross motor performance and balance and Virtual reality effective more than traditional exercise only that is clear in the gross motor performance and balance of children. spider cage chosen for this study as Spider therapy, either by itself or with other usual treatments, helps a lot in making motor skills and balance better in cerebral palsy, improve postural alignment and gait performance in spastic cp, The Cage Therapy with Spider Suit is more effective and beneficial therapy than Traditional Physical Therapy in improving Gross Motor function in cp (21) because CP rehabilitation requires motivation, as interventions are lengthy and slow to produce functional improvements. Children may lose interest in conventional training (22) So VR, with its game features and 360-degree video is a suitable intervention for children with CP, as it motivates them and enables them to play games that can give them motivation and improvement increases the neuroplasticity and motor learning associated with active participation, motivation and active repetition (23). This the main reason we select virtual reality in our study.

The literature has conflicting results on the effects of virtual reality on gross motor function in the study of Brien and Sveistrup found no significant

Table 1. Descriptive statistics and comparison of all dependent variables at different measuring periods among groups.

Dependent variables		Group (A) (n = 16)	Group (B) (n = 16)	Group A Vs. B P. value*
Age		8.4±1.92	8.47±2.2	0.98^{NS}
Gross motor performance	Pretreatment	73.04±2.08	73.83±2.11	0.31^{NS}
	Post treatment	79.61±2.25	77.51±2.21	0.02^{S}
	P. value**	$< 0.001^{S}$	$< 0.001^{S}$	
Balance	Pretreatment	25.93±2.81	25.47±2.9	0.66^{NS}
	Post treatment	31.2±3.47	27.4±3.29	$< 0.001^{S}$
	P. value**	$< 0.001^{S}$	$< 0.001^{S}$	

* Inter-group comparison; ** intra-group comparison of the results pre- and post-treatment. Data expressed by mean ± SD, NS p > 0.05 = non-significant, S p < 0.05 = significant, p = Probability

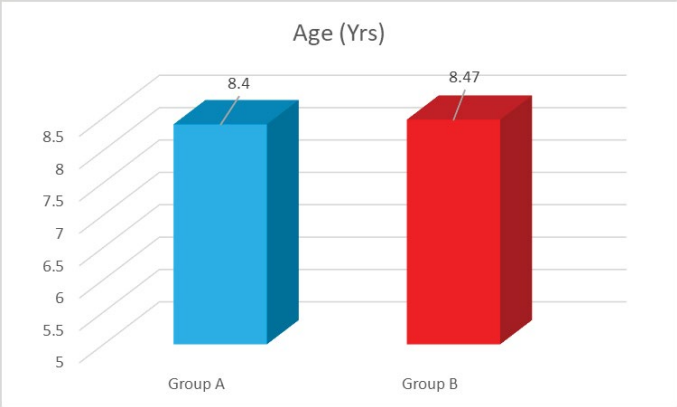

Figure 3. Mean age of groups A and B.

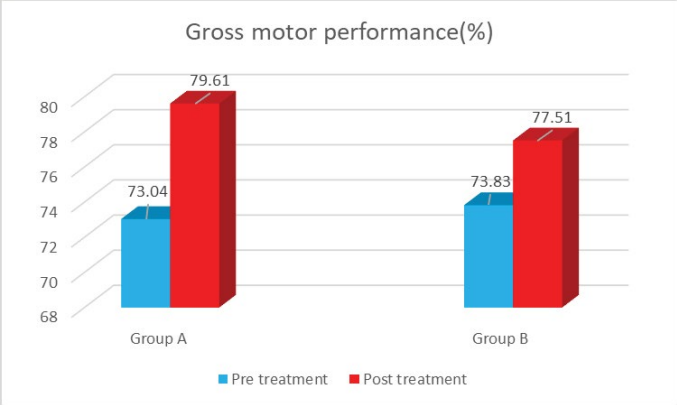

Figure 4. Mean Gross motor performance of groups A and B.

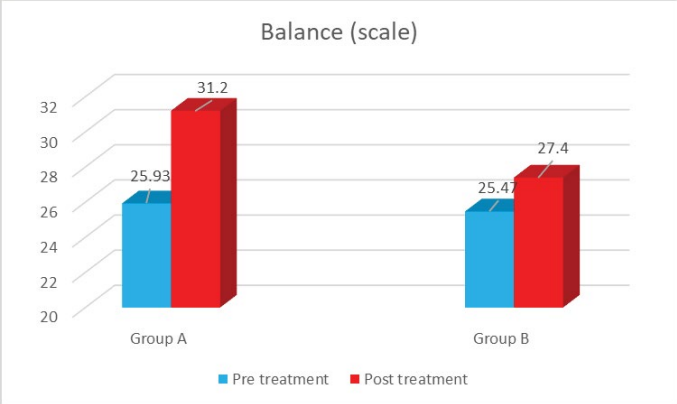

Figure 5. Mean balance of groups A and B.

improvement in GMFM classification after five days of virtual reality balance training. The training might have been too short to improve function. (24) Han et al Studied the influence of specific VR treatment modes on ADL performance in children with cerebral palsy, VR interventions in CP-treated patients confirmed the effectiveness of their effects on ADL. Intervention effects in children were not different when we studied GMFCS, otherwise, VR was applied for a duration of 6 weeks at 101-200 minutes per week, with the most significant effect observed. We can also say that virtual reality need more time to get more effect as we did in our study 3 months give the great effect of the virtual reality (25)In the literature , we have a lot of studies that agree with our result that say the virtual reality effective in the gross motor performance more than traditional exercises only Şahin et al did The study as controlled trial group , It split 60 children equally into the VR group (10 females and 20 males) and the traditional occupational therapy group (13 females and 17 males). Both groups measured motor functioning and independence in daily activities. The interventions lasted for 8 weeks and aimed to improve gross motor skills and daily activities they found that Total gross motor and independence in daily activities in both groups improved after intervention period. A comparison between groups there was a significantly improvements in both gross and fine motor functions and daily activities in the virtual group than in the traditional group ($P < 0.001$). There was significant improvement in virtual reality group in comparison with control group. (26) Also Arnoni et al did blind randomized controlled trial fifteen children with CP who regularly attending conventional physical therapy programs they were randomly assigned to 7 children in study group and 8 children in control group in both groups, children remained attending conventional therapy. In addition, in the study group intervention using an active video game twice a week for 45 min and eight weeks. Standing body sway was assessed using a force plate, and Gross Motor Function Measure (GMFM) dimensions D (Standing) and E (Walking, Running and Jumping) were tested. they found that in the study group only showed significant improvements in the GMFM dimensions D ($p = 0.021$) and E ($p = 0.008$). Improvements were clinically significant (D = 10.8%; E = 14.0%). in the control group showed no significant differences after eight weeks. they say that Intervention using video game is a promising tool that can improve the gross motor function of children with CP. (27)

After virtual reality exercises, our study found a significant improvement in balance. This agrees with several of studies in the literature that say the virtual reality training improve balance of children more than traditional exercises only. Pourazar et al The impact of virtual reality training on the dynamic balance of children with spastic hemiplegic cerebral palsy was investigated. The data collected from 20 girls' spastic hemiplegic cerebral palsy that divided into study group and control one, study group was treated using video games training therapy and result show a significant difference between the two groups. This paper suggests that this type of training can help children with cerebral palsy improve their balance ability. The virtual system is an interesting option in the treatment of children with cerebral palsy. (28) Kilcioglu et al VR appears to have a greater impact on the motor skills of children with CP. Despite the focus on balance and gross motor functions during VR training, the future study on balance and gross motor function should focus on the long-term effects of therapies such as VR on motor skill and balance. (29) Liu et al The hug number of children with cerebral palsy (CP) has a serious impact on people, and society. As a new technique, virtual reality has been used in the rehabilitation of children with Cerebral palsy. VR training can enhance the balance function and gross motor function in children with CP, but its impact on their daily lives is still contentious under investigation and need more future studies (30). The virtual environment might have stimulated the learning mechanism with multi-sensory feedback, repeated movements, and active participation, which improved the balance. VR games have unexpected body movements that challenge postural stability. Users need to keep their posture stable in space during training (27). Practice and feedback, which are key for motor gestures, might have built and coordinated new muscle synergies, which increased the balance scores (26). In our study, the balance scores in PBS show improvement in both groups but the study group give more improvement in comparison with traditional exercises only group.

The study's limitations include the high cost of virtual reality glasses, especially modern ones, which include a greater number of sensors that provide accurate information about the child's interaction. It also includes the inability of children to bear glasses due to their sensitivity to light and the rapid interaction of games, but this limitation can be overcome by using calm games and videos to be more comfortable for the eyes.

Conclusion

both virtual reality and traditional physiotherapy have an effect on gross motor performance and balance but adding virtual reality exercises more effective in comparison of traditional exercises only.

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Conflict of interest: There is no conflict of interest.

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