ORIGINAL PAPER

Physiotherapy Quarterly (ISSN 2544-4395)
2022, 30(2), 15–19

Effect of virtual reality games on motor performance level in children with spastic cerebral palsy

DOI: https://doi.org/10.5114/pq.2021.108681

Somaia A. Hamed[1], Nevien Maher Waked[2], Akram M. Helmy[3]

[1] Department of Physical Therapy for Pediatrics and Women Health, Faculty of Physical Therapy, Ahram Canadian University, Giza, Egypt

[2] Department of Pediatrics, Faculty of Medicine, October 6 University, Giza, Egypt

[3] Physical Therapy Department, College of Medical Rehabilitation, Qassim University, Buraydah, Saudi Arabia

Abstract

Introduction. The study aim was to examine the effects of virtual reality games on motor performance level in children with spastic cerebral palsy.

Methods. The study involved 30 children (boys and girls) aged 7–10 years with spastic diplegic cerebral palsy. They were randomly divided into the control group, who received a conventional selected exercise program, and the study group, who received the same conventional selected exercise accompanied by virtual reality games, 3 times per week for 3 successive months. Motor performance level was evaluated with the Gross Motor Function Measure scale (GMFM) and Gross Motor Function Classification System (GMFCS). The Wilcoxon test was applied for within-group comparison and the Mann-Whitney test for between-group comparison.

Results. The within-group comparison revealed significant improvements of GMFM and GMFCS scores in the study group, while in the control group, there was no statistically significant difference. Between-group comparisons showed a significant improvement of GMFM in the study group.

Conclusions. Virtual reality games have positive effects on the motor performance level in patients with spastic diplegic cerebral palsy.

Key words: virtual reality, cerebral palsy, motor function measure

Introduction

Cerebral palsy (CP) is one of the important severe childhood physical disabilities [1]. Limitation in the range of motion, postural disorders, decreased activity level [2], problems concerning sensory awareness, and a developmental delay in movement coordination affect daily living and need to be managed by a multidisciplinary health professional team [3].

Physiotherapy plays an important role in the rehabilitation of children with CP. It provides evaluation of motor abilities and improves daily living through different position and mobility training, family support, and equipping caregivers with relevant information on the patients' health. Physical therapy mostly consists of direct interventions, such as facilitation and training of motor tasks [4].

Virtual reality (VR) – as a recently developed technology – helps children to achieve independency by promoting a variety of simple exercises [5]. Disabled children show enthusiasm and determination to engage with VR technology; however, its efficiency is yet to be sufficiently documented, especially in children with CP [6].

VR utilizes interactive simulations designed specifically via computers in order to engage children with an environment which is nearly identical to the actual world environment [7]. VR applications create a virtual environment that allows children to interact directly when practising functional activities [8].

Levac et al. [9] reported various 'active ingredients' of VR that can improve children rehabilitation as they create an interactive exercise environment for the children by increasing time, difficulty, and repetitions of exercise. Also, ecologically, VR provides an exact environment that mimics the actual world to facilitate a child's ability to perform task-specific practices.

Moreover, virtual environments have the potential to recreate 'environmental factors' through limiting the environmental barriers, e.g. reducing finger flexion range of motion to decrease task difficulty, while emphasizing the support offered by family members or friends [9, 10].

Many assessment tools are accessible to evaluate the development of gross motor function in CP children, such as the Pediatric Evaluation of Disability Inventory or the Functional Independence Measure for children. Among them, the Gross Motor Function Measure (GMFM) is the leading and most regularly utilized tool around the world. The scale requires a qualified specialist and a suitable environmental factor [11].

GMFM evaluates change in response to an intervention and is considered the most used tool in assessing gross motor function in CP children, which detects functional changes. The arrangement of the testing items reflects the development of gross motor milestones. The GMFM-88 scale is divided into 5 dimensions: lying and rolling (17 items), sitting (20 items), crawling and kneeling (14 items), standing (13 items), and walking, running, and jumping (24 items) [12].

The Gross Motor Function Classification System (GMFCS) classifies gross motor function, providing therapists and researchers with highly reliable results, and has been widely used to evaluate CP children [13].

Correspondence address: Somaia A. Hamed, Department of Physical Therapy for Pediatrics and Women Health, Faculty of Physical Therapy, Ahram Canadian University, 4th Industrial Zone, Banks Complex, 6th of October City, Giza Governorate, Egypt. Postal code: 12451, e-mail: Somaia.ali@acu.edu.eg, https://orcid.org/0000-0001-9794-7353

Received: 03.02.2021
Accepted: 12.07.2021

Citation: Hamed SA, Waked NM, Helmy AM. Effect of virtual reality games on motor performance level in children with spastic cerebral palsy. Physiother Quart. 2022;30(2):15–19; https://doi.org/10.5114/pq.2021.108681.

GMFCS divides children's gross motor function into 5 levels, starting with level I, walking without any limitations, up to level V, walking with severe limitations even when the child uses assistive devices. It is suitable for patients aged from less than 2 years to 18 years [14]. It is applied in 5 age groups: less than 2 years, 2–4 years, 4–6 years, 6–12 years, and 12–18 years [15].

CP is considered one of the major disorders which affect movement and posture, leading to permanent disability, so the main objective of this study was to examine the effects of VR games on the level of gross motor function in children with spastic CP. We hypothesized that there would be no effects of VR games on motor performance level in children with spastic CP.

Subjects and methods

Design of the study

The pre- and post-experimental design study involved 2 equal groups: the study group, who received a physical therapy conventional exercise program in addition to VR games, and the control group, managed with the physical therapy conventional exercise program only.

Participants

A total of 30 spastic diplegic CP children (boys and girls) were enrolled in this study. They were chosen from the outpatient clinic for paediatrics, October 6 University hospital. The treatment program involved 3 sessions per week for 3 successive months. The children included in the study were diagnosed and referred by a specialized physician as having spastic diplegic CP. The degree of spasticity was grade 2 or less in the modified Ashworth scale. The patients, aged 7–10 years, were able to understand, follow, and participate in the games. Individuals were excluded from the study if they had auditory, visual, or severe cardiac disorders, significant tightness or fixed musculoskeletal deformity, or perceptual or cognitive disorders. The Pediatric Evaluation of Disability Inventory (social/cognitive domain) was used to evaluate the cognitive level, while the perception level was determined by assessing deep joint sense and stereognosis.

Randomization

The children were randomly assigned into 2 equal groups (study and control group) with the use of a computer-based randomization program. No dropping out of participants from the study was reported after randomization or intervention (Figure 1).

Outcome measures

Gross Motor Function Measure

Each child was given a specific description of the tasks. Then, the child was allowed to repeat the task 3 times, and the best trial was recorded. The time taken was 45–60 minutes. All items in (1) lying and rolling; (2) sitting; and (3) crawling and kneeling were performed on a mat. All items in (4) standing and (5) walking, running, and jumping were performed on the floor.

Particular items were scored as follows: 0 = no initiation, 1 = task initiation (< 10%), 2 = partial task completion (between 10% and < 100%), 3 = task completion [11].

Gross Motor Function Classification System

Each child was allowed to perform the function activities without any interruption from the caregiver or therapist. The level of their activity was recorded with reference to their age. The time taken was about 10 minutes.

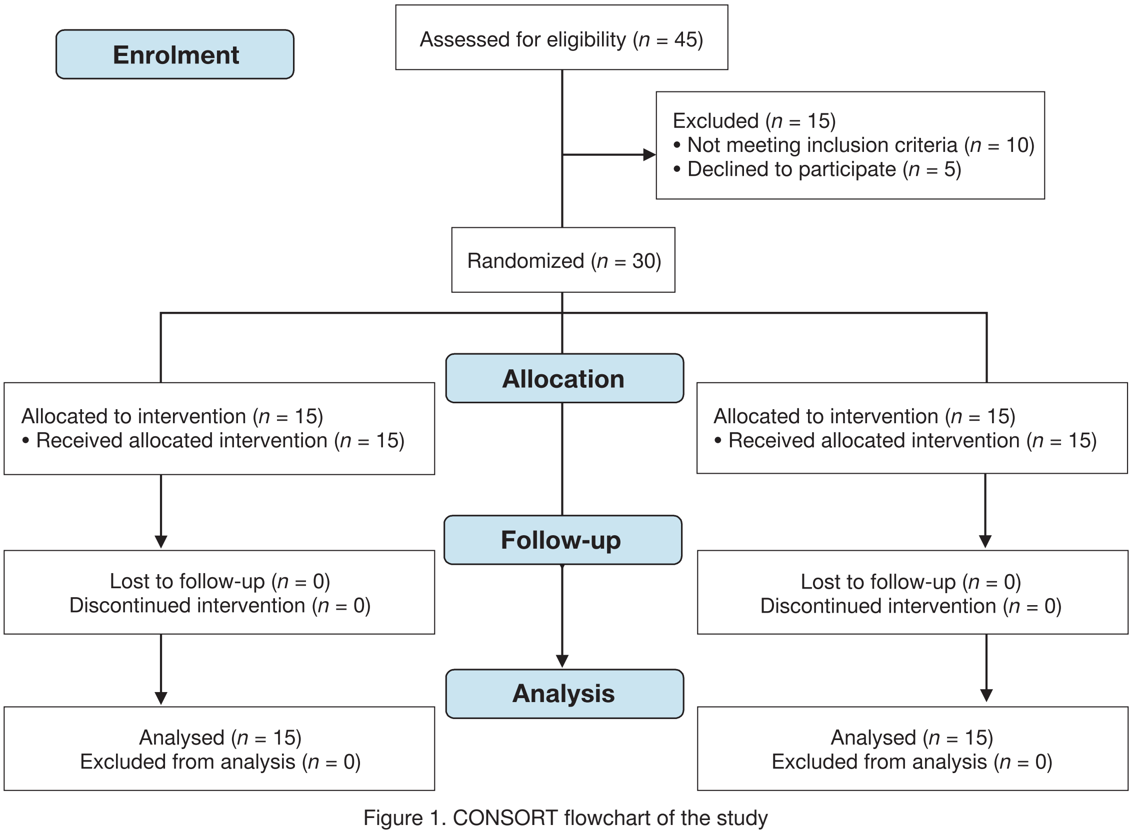

Figure 1. CONSORT flowchart of the study

Table 1. Descriptive statistics and independent *t*-test results for the participants' demographic data for both groups

Characteristics	Study group (mean ± SD)	Control group (mean ± SD)	*t*	*p*	Level of significance
Age (years)	8.260 ± 0.984	8.227 ± 0.880	0.0978	0.9228	NS
Weight (kg)	29.040 ± 2.747	28.913 ± 2.706	0.1295	0.8979	NS
Height (cm)	126.493 ± 5.897	127.460 ± 5.230	0.4750	0.6385	NS

NS – not significant

The results were categorized as follows: level I – walking without any limitations, level II – limitations in walking, level III – using a hand-held mobility device in walking, level IV – limited self-mobility with a possible use of chargeable devices, level V – using a wheelchair manually [16].

Interventions

Conventional exercise therapy program

Both groups received a conventional selected exercise program for 60 minutes, 3 sessions per week for 3 successive months. The aim was to improve the motor function of the children in the form of: (1) neuro-developmental technique to improve the pattern of normal movement through muscle tone normalization, inhibition of abnormal reflexes, and facilitation of normal postural response; (2) back and abdominal exercises to improve postural control and correct spinal deformities; (3) improving postural responses through facilitation of righting, balance, and protective reactions while sitting on a roll and ball, standing on a balance board with tilting the child in different directions: forward, backward, and sideway; (4) flexibility exercises of the soft tissue (especially the Achilles tendon, hamstrings, hip flexors, adductors); (5) strengthening exercise (particularly for knee extensors, hip abductors, and ankle dorsiflexors) via graduated active exercise; (6) improving standing, weight transfer and shift, and, finally, facilitation of the normal walking pattern.

Program of virtual reality games

All participants of the study group received a program of VR games for 30 minutes per session, 3 days per week, for 3 successive months. An Xbox 360 Kinect (Microsoft) game console was installed. It allows to practise games without touching the game controller, with the use of movement, facial motion, and verbal orders. Kinect utilizes a video camera to record the movement on exact time. Kinect Sports I, Kinect Joy Ride, and Kinect Adventures were applied for the patients, who remained under a supervision of a therapist [17]. Each session was divided into 3 types of games: (1) Kinect Sports I, in the form of beach volleyball. Standing in front of the Kinect sensor, players compete by mimicking actions performed in real-life sports, such as throwing a javelin or kicking a football. (2) Kinect Joy Ride is a racing game played as a person's avatar. The game is controlled by the player holding their arms out as if they were grabbing an invisible steering wheel and turning it in such a manner to steer. Pushing hips forward allows the player to drift, while pulling the 'wheel' towards the player and then pushing it forward produces a chargeable turbo boost. While airborne, players can perform various tricks, such as twists and spins, for extra points. (3) Kinect Adventures uses full body motion to allow the player to engage in a variety of minigames, all of which feature jump-in, jump-out multiplayer play. Each minigame lasts about 3 minutes.

Statistical analysis

The Shapiro-Wilk test for normality was used to verify the normality assumption, homogeneity of variance, and presence of extreme scores. Independent t-tests were conducted to compare the groups for the descriptive data (age, weight, and height). The independent t-test showed that there were no statistically significant differences ($p > 0.05$) between the groups concerning age, weight, or height (Table 1).

The Shapiro-Wilk test for normality demonstrated that all measured variables concerned (GMFM and GMFCS) were not normally distributed, so the Wilcoxon test for within-subject comparison and the Mann-Whitney test for between-group comparison were applied. Statistical analysis was conducted with the SPSS for Windows software, version 20 (SPSS, Inc., Chicago, USA). The *p*-value was set at < 0.05.

Ethical approval

The research related to human use has complied with all the relevant national regulations and institutional policies, has followed the tenets of the Declaration of Helsinki, and has been approved by the Ethical Committee of the Faculty of Physical Therapy, Cairo University, Egypt (No: P.T. /REC /012/ 002734).

Informed consent

Informed consent has been obtained from the legal guardians of all individuals included in this study.

Results

Comparison of GMFM results

As shown in Table 2, the pre-study median GMFM score for patients in the 2 groups (control and study) equalled 30–60%. There was no statistically significant difference in pre-study median values of GMFM between the 2 groups ($p = 0.838$). Yet, the post-study median GMFM results were

Table 2. Median values of the measured variables before and after the study

Item	Pre-study median	Post-study median	*p*
GMFM			
Control group	30–60%	30–60%	0.317
Study group	30–60%	60–90%	0.001
p	0.838	0.033	
GMFCS			
Control group	Level III	Level III	0.083
Study group	Level III	Level III	0.025
p	0.935	0.806	

30–60% in the control group and 60–90% in the study group. A statistically significant difference was observed in post-study median GMFM values in favour of the study group ($p = 0.033$).

Within-group comparison in the control group exhibited no statistically significant difference between pre- and post-study median GMFM values ($p = 0.317$). However, a statistically significant difference was revealed between pre- and post-study median GMFM scores in the study group ($p = 0.001$).

Comparison of GMFCS results

As presented in Table 2, the pre-study median GMFCS score for patients in the 2 groups (control and study) was level III. There was no statistically significant difference in pre-study median values of GMFCS between the 2 groups ($p = 0.935$). The post-study median GMFCS result for patients in the 2 groups was level III, which denotes no statistically significant difference ($p = 0.806$).

Within-group comparison demonstrated no statistically significant difference between pre- and post-study median GMFCS values in the control group ($p = 0.083$). There was, however, a statistically significant difference between pre- and post-study median GMFCS scores in the study group ($p = 0.025$).

Discussion

The purpose of this study was to examine the effect of VR games on motor performance level in children with spastic CP. Previous studies investigating the impact of VR in children with CP have shown improved ambulation, postural control, and arm function [18, 19].

The current study revealed a significant improvement in the motor performance level (GMFM) within the study group, but there was no significant difference within the control group, and a significant improvement was observed in the study group when compared with the control group. However, when comparing the GMFCS results within the control group, no significant difference was noted. The results revealed a within-group GMFCS score improvement in the study group and an insignificant difference between the groups.

The improvement in the current study may be due to increased motor learning and neural plasticity for different reasons, such as repeated task, motivational activity, and feedback mechanism through using the video game rehabilitative plan of care for patient with CP. The children were given a chance to practise problem-solving tasks, which improved their motor learning and neural plasticity.

Studies like that by Reid [20] demonstrated that practising motor activity in virtual environments improved recovery of function and automatic stimulation of the task in patients with CP.

The dynamic stimulus, the ability to graduate the level of the skills, and the automatic record of the level of task achievement and adequacy allow the therapist to guide the patient's performance in the actual world and to notice whether the child achieves the task adequately [21].

Owing to the game characteristics and animation, VR improves patients' motivation and participation level during playing [9, 10].

Harris and Reid [22] investigated if VR games were a suitable method to increase children's motivation during a training protocol. VR provides a social play chance to improve supportive play with other children, caregivers, teachers, and therapists [9].

Thus, through these attributes, VR can effectively enhance the child's motor function, e.g. by improving joint range of motion, increasing muscle strength, and enhancing the abilities to reach or walk. It can also raise the child's self-confidence and motivational level [10].

Moreover, video games based on VR allow the child to be aware of their motor abilities and let the therapist graduate the patient's activity level to improve their abilities in practising tasks in a more difficult environment that would be unachievable for a CP individual as result of limited mobility.

The ideal goal of using VR is to prepare children with CP to increase their participation in the actual environment by gradually overcoming the environmental limitations and adapting to all the constraints, which can be obtained through the transfer of task learning outcomes to the real environment [23]. However, converting of what happens in the virtual environment to the real world is yet to be proved as it depends on several factors, such as user characteristics and contextual issues [10–23].

The insignificant improvement of the GMFCS level in the control group and between the groups may be due to the nature of the ambulation process, which may need much more time to exhibit significant improvement as there are many prerequisites of normal walking. The priorities are stable lower limb in the stance phase, foot clearance during the swing phase, adequate positioning of the foot in dorsiflexion at the end of swing, proper step length, and minimizing the effort [24].

The results of the study let us reject our hypothesis that there would be no effects of VR games on the motor performance level in children with spastic CP.

Limitations

This study was a single-centre study: owing to COVID-19 restrictions, we could not reach more children from different areas across the country. Furthermore, the study did not consider the psychometric effects of the treatment intervention or the long-term impact on the quality of life in CP children.

Conclusions

The current study found that the use of a video game system based on VR in the rehabilitation program for patients with CP might be considered as an effective physical therapy intervention method and could be added to treatment programs as it resulted in a significant improvement in the motor performance level.

Acknowledgements

The authors would like to acknowledge all the patients involved in the study and their caregivers.

Disclosure statement

No author has any financial interest or received any financial benefit from this research.

Conflict of interest

The authors state no conflict of interest.

Funding

This research did not receive any specific grant from funding agencies in the public, commercial, or not-for-profit sectors.

References

1. Surveillance of Cerebral Palsy in Europe (SCPE). Prevalence and characteristics of children with cerebral palsy in Europe. Dev Med Child Neurol. 2002;44(9):633–640; doi: 10.1111/j.1469-8749.2002.tb00848.x.
2. Kim D-A, Lee J-A, Hwang P-W, Lee M-J, Kim H-K, Park J-J, et al. The effect of comprehensive hand repetitive intensive strength training (CHRIST) using motion analysis in children with cerebral palsy. Ann Rehabil Med. 2012;36(1):39–46; doi: 10.5535/arm.2012.36.1.39.
3. Weightman A, Preston N, Levesley M, Holt R, Mon-Williams M, Clarke M, et al. Home-based computer-assisted upper limb exercise for young children with cerebral palsy: a feasibility study investigating impact on motor and functional outcome. J Rehabil Med. 2011; 43(4):359–363; doi: 10.2340/16501977-0679.
4. Novak I, McIntyre S, Morgan C, Campbell L, Dark L, Morton N, et al. A systematic review of interventions for children with cerebral palsy: state of the evidence. Dev Med Child Neurol. 2013;55(10):885–910; doi: 10.1111/dmcn.12246.
5. Burke JW, McNeill MDJ, Charles DK, Morrow PJ, Crosbie JH, McDonough SM. Optimising engagement for stroke rehabilitation using serious games. Vis Comput. 2009;25:1085–1099; doi: 10.1007/s00371-009-0387-4.
6. Huber M, Rabin B, Docan C, Burdea GC, AbdelBaky M, Golomb MR. Feasibility of modified remotely monitored in-home gaming technology for improving hand function in adolescents with cerebral palsy. IEEE Trans Inf Technol Biomed. 2010;14(2):526–534; doi: 10.1109/TITB.2009.2038995.
7. Levac DE, Sveistrup H. Motor learning and virtual reality. In: Weiss PL, Keshner EA, Levin MF (eds.), Virtual reality for physical and motor rehabilitation. New York: Springer; 2014; 25–46.
8. Bilde PE, Kliim-Due M, Rasmussen B, Petersen LZ, Petersen TH, Nielsen JB. Individualized, home-based interactive training of cerebral palsy children delivered through the Internet. BMC Neurol. 2011;11:32; doi: 10.1186/1471-2377-11-32.
9. Levac D, Rivard L, Missiuna C. Defining the active ingredients of interactive computer play interventions for children with neuromotor impairments: a scoping review. Res Dev Disabil. 2012;33(1):214–223; doi: 10.1016/j.ridd.2011.09.007.
10. Weiss PL, Kizony R, Feintuch U, Rand D, Katz N. Virtual reality applications in neurorehabilitation. In: Selzer ME, Clarke S, Cohen LG, Kwakkel G, Miller RH (eds.), Textbook of neural repair and neurorehabilitation, vol. 2. Cambridge: Cambridge University Press; 2014; 198–218.
11. Ko J, Kim M. Reliability and responsiveness of the gross motor function measure-88 in children with cerebral palsy. Phys Ther. 2013;93(3):393–400; doi: 10.2522/ptj.20110374.
12. Alotaibi M, Long T, Kennedy E, Bavishi S. The efficacy of GMFM-88 and GMFM-66 to detect changes in gross motor function in children with cerebral palsy (CP): a literature review. Disabil Rehabil. 2014;36(8):617–627; doi: 10.3109/09638288.2013.805820.
13. Palisano RJ, Rosenbaum P, Bartlett D, Livingston MH. Content validity of the expanded and revised Gross Motor Function Classification System. Dev Med Child Neurol. 2008;50(10):744–750; doi: 10.1111/j.1469-8749.2008.03089.x.
14. Öhrvall A-M, Eliasson A-C, Löwing K, Ödman P, Krumlinde-Sundholm L. Self-care and mobility skills in children with cerebral palsy, related to their manual ability and gross motor function classifications. Dev Med Child Neurol. 2010;52(11):1048–1055; doi: 10.1111/j.1469-8749.2010.03764.x.
15. Rosenbaum PL, Palisano RJ, Bartlett DJ, Galuppi BE, Russell DJ. Development of the Gross Motor Function Classification System for cerebral palsy. Dev Med Child Neurol. 2008;50(4):249–253; doi: 10.1111/j.1469-8749.2008.02045.x.
16. Pavone V, Testa G. Classifications of cerebral palsy. In: Canavese F, Deslandes J (eds.), Orthopedic management of children with cerebral palsy. A comprehensive approach. New York: Nova Biomedical Books; 2015; 75–98.
17. Bryanton C, Bossé J, Brien M, McLean J, McCormick A, Sveistrup H. Feasibility, motivation, and selective motor control: virtual reality compared to conventional home exercise in children with cerebral palsy. Cyberpsychol Behav. 2006;9(2):123–128; doi: 10.1089/cpb.2006.9.123.
18. Sandlund M, Waterworth EL, Häger C. Using motion interactive games to promote physical activity and enlace motor performance in children with cerebral palsy. Dev Neurorehabil. 2011;14(1):15–21; doi: 10.3109/17518423.2010.533329.
19. Adamovich SV, Fluet GG, Tunik E, Merians AS. Sensorimotor training in virtual reality: a review. NeuroRehabilitation. 2009;25(1):29–44; doi: 10.3233/NRE-2009-0497.
20. Reid D. The influence of virtual reality on playfulness in children with cerebral palsy: a pilot study. Occup Ther Int. 2004;11(3):131–144; doi: 10.1002/oti.202.
21. Snider L, Majnemer A, Darsaklis V. Virtual reality as a therapeutic modality for children with cerebral palsy. Dev Neurorehabil. 2010;13(2):120–128; doi: 10.3109/17518420903357753.
22. Harris K, Reid D. The influence of virtual reality play on children's motivation. Can J Occup Ther. 2005;72(1):21–29; doi: 10.1177/000841740507200107.
23. Chen Y-P, Lee S-Y, Howard AM. Effect of virtual reality on upper extremity function in children with cerebral palsy: a meta-analysis. Pediatr Phys Ther. 2014;26(3):289–300; doi: 10.1097/PEP.0000000000000046.
24. Beaman J, Kalisperis FR, Miller-Skomorucha K. The infant and child with cerebral palsy. In: Tecklin JS (ed.), Pediatric physical therapy, 5th ed. Baltimore: Lippincott Williams and Wilkins; 2015; 187–246.