GAMES FOR HEALTH JOURNAL: Research, Development, and Clinical Applications
Volume 8, Number 6, 2019
© Mary Ann Liebert, Inc.
DOI: 10.1089/g4h.2019.0020

Original Article

The Effects of Virtual Reality on Motor Functions and Daily Life Activities in Unilateral Spastic Cerebral Palsy: A Single-Blind Randomized Controlled Trial

Sedef Şahin, PhD,[1] Barkın Köse, MSc,[1] Orkun Tahir Aran, PhD,[1]
Zeynep Bahadır Ağce, PhD,[2] and Hülya Kayıhan, PhD[1]

Abstract

Aim: This study was designed to investigate the effects of virtual reality (VR) through Kinect on both gross and fine motor functions and independence in daily living activities in children with unilateral spastic cerebral palsy (USCP).

Materials and Methods: This study was designed as a single-blind, randomized, controlled trial. Sixty children with USCP were randomized and split equally between the VR intervention group (10 females and 20 males with a mean age of 10.5 ± 3.62 years) and the traditional occupational therapy (TOT) intervention group (13 females and 17 males with a mean age of 10.06 ± 3.24 years). Both groups were evaluated in terms of motor functioning via the Bruininks-Oseretsky Test of Motor Proficiency-Short Form (BOTMP-SF) and were assessed in accordance with independence in daily activities via the WeeFunctional Independence Measure (WeeFIM). Interventions were conducted for 8 weeks with the main objective of improving motor functions and independence in daily activities.

Results: Total motor functions and total independence in daily lives in both groups improved after 8 weeks of intervention. A comparison between groups revealed significantly greater improvements in both gross and fine motor functions and daily activities in the VR group than in the TOT group ($P < 0.001$).

Conclusion: The Kinect-based VR intervention approach is important to improving motor functions and independence in daily activities of children with USCP.

Keywords: Cerebral palsy, Kinect, Virtual reality, Motor proficiency, Activities of daily living

Introduction

Cerebral palsy (CP) is a nonprogressive neurological disorder characterized by a permanent decrease in sensory, cognitive, or, especially, gross and fine motor functions in infancy or early childhood. The prevalence of CP in the world is estimated to be 1.5 to 4 in every 1,000 live births, so it has become one of the most common motor disabilities of childhood.[1] CP is clinically classified as spastic, athetoid, ataxic, and hypotonic, as well as unilateral or bilateral according to extremity involvement, with the most prevalent form being unilateral and spastic CP.[2]

The motor and neurological development of children with CP is affected by various neuromuscular and musculoskeletal disorders. Studies have identified that the severity of motor function limitations is a predictor of problems with mobility, self-care, communication, social interaction, and cognition, all of which affect children's independence in daily living activities.[3,4] Thus, various health professionals who work with children with CP try to enhance their ability to independently perform motor functions and daily living activities.[4] To date, there are no exact intervention methods that can entirely eliminate the effects of CP. Therefore, rehabilitation and medical approaches focus solely on reducing impairments or preserving/enhancing the current functional status of children.[5]

The CP rehabilitation process is an exhausting, extensive process and may cause psychological fatigue. It might have negative effects on children in the form of boredom and decreased motivation to continue the interventions.[5,6] It has also been emphasized that there is a need for supportive rehabilitation methods that will be more fun for children and may be of interest to them.[7]

Virtual reality (VR) was integrated into the rehabilitation field in the 1990s, and it is still in the development process as

---

[1]Department of Occupational Therapy, Hacettepe University Faculty of Health Sciences, Ankara, Turkey.
[2]Department of Occupational Therapy, Üsküdar University Faculty of Health Sciences, Istanbul, Turkey.

an intervention approach for children with CP. Studies that are focused on plasticity have demonstrated that VR is positively associated with active engagement and high motivation during interventions.[8,9] In addition to motivation, VR also enhances neural reorganization, which enhances functional outcomes in children with CP.[9] VR environments provide interaction with life-like items and events for participants. Microsoft Kinect v1.0 (henceforth, to be referred to as Kinect) enables users to control and interact with the game environment through a natural user interface through the use of gestures and without touching any game controller. Furthermore, 3D motion capture and gesture recognition are the most prominent characteristics of Kinect compared to other VR products.[10] Despite the striking advantages of these systems, studies programmed with an external control interface have outnumbered those programmed with complex camera systems.[11–13]

The studies using systems other than Kinect have indicated positive effects on gross motor functions, particularly on balance, in children with CP. However, these studies have underlined the need for a combined analysis of the effects of VR on gross and fine motor functions, which are commonly used in daily living activities.[7] In light of this information, the aim of our study is to investigate via Kinect the effects of VR on children with unilateral spastic cerebral palsy (USCP), particularly the effects on their gross and fine motor functions and independence in daily living activities.

Materials and Methods

This study was designed as a single-blind, randomized, controlled trial of VR on motor functions and daily living activities in children with USCP compared with their usual care. The protocol used in this study was approved by the University Ethics Boards and Commissions (permission number: GO16/290), and written informed consent was obtained from every child and his/her legal guardian.

Participants

The study was conducted at the pediatric clinic of the Department of Occupational Therapy. Children were regarded as eligible if they met the following inclusion criteria: (1) aged between 7 and 16 years, (2) having >24 score of Mini-Mental State Examination for children, (3) having been classified in levels I–II of the Manuel Ability Classification System, (4) having been classified in levels I–III of the Gross Motor Function Classification System, and (5) able to follow and accept verbal instructions. Children were regarded as ineligible if they: (1) had any orthopedic surgery or botulinum toxin injection in the past 6 months, (2) were unwilling to take part or their parents refused to participate, and (3) had participated in another therapy program, such as physiotherapy or speech therapy, during our intervention.

Sixty-six children were found to be eligible, yet, six children subsequently met the exclusion criteria, as they had had a

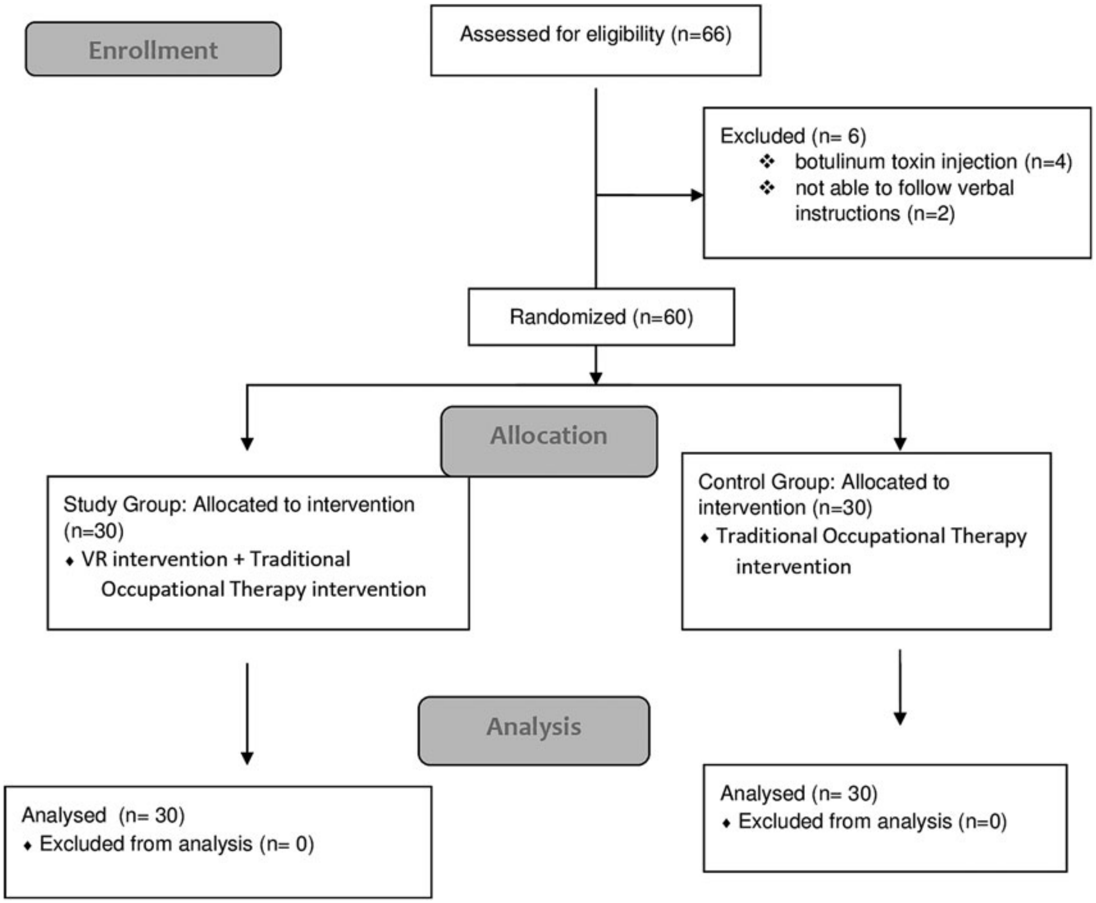

FIG. 1. CONSORT diagram.

botulinum toxin injection in the past 6 months ($n=4$) and were not able to follow verbal instructions ($n=2$). Therefore, 60 children were eventually found to be eligible. They were randomly allocated to either the study group (VR intervention+Traditional Occupational Therapy [TOT] intervention) ($n=30$) or the control group (TOT intervention) ($n=30$) through a simple randomization technique by using sequentially numbered and opaque sealed envelopes. The allocation was performed by the fourth author of this study Fig. 1.

Measurements

Treatments were performed by the second and third authors, while assessments were completed by the first author, who was blind to the group allocation process. The tests described in detail below were applied as preintervention and postintervention tests to both the study and control groups at 8-week intervals. Evaluations were carried out face-to-face with children and without interruption.

The sociodemographic data of the children, including age, gender, hemiplegic extremity, and dominant extremity, were recorded.

The Bruininks-Oseretsky Test of Motor Proficiency-Short Form (BOTMP-SF) was used to measure gross and fine motor functions since it is a standard test of motor proficiency for children aged between 4.5 and 16.5 years. The BOTMP-SF includes 8 subscales that contain 46 items. It consists of three composites, which are gross motor functions, combined gross and fine motor functions, and fine motor functions. Gross motor functions consist of four subtests: running speed and agility, balance, bilateral coordination, and strength. Combined gross motor and fine motor functions are included in the upper-limb coordination subtest. Fine motor functions consist of three subtests: response speed, visual motor control, and upper-limb speed and dexterity. The BOTMP-SF was conducted both before and after the treatment to show the effect of treatment on motor functionality in children.[14] The Turkish validity and reliability of the BOTMP-SF were conducted by Balli in children and resulted in a Cronbach's α value of 0.86–0.87.[15]

The WeeFunctional Independence Measure (WeeFIM) for Children is a valid and reliable test that was selected to determine the level of independence of children in their daily lives. The test includes six subtests: self-care, sphincter control, transfer, locomotion, communication, and social cognition. The maximum score of the test is 126 points, with levels ranging from 7 (complete independence) to 1 (total assistance) on a Likert scale. The Turkish validity and reliability of the WeeFIM in children with CP were conducted by Tur in 2008 and resulted in a Cronbach's α value of 0.91–0.98.[16]

Interventions

When we reviewed the literature on the duration of the VR interventions, researchers stated that an intervention implemented over an 8-week period for a total of 720 minutes of treatment (equal to 16 sessions for 45 minutes) should be enough to result in improvement.[6,17] With this knowledge, we chose to implement the VR intervention in children with USCP over an 8-week period, twice a week, and for a session duration of 45 minutes.

At the end of the 8 weeks, the whole intervention period was an aggregate of 720 minutes. Starting from the first session, each game was allocated equal time and all the games were played during a single session. However, difficulty levels varied according to each child's performance. The VR intervention consisted of five different VR games:

Air challenge. Air challenge is a game whose character skydives and travels through circles and checkpoints. The game requires the participants to move their arms and upper bodies in a standing position to complete tasks for the game. The most important part of the game is that the body movements have to be perceived in the opposite direction by the participant.

Boxing trainer. In this game, participants control two boxing gloves on the screen through the first-person point of view. Participants gain points by throwing punches at determined targets within a certain period.

Wall breaker. The main theme of the game is similar to that of a real-life tennis game. Players compete with another player to break as many parts of a wall as possible. Across the court is a wall that comprised nine square pieces. Participants have to respond within 3 seconds of their shots bouncing from the wall.

Jet run. This is a racing game, in which the avatar is controlled by body movements and jumping. There is a racetrack that consists of a straight road, a switchback, and obstacles. The game requires the participant to use his/her body movements by leaning to the left, right, front or backward, and by jumping to control his/her avatar. While playing the game, a sudden obstacle might occur and the participant has to react immediately to complete the racecourse; hence, this makes timing the most important part of the game.

Super kick. This is a penalty shootout game, which consists of a goalkeeper, a goal post, a soccer field, and defense players. Each goal gives the participant a point. After every penalty shot, the number and location of the defense players change.

The VR intervention room's width, which had a soft floor covered with cushions, was 15 m^2. The system consisted of a television, a Kinect sensor, and a computer. The sensor scanned the planned area (9 m^2) used to play the games in front of a 55-inch TV.

The control group received only the TOT intervention twice a week over a period of 8 weeks. The TOT consisted of neurodevelopmental treatment carried out by the same clinical occupational therapist. The goal of the therapy was to promote the active use of the participant's extremities and to improve his/her activities in daily life. The TOT included activities that were created for both children's motor skills and daily activities, such as dressing, feeding, playing table and ball games, writing, painting, drawing, and doing puzzles. The study group also attended these traditional treatments.

Statistical analysis

Data were analyzed using IBM Statistical Package for the Social Sciences (SPSS) version 22.0. The variables were investigated using visual (plots/histograms) and analytical

Table 1. Demographic Characteristics of the Children

	Study group	*Control group*	P	χ^2
Age (mean ± SD)	10.5 ± 3.62	10.06 ± 3.24	0.759	
Gender (*n*)	10 female 20 male	13 female 17 male	—	0.42
Hemiparetic extremity (*n*)	22 right 8 left	18 right 12 left	—	0.27
Dominant extremity (*n*)	8 right 22 left	12 right 18 left	—	0.27

P, Mann–Whitney *U* test; χ^2, chi-square test.

(Kolmogorov–Smirnov test) methods to determine whether they were normally distributed. Quantitative data are described as mean ± standard deviation ($X \pm$ SD), and qualitative data are described in percentage (%) values. Mann–Whitney *U* and chi-squared tests were used to compare the group members in terms of age, gender, hemiparetic and dominant extremities. A Wilcoxon signed-rank test was used to test the mean differences between the beginning and end of the intervention process. The Mann–Whitney *U* test was used to determine whether the differences and changes between the scores in the study and control groups were statistically significant. Significance was set at an alpha level of 0.05. Cohen's *d* ([mean 1 − mean 2]/standard deviation 1) was used to determine the effect size and magnitude of difference between the assessments; this test estimates effect sizes as small (0.2), medium (0.5), large (0.8), and very large (1.3).[18,19]

Results

This study included 60 children with USCP, divided into 2 groups (study and control) of 30 children. The mean age was 10.5 ± 3.62 years in the study group and 10.06 ± 3.24 years in the control group. Both groups were statistically identical in terms of age, gender, hemiparetic side, and preintervention assessment scores ($P > 0.05$) (Tables 1 and 2).

Total motor function and total independence in daily lives for both groups improved after 8 weeks of intervention ($P < 0.05$) (Table 3). The levels of increase in all subtests in the study group, with the exception of sphincter control, were found to be higher than in the control group ($P < 0.05$) (Table 3). Comparisons between the groups revealed significantly greater improvements in gross and fine motor functions and WeeFIM totals in the study group than in the control group ($P < 0.001$) (Table 3).

Comparisons of the changes over time in motor function and activities of daily living (ADL) within and between the groups, as well as the degrees of impact, are shown in Table 3. Comparing the two groups, the degree of impact on gross, fine, and total motor functions was strong (Cohen's $d > 0.80$), while the degree of impact on some subscales in the BOTMP-SF and WeeFIM was moderate (0.30–0.80).

However, the degrees of impact in the control group were smaller (Cohen's $d < 0.30$) than those in the study group (Table 3). The changes in scores for gross, fine, and total motor functions in the BOTMP-SF were statistically significantly different between groups, as were the total, self-care, and locomotion WeeFIM scores ($P < 0.01$) (Table 4).

Discussion

The purpose of this study was to examine the effect of VR on motor functions and independence in the daily life activities of children with USCP. It was found that VR provides beneficial effects by enhancing motor functions and improving functional status in daily life activities throughout the therapy program. As far as we know, this is the first study that has examined the effects of VR on both motor function and daily life activities of children with USCP.

CP is a chronic neurological disorder that usually impairs children's motor developmental levels and is usually nonprogressive.[20,21] Although the examination of motor

Table 2. Preintervention Group Similarities of Groups in BOTMP-SF and WeeFIM Scores

	Study group *X ± SD*	*Control group* *X ± SD*	P
BOTMP-SF—total score	35.46 ± 20.29	36.36 ± 19.83	0.853
Subtest 1—running speed and agility	4.30 ± 4.64	4.26 ± 4.61	0.951
Subtest 2—balance	6.26 ± 3.62	6.40 ± 3.56	0.812
Subtest 3—bilateral coordination	2.53 ± 2.41	2.63 ± 2.42	0.816
Subtest 4—strength	3.40 ± 2.35	3.50 ± 2.23	0.787
Subtest 5—upper-limb coordination	2.10 ± 2.12	2.26 ± 2.09	0.530
Subtest 6—fine motor functions	6.23 ± 5.21	6.20 ± 5.20	0.988
Subtest 7—visual motor control	8.20 ± 6.60	8.53 ± 6.45	0.817
Subtest 8—upper-limb speed and dexterity	2.43 ± 1.71	2.56 ± 1.73	0.794
Total gross motor functions	16.50 ± 10.60	16.80 ± 10.35	0.801
Total fine motor functions	16.86 ± 11.41	17.30 ± 11.11	0.900
WeeFIM—total score	103.06 ± 15.04	102.56 ± 14.88	0.812
Subtest 1—self-care	26.33 ± 7.33	26.23 ± 7.22	0.929
Subtest 2—sphincter Control	13.80 ± 0.61	13.46 ± 1.16	0.252
Subtest 3—transfer	18.36 ± 3.22	18.03 ± 3.79	0.713
Subtest 4—locomotion	15.25 ± 4.23	15.00 ± 3.75	0.356
Subtest 5—communication	11.76 ± 2.73	11.70 ± 2.70	0.871
Subtest 6—social cognition	17.80 ± 3.60	17.76 ± 3.69	0.934

BOTMP-SF, Bruininks-Oseretsky test of Motor Proficiency Short Form; WeeFIM, WeeFunctional Independence Measurement.

Table 3. Comparison of BOTMP-SF and WeeFIM Scores in the Groups

	Study group				Control group			
	Preintervention	*Postintervention*			*Preintervention*	*Postintervention*		
	$X \pm SD$	$X \pm SD$	P	*Effect size*	$X \pm SD$	$X \pm SD$	P	*Effect size*
BOTMP-SF—total score	35.46 ± 20.29	69.96 ± 34.42	**0.0001****	1.70	36.36 ± 19.83	45.10 ± 18.14	**0.028***	0.44
Subtest 1—running speed and agility	4.30 ± 4.64	6.33 ± 5.26	**0.0001****	0.44	4.26 ± 4.61	5.00 ± 4.18	**0.026***	0.16
Subtest 2—balance	6.26 ± 3.62	7.30 ± 3.32	**0.024***	0.29	6.40 ± 3.56	7.43 ± 2.88	**0.026***	0.29
Subtest 3—bilateral coordination	2.53 ± 2.41	2.83 ± 2.29	**0.024***	0.12	2.63 ± 2.42	3.43 ± 2.32	**0.026***	0.33
Subtest 4—strength	3.40 ± 2.35	5.03 ± 2.57	**0.0001****	0.69	3.50 ± 2.23	4.03 ± 1.93	**0.026***	0.24
Subtest 5—upper-limb coordination	2.10 ± 2.12	3.46 ± 2.22	**0.007****	0.64	2.26 ± 2.09	2.90 ± 2.24	**0.049***	0.31
Subtest 6—fine motor functions	6.23 ± 5.21	7.80 ± 5.96	**0.014***	0.30	6.20 ± 5.20	7.16 ± 4.50	**0.024***	0.18
Subtest 7—visual motor control	8.20 ± 6.60	10.00 ± 6.59	**0.009****	0.27	8.53 ± 6.45	11.73 ± 8.11	**0.027***	0.5
Subtest 8—upper-limb speed and dexterity	2.43 ± 1.71	3.43 ± 2.31	**0.014***	0.58	2.56 ± 1.73	3.43 ± 2.14	**0.028***	0.5
Total gross motor functions	16.50 ± 10.60	31.63 ± 16.21	**0.0001****	1.43	16.80 ± 10.35	19.86 ± 8.32	**0.027***	0.3
Total fine motor functions	16.86 ± 11.41	34.66 ± 20.59	**0.0001****	1.56	17.30 ± 11.11	22.33 ± 11.79	**0.028***	0.45
WeeFIM—total score	103.06 ± 15.04	112.96 ± 10.20	**0.0001****	0.66	102.56 ± 14.88	104.70 ± 13.67	**0.012***	0.14
Subtest 1—self-care	26.33 ± 7.33	30.46 ± 5.27	**0.0001****	0.56	26.23 ± 7.22	26.86 ± 6.68	0.102	0.09
Subtest 2—sphincter control	13.80 ± 0.61	14.00 ± 0.45	0.063	0.33	13.46 ± 1.16	13.66 ± 0.92	0.083	0.17
Subtest 3—transfer	18.36 ± 3.22	19.00 ± 3.97	**0.006****	0.2	18.03 ± 3.79	18.53 ± 3.22	0.180	0.13
Subtest 4—locomotion	15.25 ± 4.23	16.86 ± 3.15	**0.006****	0.38	15.00 ± 3.75	15.60 ± 3.66	0.102	0.16
Subtest 5—communication	11.76 ± 2.73	12.96 ± 2.10	**0.014***	0.44	11.70 ± 2.70	11.96 ± 2.49	0.109	0.1
Subtest 6—social cognition	17.80 ± 3.60	19.00 ± 2.88	**0.004****	0.33	17.76 ± 3.69	18.06 ± 3.50	0.109	0.08

*$P < 0.05$; **$P < 0.01$.

Table 4. BOTMP-SF and WeeFIM Changes and Comparisons Between Groups

	Study group	*Control group*	
	X ± *SD*	*X* ± *SD*	P
BOTMP-SF—total score	34.50 ± 15.71	8.73 ± 19.77	**0.0001****
Subtest 1—running speed and agility	2.03 ± 1.12	0.73 ± 1.55	**0.0001****
Subtest 2—balance	1.03 ± 1.18	1.03 ± 2.32	**0.045***
Subtest 3—bilateral coordination	0.30 ± 0.65	0.80 ± 1.78	0.751
Subtest 4—strength	1.63 ± 2.09	0.53 ± 1.16	**0.0001****
Subtest 5—upper-limb coordination	1.36 ± 2.96	0.90 ± 1.76	0.052
Subtest 6—fine motor functions	1.56 ± 3.14	0.96 ± 2.14	0.095
Subtest 7—visual motor control	1.80 ± 3.10	3.2 ± 7.26	0.17
Subtest 8—upper-limb speed and dexterity	1.00 ± 2.24	0.86 ± 2.06	0.26
Total gross motor functions	15.13 ± 6.75	3.06 ± 6.83	**0.0001****
Total fine motor functions	17.80 ± 11.39	5.03 ± 11.36	**0.0001****
WeeFIM—total score	9.90 ± 10.02	2.13 ± 5.89	**0.0001****
Subtest 1—self-care	4.13 ± 4.24	0.20 ± 0.61	**0.0001****
Subtest 2—sphincter control	0.20 ± 0.55	0.63 ± 2.02	0.75
Subtest 3—transfer	1.30 ± 2.35	0.16 ± 0.74	**0.013***
Subtest 4—locomotion	1.86 ± 2.96	0.60 ± 2.04	**0.008****
Subtest 5—communication	1.20 ± 2.65	0.26 ± 0.98	0.28
Subtest 6—social cognition	1.20 ± 1.93	0.20 ± 0.55	**0.024***

*$P < 0.05$; **$P < 0.01$.

proficiency in children with CP and associated treatment approaches is quite old, the number of studies investigating fine motor functions is still small compared to those studying gross motor functions.[22,23] Motor-based rehabilitation treatments for children with CP worldwide adopt the neurodevelopmental approach. TOT interventions also adopt this approach, but focus during the rehabilitation on the development of motor functions through daily activities that the child finds meaningful and purposeful. In a systematic review by Lucas et al., it was shown that 12-session task-oriented interventions are the best practice for improving children's motor performance. Moreover, it was demonstrated that traditional therapy approaches (at least 6 weeks) applied to children were very beneficial for motor function.[24] Our study showed that 8-week TOT interventions, which formed the basis of our approach, provided gains in both motor function and daily life activities in the two groups.

As rehabilitation interventions extend over a long period of time, the monotony may become boring for children. Motivation is an important factor in the CP rehabilitation process because it often takes a long time to reach the desired functional level.[22] Advanced technology provides the opportunity for professionals to motivate children in the rehabilitation process with the enjoyable nature of games, thereby allowing critical, objective data to be collected.[25] In the rehabilitation process, with the goal of increasing functional independence in everyday activities, VR provides opportunities for repeated practice and positive feedback from motor performance.[26] In our study, the improvement in motor function and daily living activities in the VR intervention group was significantly larger than in the control group.

Gross motor impairments, such as balance, coordination, and strength, are common negative outcomes of preterm births, with CP the most severe form.[20] Tarakci et al. showed that an external control interface system (Nintendo Wii) had positive effects on the balance development of children with CP.[22] Studies using complex camera systems, such as Kinect, have also shown that there is often an improvement in balance in children with CP.[23,27] Our study has shown that there was a statistically significant improvement with a Kinect VR intervention in children, not only in terms of balance but also in other gross motor functions, such as running speed and agility, bilateral coordination, and strength. In the CP rehabilitation process, it is known that enhancing these functions is an important goal; thus, we recommend that clinicians add VR as a supportive intervention method in the routine treatment of children.

We observed improvements in the children's fine motor functions, such as upper extremity coordination, response speed, visual motor control, speed, and dexterity. The possible reason for this is that the selected VR games may include repetitive movements that require sequential velocity, coordination, and visual tracking. However, one of the games required participants to coordinate their wrist and elbow movements to hit blocks that suddenly appeared on the screen. The activation of these joints can be particularly difficult for children with USCP because their upper limbs have a flexion-pronation pattern. Thus, constant repetition of the movement, associated with the visual feedback of the video game and the therapist's verbal commands, enabled children to analyze and correct their movement errors during the game, which was reflected in their fine motor coordination.

Chen et al. suggested that, by repeatedly practicing VR games, children improved eye–hand coordination as reflected in their scores on visual motor skills, which is one of the fine motor functions.[28] In the systematic review addressing children with bilateral CP, the development of the use of hands in children is one of the most challenging issues in the rehabilitation process.[29] To develop hand functions, it is stated that treatment methods that are applied alone (e.g., physiotherapy, occupational therapy, robot therapy) are insufficient. Improving the use and function of hands, which is an indispensable part of one's daily life, is very important for the effectiveness of treatment. Our study results indicate that TOT intervention applied alone had a positive effect on fine motor functions. However, when TOT was applied with VR, the changes in children's fine motor functions were higher. None of the preferred games was intended to develop directly affect fine motor functions in our study. Nevertheless, our results are promising and suggest that VR should be used in treatment approaches.

For children with USCP to achieve independence in daily life activities, they must have effective use of the upper and lower limbs. Many researchers have investigated the effectiveness of neurodevelopmental approaches in daily life activities.[30] Research has shown that increasing the motor functionality of children with CP in traditional therapy interventions can improve their level of independence in daily activities.[31] However, some studies have suggested that VR practice may indirectly affect daily life activities.[32,33] Therefore, there is insufficient evidence available that indicate using VR in clinical practices. In these studies, researchers have underlined the need for randomized studies to draw conclusive results about the effectiveness of these interventions.[27] Our study has made a significant contribution to this field, and it has shown that the use of VR has dramatically improved children's motor functions as well as their level of independence in daily activities. The extent of improvement in independence levels in daily life activity requirements, such as self-care, transfer, locomotion, communication, and social cognition, is especially important in rehabilitation approaches. To achieve this important aim, children can be more motivated with VR to participate in the rehabilitation process to improve their independence in activities.

The primary limitation of our study is that the VR games we used do not contain daily life activities and are not suitable for direct training. The other limitation is that we used only five of the myriad VR game options on the market. Future studies could potentially increase the effectiveness of the intervention by selecting different games designed to improve fine motor functions. Therefore, more randomized studies using different VR intervention methods (e.g., Kinect, Nintendo Wii) and/or different games directed to fine motor functions are needed.

Conclusion

In conclusion, this study demonstrated that a Kinect-based VR intervention has the potential to improve both the motor functions of children with USCP and their ability to perform in daily activities. Our study emphasizes the need to use VR interventions, which is one of the most motivating rehabilitation approaches in treatment or development of these functions.

Author Disclosure Statement

No competing financial interests exist.

References

1. Anttila H, Autti-Rämö I, Suoranta J, et al. Effectiveness of physical therapy interventions for children with cerebral palsy: A systematic review. BMC Pediatr 2008; 8:14.
2. Galli M, Cimolin V, Rigoldi C, et al. Gait patterns in hemiplegic children with cerebral palsy: Comparison of right and left hemiplegia. Res Dev Disabil 2010; 31:1340–1345.
3. Wagner JM, Lang CE, Sahrmann SA, et al. Sensorimotor impairments and reaching performance in subjects with poststroke hemiparesis during the first few months of recovery. Phys Ther 2007; 87:751–765.
4. Shaughnessy M, Resnick BM, Macko RF. Testing a model of post-stroke exercise behavior. Rehabil Nurs 2006; 31:15–21.
5. Weiss PL, Tirosh E, Fehlings D. Role of virtual reality for cerebral palsy management. J Child Neurol 2014; 29:1119–1124.
6. Ravi D, Kumar N, Singhi P. Effectiveness of virtual reality rehabilitation for children and adolescents with cerebral palsy: An updated evidence-based systematic review. Physiotherapy 2017; 103:245–258.
7. Snider L, Majnemer A, Darsaklis V. Virtual reality as a therapeutic modality for children with cerebral palsy. Dev Neurorehabil 2010; 13:120–128.
8. Parsons TD, Rizzo AA, Rogers S, et al. Virtual reality in paediatric rehabilitation: A review. Dev Neurorehabil 2009; 12:224–238.
9. Weiss PL, Rand D, Katz N, et al. Video capture virtual reality as a flexible and effective rehabilitation tool. J Neuroeng Rehabil 2004; 1:12.
10. Mousavi Hondori H, Khademi M. A review on technical and clinical impact of microsoft kinect on physical therapy and rehabilitation. J Med Eng 2014; 2014:846514.
11. Tanaka K, Parker J, Baradoy G, et al. A comparison of exergaming interfaces for use in rehabilitation programs and research. Loading 2012; 6:69–81.
12. Lee JC. Hacking the Nintendo Wii remote. IEEE Pervas Comput 2008; 7:39–45.
13. Garcia J, Zalevsky Z, Garcia-Martinez P, et al., editors. Projection of speckle patterns for 3D sensing. Journal of Physics: Conference Series; 2008. IOP Publishing.
14. Köse B. Validity, Reliability and Turkish Adaptation of Bruininks-Oseretsky Test of Motor Proficiency Second Edition Brief Form in Children with Specific Learning Disability, Hacettepe University Graduate School of Health Sciences, Occupational Therapy Master's Dissertation, Ankara, 2018.
15. Balli ÖM, Gürsoy F. The Study of Validity and Reliability of Bruininks-Oseretsky Motor Proficiency Test for Five-Six Years Old Turkish Children Hacettepe J. of Sport Sciences 2012; 23(3):104–118.
16. Tur BS, Küçükdeveci AA, Kutlay Ş, et al. Psychometric properties of the WeeFIM in children with cerebral palsy in Turkey. Dev Med Child Neurol 2009; 51:732–738.
17. Palisano RJ, Begnoche DM, Chiarello LA, et al. Amount and focus of physical therapy and occupational therapy for young children with cerebral palsy. Phys Occup Ther Pediatr 2012; 32:368–382.
18. Ferguson CJ. An effect size primer: A guide for clinicians and researchers. Prof Psychol Res Pract 2009; 40:532.
19. Sullivan GM, Feinn R. Using effect size—Or why the P value is not enough. J Grad Med Educ 2012; 4:279–282.
20. Williams J, Lee KJ, Anderson PJ. Prevalence of motor-skill impairment in preterm children who do not develop cerebral palsy: A systematic review. Dev Med Child Neurol 2010; 52:232–237.
21. Arnould C, Bleyenheuft Y, Thonnard J-L. Hand functioning in children with cerebral palsy. Front Neurol 2014; 5:48.
22. Tarakci D, Ersoz Huseyinsinoglu B, Tarakci E, et al. Effects of Nintendo Wii-Fit® video games on balance in children with mild cerebral palsy. Pediatr Int 2016; 58:1042–1050.

23. Brien M, Sveistrup H. An intensive virtual reality program improves functional balance and mobility of adolescents with cerebral palsy. Pediatr Phys Ther 2011; 23:258–266.
24. Lucas BR, Elliott EJ, Coggan S, et al. Interventions to improve gross motor performance in children with neurodevelopmental disorders: A meta-analysis. BMC Pediatr 2016; 16:193.
25. Harris K, Reid D. The influence of virtual reality play on children's motivation. Can J Occup Ther 2005; 72:21–29.
26. Golomb MR, McDonald BC, Warden SJ, et al. In-home virtual reality videogame telerehabilitation in adolescents with hemiplegic cerebral palsy. Arch Phys Med Rehabil 2010; 91:1–8.e1.
27. Pavão SL, Arnoni JL, de Oliveira AK, et al. Impact of a virtual reality-based intervention on motor performance and balance of a child with cerebral palsy: a case study. Rev Paul Pediatr 2014; 32:389–394.
28. Chen Y-P, Kang L-J, Chuang T-Y, et al. Use of virtual reality to improve upper-extremity control in children with cerebral palsy: A single-subject design. Phys Ther 2007; 87:1441–1457.
29. Plasschaert VF, Vriezekolk JE, Aarts PB, et al. Interventions to improve upper limb function for children with bilateral cerebral palsy: A systematic review. Dev Med Child Neurol 2019; 61(8):899–907.
30. Gordon AM, Charles J, Wolf SL. Methods of constraint-induced movement therapy for children with hemiplegic cerebral palsy: Development of a child-friendly intervention for improving upper-extremity function. Arch Phys Med Rehabil 2005; 86:837–844.
31. Østensjø S, Carlberg EB, Vøllestad NK. Motor impairments in young children with cerebral palsy: Relationship to gross motor function and everyday activities. Dev Med Child Neurol 2004; 46:580–589.
32. Aran OT, Şahin S, Torpil B, et al. Virtual Reality and Occupational Therapy. Occupational Therapy-Occupation Focused Holistic Practice in Rehabilitation: InTech. 2017.
33. Bryanton C, Bosse J, Brien M, et al. Feasibility, motivation, and selective motor control: Virtual reality compared to conventional home exercise in children with cerebral palsy. Cyberpsychol Behav 2006; 9:123–128.

Address correspondence to:
Orkun Tahir Aran, PhD
Ergoterapi Bölümü
Hacettepe Universitesi Sağlık Bilimleri Fakültesi
Ankara 06100
Turkiye

E-mail: orkunaran@gmail.com