RESEARCH ARTICLE

AUGMENTED EFFECTS OF SENSORY INTEGRATION THERAPY AND VIRTUAL REALITY ON MOVEMENT AND BALANCE ISSUES IN CEREBRAL PALSY: A PILOT STUDY

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ABSTRACT

Background: Cerebral Palsy (CP) causes many sensory and motor deficits in children which may lead to deterioration of their functional activities and daily life. Effective interventions are required to be worked on, which can improve the movement status of such subjects. **Objective:** To determine the effects of sensory integration therapy (SIT) in addition with virtual reality (VR) and Conventional Physical Therapy in subjects with cerebral palsy. **Methods:** A Pilot randomized control trial (RCT) was conducted at Pakistan Railway Hospital Rawalpindi from July to December 2019. The n=26 subjects were recruited after fulfilment of inclusion criteria; male and female diagnosed spastic CP subjects, with age 5-12 years, gross motor function classification system (GMFC) level I-II, can independently walk ≥ 5 meters, spasticity of lower limb <3 on Modified Ashworth Scale (MAS), able to understand commands and play games. The subjects were randomly divided into group A, receiving sensory integration therapy (SIT) in addition to virtual reality (VR) and conventional physical therapy CPT), while group B received only virtual reality (VR) and conventional physical therapy CPT). The interventions were given for 6 weeks with assessments at baseline, 3[rd] and 6[th] weeks. The outcome measures were gross motor function measurement (GMFM) for assessment of gross motor functions, pediatric balance scale (PBS) for assessment of balance in children and 2-minute walk test (2MWT) for mobility. The analysis was done via SPSS 21 and ANOVA test was applied. **Results:** The mean age of the study participants was 7.52±2.25 years. The balance Scale and 2-minute walk test showed significant interaction (p<0.001) between intervention and time. Between group analyses done by one way ANOVA, the assessment at 3rd and 6 weeks has shown significant difference (p<0.001) for GMFM standing, walking/running and total along with PBS and 2 MWT. **Conclusion:** Augmentation of sensory integration therapy with virtual reality has significant effects on improving gross motor functions, balance and mobility in cerebral palsy as compared to virtual reality.

Keywords: Balance, cerebral palsy, gross motor functions, virtual reality, sensory integration therapy

INTRODUCTION

Cerebral palsy (CP) is a non-progressive neurodevelopmental disorder that occurs due to trauma or injury to the brain while its development has not been completed. It affects 2-3 children out of 1000 live births[1, 2]. CP is not merely a disease but a clinical syndrome in which the expression and presentation changes with the passage of time as the brain matures. CP syndrome can be recognized by the age of 3-5 years, but signs can be detected in early months that can lead towards the diagnosis[1,3]. The causes of CP can vary from prenatal to postnatal[4, 5].

The major implication is motor dysfunction along with other complications which including perceptual, sensory, behavioural, communication and cognitive issues[4]. There are three major CP syndromes recognized; spastic, ataxic and dyskinetic. CP affected children usually suffer hypotonic syndrome earlier in life, which take form of spastic, ataxic or dyskinetic later. Spastic CP is the most common among all CP syndromes. Spastic CP patients have the typical features of upper motor neuron lesion; spasticity, exaggerated reflexes and extensor plantar responses[6,7]. These children usually lack fine and specific movements and have to put extra effort to perform the voluntary actions. Spastic CP has further three types diplegia, hemiplegia and quadriplegia[8].

Diplegic CP is the most common syndrome and affected children suffer from muscle weakness, poor balance and coordination, lack of postural control which lead to abnormal movement patterns which reduces the performance and enhances the energy costs[9, 10]. Physical therapy interventions have vital role in the reducing the intensity and progression of complications in CP. Sensory integration is one of the techniques which is being used in CP to increase their orientation and contact with environment and the received stimuli and perform body movements and functions effectively[11].

About 45% of CP children have loss of white matter which result in various sensory abnormalities, which can affect the development of thalamus and cortical areas which are responsible for processing of sensory information and thus can result in sensory integration dysfunction (DIS)[11, 12]. Sensory integration therapy (SIT) can reduce these issues and help in improving balance, coordination and movement control[11].

Virtual reality (VR) has also been explored as an effective mode of improving motor functions among CP children. It provides simulations to interact in a virtual environment which is similar to real world scenarios[13]. So the child can engage in performing different tasks which improve its overall functional ability. Instant visual and auditory feedback can further enhance the performance of the subject in any task. VR has been reported to improve mobility, ambulation, postural control; standing balance and upper limb function in CP. Lower limb functions, muscle strength, gross motor functions and gait have also been found to have positive effects after VR[14, 15].

The study targeted the combined effect of VR and SIT, as they both target the sensory processing pathways and improves performance of the subject within the environment. The combination therapy can provide augmented positive effects on gross motor and lower limb functions along with the interaction effect of VR with and without SIT.

METHODOLOGY

A single blinded pilot randomized clinical trial conducted in Railway General Hospital Rawalpindi and National Institute of Rehabilitation Medicine Islamabad from July to December 2019 after the approval from Research and Ethical Committee (REC) of Faculty of Rehabilitation & Allied Health Sciences with reference number RIPHAH/RCRS/REC/Letter-00557. The sample size was calculated through Open Epi- tool version 3 with a 95 % confidence interval (CI), and power of 80%[13]. The inclusion criteria was the subject with spastic diplegic CP of either gender with age 5-12 years, gross motor function classification system (GMFC) level I-II, can independently walk ≥ 5 meters, spasticity of lower limb <3 on Modified Ashworth Scale (MAS), able to understand commands and play games. Subjects with visual, hearing and cognitive impairments, chronic illness and any systemic disease or previous surgeries were excluded from the study. Initially n=38 subjects were screened and n=26 were recruited for the study. The n=26 subjects were randomly divided into group A (n=13) and control group B (n=13) by concealed envelope method. (Figure 1).

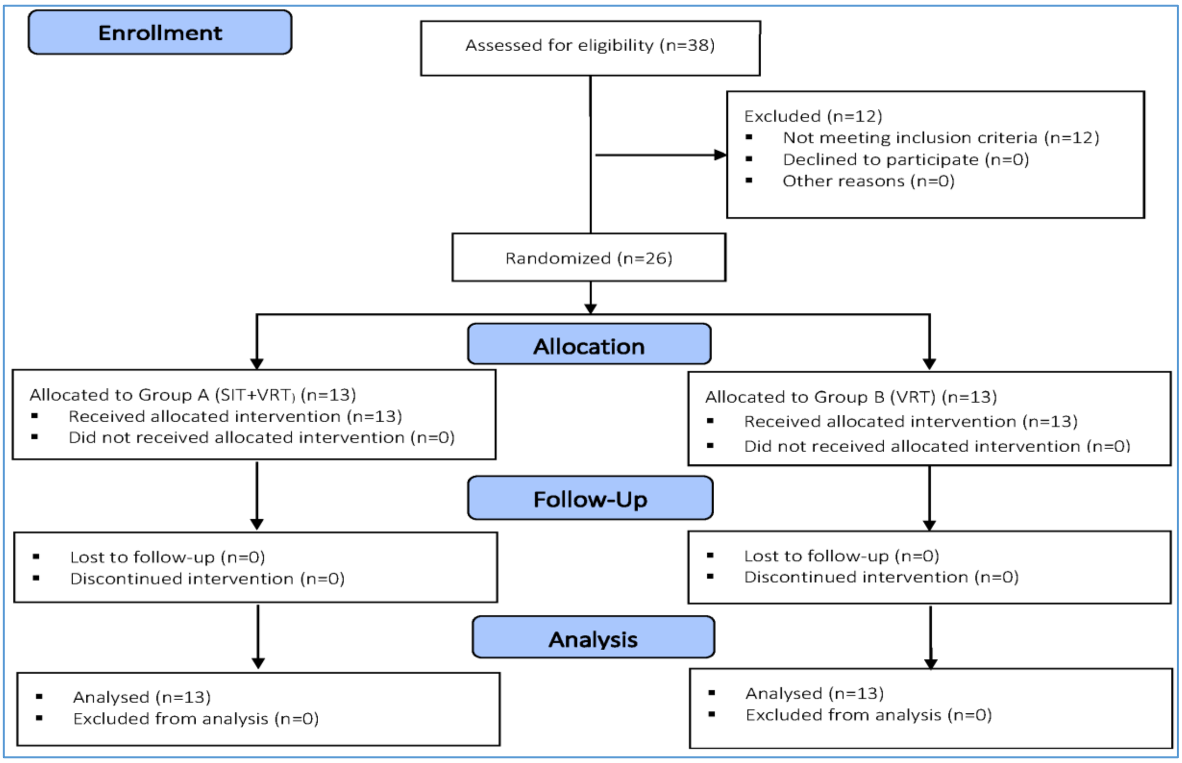

Figure 1: CONSORT Flow Diagram

The written informed consent was taken from the parents before starting the data collection. The group A received Virtual reality training (VRT) included The Your Shape: Fitness Evolved (walking and walking with obstacles), Coconut Shooters VR, Ninja flip VR. Each game was played for 5 minutes. As well as The both the conventional physical therapy (CPT) exercises included passive stretching exercises for the hip flexors and adductors, hamstring and calf muscle while strengthening of abdominal, back, hip, knee, and ankle muscles. Stretching was sustained for 30seconds with 30seconds rest for each muscle group within pain limit. Strengthening of abdominal and back muscles, hip abductors, knee extensors ankle dorsiflexors were performed with 3 sets of 10 repetitions in each set and 2-minute interval between each set.

The group B Received only Sensory integration training (SIT) in addition to VRT and CPT, included exercises on Both sides up (BOSU) ball and mini trampoline. The activities included passive bouncing with child standing with his/her feet shoulder width apart for 2.5 and 2.5 minutes on both sides and active bouncing (the child bounces and therapist controlled the rate) for 2.5 and 2.5 minutes on each side. Mini-squat exercises with feet apart and feet together was given for 2.5 minutes on each side.

The protocol was given in 3 sessions per week for 6 weeks (18 sessions). The outcome measures used were Gross motor Function measure (GMFM) for gross motor function assessment and Pediatric Balance Scale (PBS) for assessment of balance in CP children, and 2-Minute walk test (2MWT) for mobility[13,16]. The assessment was made at baseline and at 3rd week and after completion of 6 weeks of intervention. There was normal distribution of data as well as homogeneity of variances, which was assessed by levene's test (p>.05) for GMFM, 2MWTand PBS. Equality of covariance was assessed by Box's M which also showed homogeneity (p >.05) for GMFM, 2MWTand PBS. Mauchly's test of indicated sphericity assumption was met for GMFM, 2-MWTand PBS for two-way interaction with p>.05. so, the determine the difference in the group, mixed ANOVA was used. The data analysis was done via SPSS 21.

RESULTS

The mean age of the study participants was 7.52±2.25 years with 7.75±2.22 for control and 7.27±2.28 for experimental group. The MAS and GMFM are described in table 1.

Table 1: Demographics

Variable	Level	Percentage	Group A (SIT+VRT)	Group B (VRT)
MAS	I	15.4%	27.3%	8.3%
	I+	50.0%	54.5%	58.3%
	II	23.1%	18.2%	33.3%
GMFM	I	16.4%	5%	8.3%
	II	84.6%	95%	91.7%

(MAS: Modified Ashworth Scale, GMFM: Gross Motor Function Measurement)

As the sphericity was assumed, the Greenhouse-Geisser values showed that there is significant interaction effect between interventions and time factor/assessment in all domains for GMFM standing {F= 148.3(1,21), p<0.001, ηp^2=.876}, GMFM walking {F=47.98(1,21), p<0.001, ηp^2=.696}, GMFM total {F=182.04(1,21), p<0.001, ηp^2=.897}, Pediatric Balance Scale {F=130.98(1,21) p<0.001, ηp^2=..868} and 2 minute walk test {F=33.32(1,21), p<0.001, ηp^2=.613}. (Figure 2)

With-in group analysis, all the domains including GMFM standing, walking and total score as well as pediadric balance scale and 2MWT, showed significant improvement in both (VRT) group and (SIT) in addition to VRT group throughout the treatment duration (*p<0.001*) with large effect size till the end of six-week intervention. (Table 2). Between group analyses done by one way ANOVA is explained in detail in table 4. Mid (at 3 weeks) and post assessment (at 6 weeks) has been found to be significant for GMFM standing, walking/running and total along with PBS and 2 MWT. (Table 3)

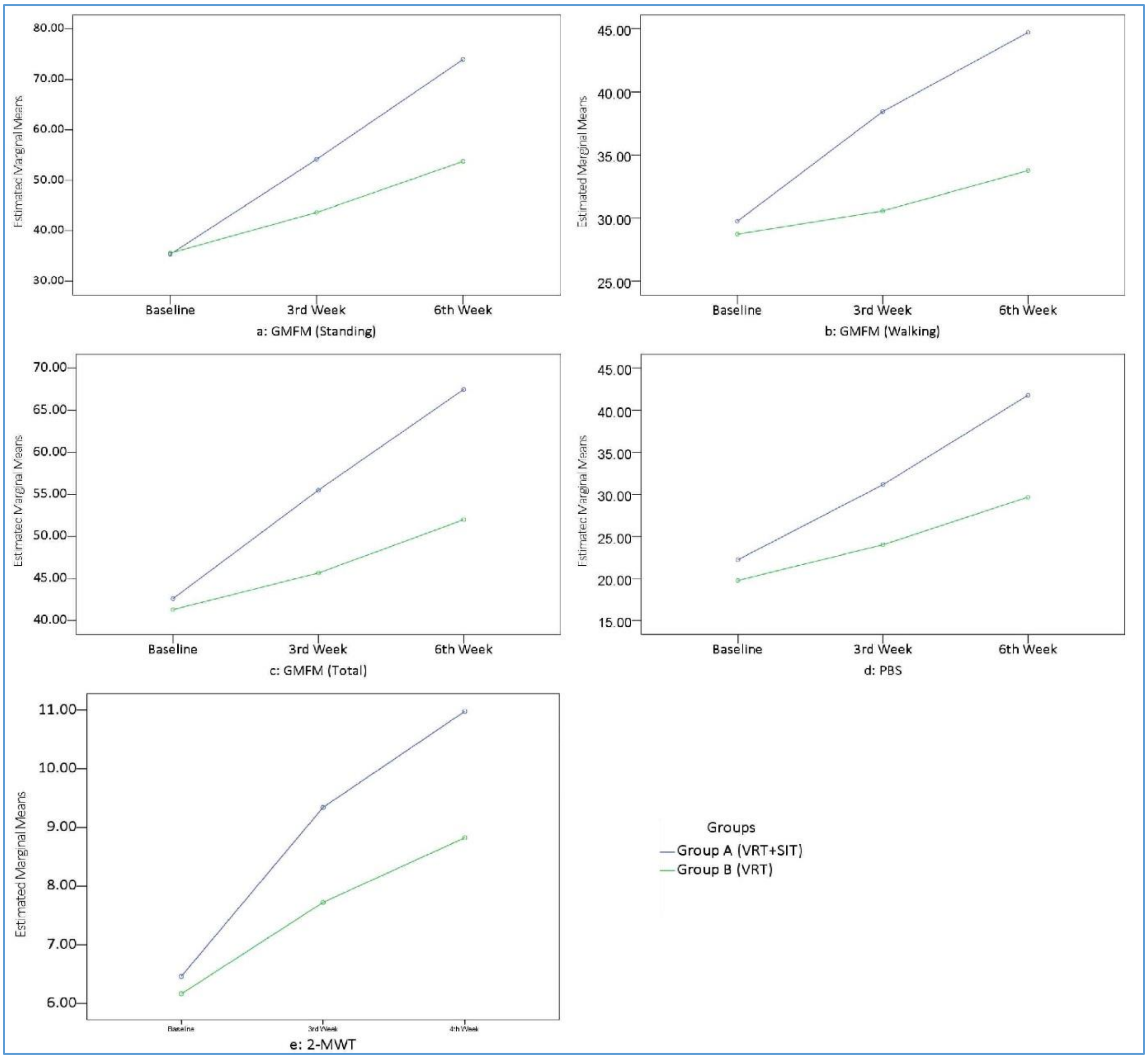

Figure 2: Interaction effect between intervention and level of assessment.

Table 2: With-in group (Main effects) changes in both groups

		Group A (SIT+VRT)				Group B (VRT)			
		Mean±SD	MD/ F(df)	*p-value*	ηp2	Mean±SD	MD/ F(df)	*p-value*	ηp2
GMFM standing	Baseline	35.37±2.31	-18.85	[a]0.00***		35.56±1.97	-8.17	[a]0.00***	
	3rd week	54.23±1.84	-20.27	[b]0.00***	0.993	43.76±1.89	-10.20	[b]0.00***	.988
	6th week	74.50±4.88	688(2,10)	[c]0.00***		53.94±1.66	370(2,9)	[c]0.00***	
GMFM walking	Baseline	29.99±2.73	-8.38	[a]0.00***		28.97±2.82	-1.84	[a]0.00***	
	3rd week	38.37±2.16	-6.25	[b]0.00***	0.984	30.81±2.52	-3.21	[b]0.00***	.931
	6th week	44.63±1.56	308(2,10)	[c]0.00***		34.03±2.45	61.16(2,9)	[c]0.00***	
GMFM total	Baseline	42.55±1.56	-12.83	[a]0.00***		41.51±1.80	-4.37	[a]0.00***	
	3rd week	55.39±1.37	-12.24	[b]0.00***	.997	45.89±2.57	-6.11	[b]0.00***	.981
	6th week	57.63±1.66	1645(2,10)	[c]0.00***		52.00±1.39	227(2,9)	[c]0.00***	
PBS	Baseline	20.83±2.16	-9.41	[a]0.00***		19.81±1.40	-4.36	[a]0.00***	
	3rd week	31.25±2.66	-9-97	[b]0.00***	.984	24.18±1.40	-5.72	[b]0.00***	.975
	6th week	41.18±1.40	315.27(2,10)	[c]0.00***		29.90±1.75	176.11(2,9)	[c]0.00***	
2MWT	Baseline	6.45±0.57	-2.95	[a]0.00***		6.20±0.62	-1.58	[a]0.00***	
	3rd week	9.38±0.55	-1.63	[b]0.00***	.995	7.79±0.70	-1.09	[b]0.00***	.994
	6th week	11.01±0.47	947(2,10)	[c]0.00***		8.88±0.48	767(2,9)	[c]0.00***	

MAS: Modified Ashworth Scale, GMFM: Gross Motor Function Measurement, PBS: Pediatric balance scale, 2-MWT: 2 minute walk test)

[a]Baseline to 3rd week, [b]3rd week to 6th week & [c]baseline to 6th week

Significance Level: p<0.05, p<0.01**, p<0.001****

Table 3: One way ANOVA for between group analysis at three different points

Variable		Group A (SIT+VRT) Mean±SD	Group B (VRT) Mean±SD	F(df)	p-value	ηp^2
GMFM standing	Baseline	35.37±2.31	35.56±1.97	0.04(1,21)	0.83	0.009
	3rd week	54.23±1.84	43.76±1.89	181.29(1,21)	<0.001***	0.891
	6th week	74.50±4.88	53.94±1.66	175.51(1,21)	<0.001***	0.891
GMFM walking	Baseline	29.99±2.73	28.97±2.82	0.77(1,21)	0.39	0.035
	3rd week	38.37±2.16	30.81±2.52	59.73(1,21)	<0.001***	0.739
	6th week	44.63±1.56	34.03±2.45	154.90(1,21)	<0.001***	0.880
GMFM total	Baseline	42.55±1.56	41.51±1.80	2.17(1,21)	0.15	0.113
	3rd week	55.39±1.37	45.89±2.57	124.78(1,21)	<0.001***	0.855
	6th week	57.63±1.66	52.00±1.39	590.13(1,21)	<0.001***	0.965
PBS	Baseline	20.83±2.16	19.81±1.40	7.49(1,21)	0.12	0.263
	3rd week	31.25±2.66	24.18±1.40	61.51(1,21)	<0.001***	0.745
	6th week	41.18±1.40	29.90±1.75	276.54(1,21)	<0.001***	0.929
2MWT	Baseline	6.45±0.57	6.20±0.62	0.99(1,21)	0.32	0.045
	3rd week	9.38±0.55	7.79±0.70	36.88(1,21)	<0.001***	0.637
	6th week	11.01±0.47	8.88±0.48	112.72(1,21)	<0.001***	0.842

MAS: Modified Ashworth Scale, GMFM: Gross Motor Function Measurement, PBS: Pediatric balance scale, 2-MWT: 2-minute walk test)
Significance Level: p<0.05, p<0.01**, p<0.001****

DISCUSSION

The objective of the study was to determine the effects of sensory integration therapy (SIT) in addition with virtual reality (VR) and Conventional Physical Therapy in subjects with cerebral palsy (CP). The results showed that the interaction effects of intervention and level of assessment showed significant difference between interventions at each level of assessment till 6th week. A systematic review by Yuping Chen on the effectiveness of VR a, showed that VR was found to be effective in improving motor functions than other physical therapy approaches used for CP. [13] A study included GMFM and pediatric balance scale as major outcomes[13].

The VR targets different personal and environmental barriers in CP subjects which help them in improving their mobility. According to motor learning perspective there is need for hundreds of repetitions of a certain functional task per day, which will ultimately cause a structural change. So Using VR based games exactly targets this principle where a certain task or a game can be repeated again and again along with increasing the interest of the user. Combining it with SIT incorporates the sensory component to it making it and impactful choice for movement disorders like CP. The user not only performs the motor task but also gets involved cognitively by problem solving and decision making while playing specific games.

The Gagliardi et al studied the effects of VR on gait and walking ability in CP. it was concluded that the positive impact of VR on walking abilities by significant improvements in GMFM and 6 minute walk test[16]. The current study has also similar results in terms of Pre and post analyses on the control group which was provided with VR. The GMFM and 2MWT shoed improvements highlighting the significance of VR in CP. Although the Gagliardi has used immersive VR where the type of VR here in this study is non-immersive.

The Mahaseth and Olfatian have found the significant effects of SIT in CP subjects as compared to conventional therapy[11,17]. Mahaseth et al have combined the VR with conventional therapy and found promising effects as compared to conventional therapy alone[11]. So using the combinations of interventions in CP has been always an option in order to augment the outcomes. This study also considered combining the SIT and VR in order to gain the augmented effects, and the results obtained are in favor of using combination.

According to Rajesh Padnani SIT makes the CP subject make sense of their movement patterns and hence gives encouraging results in improving their overall motor function and reducing the spasticity[18]. The same effects can be seen in current study as well. Although the combined effects have not been observed in this study, which could be considered as limitation here.

As Durga Prasad suggest that the sensory processing abilities in CP are related to functional mobility. CP children have difficulties in performing different functions not just because of bad postural control or abnormal tone but also due to issues in sensory processing[19]. So if we keep this key principle in and target the sensory processing along with motor aspects then functional outcomes can be gained and improved.

The less social participation and limited opportunities can further limit the active mobility of CP children, which needs the attention to be worked on in future.

CONCLUSION

There are promising effects of augmentation of sensory integration therapy with virtual reality on improving gross motor functions, balance and mobility in cerebral palsy as compared to virtual reality. Further work can be done to look for the psychological impacts of such physical activities in such population.

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