



The Effectiveness of Virtual Reality in the Rehabilitation of Balance and Gait in Children with Cerebral Palsy: Mini-Review

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Abstract

Cerebral palsy (CP) is the most common physical disability in newborn and children. The child's functioning and development strategies are affected by a variety neuromuscular and musculoskeletal impairments. Gait and postural control disfunctions are common in children with cerebral palsy and depend on the impairments of the neuromuscular and musculoskeletal systems. Balance and gait training are important for most daily activities and helps children recover from balance problems, helps to participation in daily life activities and improvement in quality of life. Treatment programs commonly includes stretching, strengthening, positioning, casting, and the facilitation of correct movement and normal postural strategies. In last decades, computer based games (virtual reality training) are used to create interactive play environments in order to achieve specific tasks and treatment goals.

Keywords: Cerebral palsy; Virtual reality; Gait, Balance; Postural control

The Effectiveness of Virtual Reality in the Rehabilitation of Balance and Gait in Children with Cerebral Palsy

Cerebral palsy (CP) is the most common physical disability in newborn and children and it is caused by damage of the developing brain resulting in motor disability and development delays [1-3]. The nonprogressive neurodevelopmental and musculoskeletal disorders begins in the early stage of life. The child's functioning and development strategies are affected by a variety neuromuscular and musculoskeletal impairments [4]. Besides motor involvement, CP also affects sensation, perception, cognition, behavioral performance and communication [5]. Existing postural problems, changes in muscle tone and may have limited voluntary movement in the both upper and lower extremities [6]. The more common symptoms are hypertonus (spasticity), involuntary movements, balance problems and unsteady gait. Loss of functional capacity and performance in individuals with CP can limit participation in physical activity resulting decrease in life satisfaction and quality of life both children and their family [7,8].

Gait and postural control disfunctions are common in children with cerebral palsy and depend on the capacities of the neuromuscular and musculoskeletal systems [9]. That problems may result from difficulty in activating and timing muscle activation. In children with cerebral palsy neuromuscular system has a

restricted capacity for coordinating muscles in postural synergies [10]. Gait rehabilitation is one of the primary goals in physiotherapy and rehabilitation of children with CP. Balance and gait training are important for most daily activities and helps children recover from balance problems, falls, injuries and helps to participation in daily life activities. There is no cure for the CP, neither more effective treatment method. But, different therapies, using assistive devices and special education and rehabilitation programs are beneficial in increasing functional independence and participation. Traditional physiotherapy and rehabilitation program consisting of stretching, strengthening, positioning, casting, and the facilitation of correct movement and normal postural strategies and it plays a central role in disease management [11,12].

The main goals of rehabilitation programs focus on developing motor skills to improve the child's abilities in activities of daily living, increase social participation and to enhance the quality of life. Although, the conventional physiotherapy programs are useful and effective, children with CP find physical therapy to be monotonous, boring and exhausting, over the years [13]. However, some researchers suggest that motivation and active participation in rehabilitation programs are among basic elements in motor learning [14,15]. Due to chronic disorder in children with CP, rehabilitation takes a long time and children can be bored out of rehabilitation and traditional exercises are not attractive options

to participants to the rehabilitation [16]. In this regard, robotic trainers and virtual reality applications which usefull, funny, easy way of doing some activites, have been increasing in the recent years in the field of pediatric neurologic rehabilitation [17]. There is also increasing interest in these approaches as a rehabilitative tool for adult and geriatric populations [18,19]. In many studies, VR combined with physiotherapy appears to be a promising new treatment approach and the researchers recommends that to use these approach together [18-20].

Virtual reality (VR) is a relatively new technology that enables individuals to immerse themselves in a virtual world. VR is defined as "the use of interactive electronic simulations created with computer hardware and software to present players with opportunities to engage in environments that appear to be and feel similar to real-world objects and events [21]. In rehabilitation programs, VR is used to create interactive play environments in order to achieve specific tasks and treatment goals. VR approaches have been applied to develop four primary outcome in clinical rehabilitation: motor re-learning and motor control, gait, strength and postural control (balance) [4,22,23]. VR is reported to augment the desirable motor performance because of brain plasticity and brain reorganization through active participation, receiving feedback, and repetition of movements [11]. With the goal of increasing functional performance in daily life activities, VR provides opportunities for repeated practice and positive feedback. Besides, the users are also get feedback about their motor performance (i.e. their score) during the games [10].

In last decades, neuroplasticity studies have demonstrated that VR training are positively associated with active engagement and motivation. As well as motivation, VR training also increases cortical re-organization. All these positive effects enhance rehabilitation outcomes in children with CP [4,24,25]. Early research studies demonstrate that VR training is feasible, highly enjoyable and non-threatening for children with CP [26]. In more studies reported that VR rehabilitation could use to improve cognitive, sensory and motor function in patients with central nerve system lesions [12,27]. Recent experimental and review studies have reported the beneficial influence of virtual-reality training strategies to considerably influence gait performance and balance in children with cerebral palsy. In a study Aminov et al. [27] showed that, virtual reality is a superior rehabilitative approach when compared with traditional approaches [28]. Chen et al. [21] reported a meta analysis study on eight stuides and concluded that a positive effect size of 0.75 (0.34-1.16) on the ambulation level after VR training in children with CP [21].

Ghai and Ghai performed a systematic review and meta-analysis study on 13 studies to determine the effects of VR training on spatiotemporal gait parameters (i.e., gait velocity, caddence, and stride length) in children with CP. In their study, they reported that there were a positive influence of VR training to enhance gait performance. A III Level of Evidence was supported the beneficial effects of virtual-reality-based training on gait performance and gross motor function. Evidence, suggests a training duration of

at least 20-30 min, ≤ 4 times per week across ≥ 8 weeks. For the weak level of evidence, the authors stated that there is need more multiple, high-quality, multicentered, randomized controlled trials to support the application of virtual-reality training on gait performance in children with cerebral palsy [29]. Ravi et al. [4] reviewed the effectiveness of VR rehabilitation in children with CP. Thirty-one studies and 369 participants were investigated. In results of study authors observed, the impact of VR rehabilitation in children and adolescents with CP. In their study, moderate evidence was found for balance and overall motor development. The evidence for other motor skills were reported as limited.

They concluded that, VR techniques are growing, so long-term follow-up and further research-include well-designed multicentre randomized controlled studies with high quality, large sample size and follow-up- are required to determine the effects on children with CP [4]. In review studies Pereira et al. [10] were recruited 13 articles and 97 participants. They determined that significant improvements in outcome measures associate with postural control and balance, upper limb function, selective motor control and gait parameters. They found also strong evidence of an acceptable recommendation for the use of virtual reality systems in the treatment of CP. In their study authors discussed some limitations: the limited number of patients enrolled, clinical diversity and age range, as well as the methodological quality of existing trials [20]. In a case study, Brien and Sveistrup found that 90 minutes of virtual reality gaming over a five day period was found to improve functional balance and mobility in adolescents with CP classified at GMFCS level I [30].

On the other hand, Jelsma et al. [30] found that regular physiotherapy sessions with Nintendo Wii Fit training was found to be enjoyable and effective in improve balance scores and motor/functional performance. But, they stated that interactive virtual games should not be used in place of traditional therapy. They recommend that there is need more randomized controlled studies to examine the impact of alternating interactive video games and conventional therapy, or adding interactive virtual game sessions at the end of therapy sessions. They concluded that also future studies needed to determine the most appropriate and effective game choices in Nintendo Wii Fit and integration with conventional therapy [31]. In recent research studies support the use of full-body movement VR-based exercise available intervention to improve functional balance and mobility outcomes in children with CP [32-34]. In a study Mills et al. found that there was no effect of a 5 day VR-based training on anticipatory or reactive postural control mechanisms used in response to oscillating platform perturbations in children with CP. They also stated that increasing the sample size and increasing the intensity, specificity, and duration of the activity, there is needed more research to investigate the effect of VR-based exercise program on benefits of balance and postural control mechanisms [35].

In another systematic review study, Snider et al. [12] reviewed literature to observe the results of VR as as therapeutic modality for children with CP. In that research, 11 articles was observed. In

conclusion they stated that VR rehabilitation has positive effects on body structures and functions, amoderate level evidence (Level 1b), but, does not positively impact on activity and participation in children with CP. At the end of the study the authors point that the current level of evidence is poor and empirical data is lacking. There is needed future methodologically rigorous studies [10]. Meyns et al. [35] studied the effects of VR games on clinical balance scores in children with CP. The results of randomized controlled study shown that balance scores are improved using VR home-training for 6 weeks [36]. In different studies, researchers also stated that VR training could help in improving the walking pattern both as a whole competence and as to control of more local levels in children with CP [37-39]. In a study, Howard aimed to answer two important research questions, to determine about future of VR rehabilitation programs.

The questions were: Are VR rehabilitation programs effective and why are VR rehabilitation programs effective? In results of study, the meta-analysis studies showed that VR rehabilitation programs are, overall, more effective than comparable rehabilitation programs, demonstrating a significant and moderate effect. VR programs are effective to developing strength and gait. For strength, the observed effect was large and statistically significant, but notable variation was observed in results for gait. Otherwise, VR rehabilitation programs were more effective than alternatives for developing motor control and balance, but the effects were small. For the first question, the author answered like that- yes, VR programs are so effective. For the second question, the author noted that three mechanisms have been proposed to explain VR training success. These are increased excitement, physical fidelity and cognitive fidelity. At the end of study author recommend that the implications of study results, effectiveness of VR training and possible avenues for future research and practice are discussed [39].

Conclusion and Future Directions

As a general conclusion, VR rehabilitation may become valuable and enjoyable treatment method for the improvement of the motor learning process in children with CP. Current evidence for the use of VR showed that using together of VR games and traditional physiotherapy exercises are more effective methods to improve gait, postural control, and balance problems than use alone physiotherapy methods in children with CP. But, the evidence for its use in improving motor function, walking pattern and postural strategies are limited. Further study is required to determine if can use placed to traditional rehabilitation programs to develop gait strategies and balance problems.

References

- Jones MW, Morgan E, Shelton JE, Thorogood C (2007) Cerebral palsy: introduction and diagnosis (part I). *J Pediatr Health Care* 21: 146-152.
- Krigger KW (2006) Cerebral palsy: an overview. *Am Fam Physician* 73: 91-100.
- Badawi N, Keogh JM (2013) Causal pathways in cerebral palsy. *J Pediatr Child Health* 49(1): 5-8.
- Ravi DK, Kumar N, Singhi P (2017) Effectiveness of virtual reality rehabilitation for children and adolescents with cerebral palsy: an updated evidence-based systematic review. *Physiother* 103: 245-258.
- Rosenbaum P, Paneth N, Leviton A, Goldstein M, Bax M, et al (2007) A report: the definition and classification of cerebral palsy April 2006. *Dev Med Child Neurol Suppl* 109: 8-14.
- Thorley M, Donaghey S, Edwards P, Copeland L, Kentish M, et al (2012) Evaluation of the effects of botulinum toxin A injections when used to improve ease of care and comfort in children with cerebral palsy whom are non-ambulant: a double blind randomized controlled trial *BMC Pediatr* 12: 120.
- Hombergen SP, Huisstede BM, Streur MF, Stam HJ, Slaman J, et al (2012) Impact of cerebral palsy on health-related physical fitness in adults: Systematic review. *Arch Phys Med Rehab* 93(5): 871-881.
- Engel-Yeger B, Jarus T, Anaby D, Law M (2009) Differences in patterns of participation between youths with cerebral palsy and typically developing peers. *Am J Occup Ther* 63(1): 96-104.
- Armand S, Decoulon G, Bonnefoy-Mazure A (2016) Gait analysis in children with cerebral palsy. *EFORT Open Rev* 1: 448-60.
- Pereira EM, Rueda FM, Diego IMA, Cano De La Cuerda R, De Mauro A, et al (2014) Use of virtual reality systems as proprioception method in cerebral palsy: clinical practice guideline. *Neurología* 29(9): 550-559.
- Rathinam C, Mohan V, Peirson J, Skinner J, Nethaji KS, et al. (2018) Effectiveness of virtual reality in the treatment of hand function in children with cerebral palsy: A systematic review. *J Hand Ther* XXX: 1e8
- Snider I, Majnemer A, Darsaklis V (2010) Virtual reality as a therapeutic modality for children with cerebral palsy. *Dev Neurorehab* 13(2): 120-128.
- Brumels KA, Blasius T, Cortright T, Oumedian D, Solberg B (2008) Comparison of efficacy between traditional and video game-based balance programs. *Clin Kinesiol* 62(4): 26-32.
- Shumway Cook A, Woollacott MH (2007) *Motor control: Translating research into clinical practice*. Philadelphia: Lippincott Williams & Wilkins.
- Boroumand S, Hassani Mehraban A (2018) The Effect of Virtual Reality Practice on Postural Control and Balance in Children With Cerebral Palsy: A Single-Subject Study. *Iran Rehab J* 16(4): 413-424.
- Howcroft J, Klejman S, Fehlings D, Wright V, Zabjek K, et al (2012) Active video game play in children with cerebral palsy: Potential for physical activity promotion and rehabilitation therapies. *Arch Phys Med Rehab* 93(8): 1448-1456.
- Ghafar MAA, Abdelraouf OR (2017) Effect of virtual reality versus traditional physical therapy on functional balance in children with Down syndrome: a randomized comparative study. *Int J Physiother Res* 5(3): 2088-2094.
- Li Z, Han XG, Sheng J, Ma SJ (2016) Virtual reality for improving balance in patients after stroke: A systematic review and meta-analysis. *Clin Rehabil* 30(5): 432-440.
- Laufer Y, Dar G, Kodesh E (2014) Does a Wii-based exercise program enhance balance control of independently functioning older adults? A systematic review. *Clin Interv Aging* 23(9): 1803-1813.
- Monge Pereira E, Molina Rueda F, Alguacil Diego IM, Cano De La Cuerda R, De Mauro A, et al. (2014) Use of virtual reality systems as proprioception method in cerebral palsy: clinical practice guideline. *Neurol* 29: 550-559.
- Chen Y, Fanchiang HD, Howard A (2018) Effectiveness of Virtual Reality in Children With Cerebral Palsy: A Systematic Review and Meta-Analysis of Randomized Controlled Trials. *Phys Ther* 98(1): 63-77.
- Pin TW (2019) Effectiveness of interactive computer play on balance and postural control for children with cerebral palsy: A systematic review. *Gait & Posture* 73: 126-139.

23. Rose T, Nam CS, Chen KB (2018) Immersion of virtual reality for rehabilitation-Review. *Applied Ergonomics* 69: 153-161.
24. Reid DT (2002) Benefits of a virtual play rehabilitation environment for children with cerebral palsy on perceptions of self-efficacy: A pilot study. *Pediatr Rehab* 5: 141-148.
25. Tatla SK, Sauve K, Virji-Babul N, Holsti L, Butler C, et al. (2013) Evidence for outcomes of motivational rehabilitation interventions for children and adolescents with cerebral palsy: an American Academy for Cerebral Palsy and Developmental Medicine systematic review. *Dev Med Child Neurol* 55: 593-601.
26. Massetti T, Da Silva TD, Ribeiro DC, Pinheiro Malheiros SR, NicolaiRe AH, et al. (2014) Motor learning through virtual reality in cerebralpalsy—a literature review. *Med Express* 1: 302-306.
27. Aminov A, Rogers JM, Middleton S, Caeyenberghs K, Wilson PH (2018) What do randomized controlled trials say about virtual rehabilitation in stroke? A systematic literature review and meta-analysis of upper-limb and cognitive outcomes. *J Neuro Eng Rehabil* 15(1): 29.
28. Ghai S, Ghai I (2019) Virtual Reality Enhances Gait in Cerebral Palsy: A Training Dose-Response Meta-Analysis. *Front Neuro* 110: 236.
29. Brien M, Sveistrup H (2011) An intensive virtual reality program improves functional balance and mobility of adolescents with cerebral palsy. *Pediatr Phys Ther* 23: 258-266.
30. Jelsma J, Pronk M, Ferguson G, Jelsma-Smit D (2013) The effect of the Nintendo Wii Fit on balance control and gross motor function of children with spastic hemiplegic cerebral palsy. *Dev Neurorehab* 16(1): 27-37.
31. Glegg SM, Tatla SK, Holsti L (2014) The Gesture Tek virtual reality system in rehabilitation: A scoping review. *Disabil Rehabil Assistive Technology* 9(2): 89-111.
32. Levac D, McCormick A, Levin MF, Brien M, Mills R, et al. (2018) Active video gaming for children with cerebral palsy: Does a clinic-based virtual reality component offer an additive benefit? A pilot study. *Phys Occup Ther Pediatr* 38(1): 74-87.
33. Bonnechere B, Omelina L, Jansen B, Van Sint Jan S (2017) Balance improvement after physical therapy training using specially developed serious games for cerebral palsy children Preliminary results. *Disabil Rehabil* 39(4): 403-406.
34. Mills R, Levac D, Sveistrup H (2019) The Effects of a 5-Day Virtual-Reality Based Exercise Program on Kinematics and Postural Muscle Activity in Youth with Cerebral Palsy. *Phys Occup Ther Pediatr* 39(4): 388-403.
35. Meyns P, Harlaar J, van de Pol L, Barkhof F, Buizer A (2017) Can Virtual Reality games improve scores on clinical balance scales in children with cerebral palsy: Preliminary results of a randomized controlled clinical trial. *Gait & Posture* 57: 234-235.
36. Gagliardi C, Turconi AC, Biffi E, Maghini C, Marelli C, et al. (2018) Immersive Virtual Reality to Improve Walking Abilities in Cerebral Palsy: A Pilot Study. *Ann Biomed Engineer* 46(9): 1376-1384.
37. Van Der Krogt MM, Sloot LH, Harlaar J (2014) Overground versus self-paced treadmill walking in a virtual environment in children with cerebral palsy. *Gait & Posture* 40: 587-593.
38. Van Gelder L, Booth AT, van de Port I, Buizer AI, Harlaar I, et al. (2017) Real-time feedback to improve gait in children with cerebral palsy. *Gait & Posture* 52: 76-82.
39. Howard MC (2017) A meta-analysis and systematic literature review of virtual reality rehabilitation programs. *Comput Human Behav* 70: 317-327.