Evaluation of Horse Riding Simulator with Strengthening Training Program and Conventional Physiotherapy in treatment of Children with Spastic Diplegic Cerebral Palsy

Hossein Bagheri (MBChB, FICMS)[1], **Olyaei Gholmreza** (BChB, FICMS)[2] , **Raed Farooq Khaleel** (MBChB)[3], **Hadian Mohammad**(PhD)[4] , **Shohreh Jalaie1**(PhD)[5] **and Abdulkareem S. Diab (** PhD)[6]

Abstract

Background: Cerebral Palsy is a group of disorders that affect the development and growth of the movement leading to the determination in the activities of the body, especially related to movements. These disorders occur as a result of damage or deterioration in certain parts of the brain.

Objective: To evaluate the effectiveness of horse riding simulator with strengthening training program on children with spastic diplegic cerebral palsy and comparing it with conventional physiotherapy program which is used in rehabilitation.

Patients and Methods: Thirty participants were recruited in this study, who were diagnosed with spastic diplegic cerebral palsy. Their ages between four and twelve years old, the children were randomly classified into three groups of interventions Horse Riding Simulator with Strengthening Training, Horse Riding Simulator with conventional physiotherapy and control group with conventional physiotherapy).for each intervention, the children receive 24 sessions three times a week, [Gross Motor Function Measure-66, pediatric balance scale, and Modified Modified Ashworth Scale] were used to evaluate children in all groups both pre and post each intervention.

Results: Post-intervention in the groups of horse riding simulator and strengthening training and horse riding with conventional physiotherapy shows significantly improved in gross motor function measures -66(P=0.021), (P=0.001) respectively, while no significant difference have been noted in conventional physiotherapy group. on the other hand, no significant improvement have been shown in all intervention groups in Pediatric Balance Scale. Furthermore, muscle tone reduced with a too small value of significant improvement in a group of horse riding simulator with strengthening training in adductor muscle of hip joint for right and left leg (P=0.052),(P=0.059) respectively, while no significant differences have been reported in other studies groups, there wasno significant improvement have been shown in muscle tone for knee extensor and ankle plantar flexors except too small values close to significant level in the ankle plantar flexors for the right leg in a group of horse riding with strengthening training (P= 0.050).

Conclusion: The evidence from this study confirmed that horse riding simulator with strengthening training has a positive effect on (GMFM-66) and could reduce spasticity in the muscle for children with spastic diplegia cerebral palsy.

Key words: Cerebral Palsy, Spastic Diplagia, Horse Riding Machine, Strengthening Training, Balance.

Corresponding Author: al_obadi_76@yahoo.com.

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[1,2,3,4,5,6] Tehran University of Medical Sciences – Tehran - Iran.

Introduction

Cerebral Palsy is a broad term used to describe the children who are suffering from permanent movement and posture disorder. It occurs as a result of non-progressive disturbance in the developing fetus brain [1]. Low birth weight [2]. And, children prematurely born are more susceptible for cerebral palsy [3]. Sensory disturbances, cognition, perception, communication and abnormality of behavior are found to be frequently associated beside other motor disturbances [1]. Spastic diplegia represents the most common form of cerebral palsy [4]. A Study of children born with low birth weight (<1500 gram.) was conducted between 1981 to 1991reported that 37.5% of children were diplegic cerebral palsy[5]. Diplegia may result as a consequence of brain deterioration due to abnormalities in the blood vessels of the central nervous system that influence blood flowand perfusion, toxins and medication [6]. Magnetic Resonance Imaging of children with spastic diplegia shows dilatation of the trigon, atrophy of the peritrigonal white matter and prominent deep cortical sulci. The severity of motor disability is correlated with the reduction in the white matter [7]. It also involve the muscles of the lowers extremities in comparison to upper extremities and trunk [4].

Horse riding therapy is one of the relatively more advanced therapeutic methods. Manyresearchers have studied the effect of horse riding therapy and its beneficialresults in rehabilitation of neurological disorders and how it can effectively enhance the gross motor functions [8]. Functional performance on skills and posture [9], head and torso control [10], balance and muscles tone [11] in children with spastic diplegic cerebral palsy. Recent years have seen the manufacture of various devices, owns movements mimic the movements of the horse. Previous research findings that significant improvement occurs in children with CP especially in postural control from sitting position when using the simulator on them [12]. Likewise, recent evidence suggests that horse riding simulator is one of the best ways to improve sitting and balance, and it recommends that dynamic horse riding simulator might be a successful surrogate in rehabilitation of cerebral palsy if real horses is unavailable [13]. Several studies reported that motor function, activities and muscle strength are significantly improved in children with C.P. when they are focusing on strengthening exercise program in rehabilitation [14][15]. Accordingly, The main objective of the present experimental study was to evaluate the beneficial effects of proposing an innovative method in the rehabilitation of children with spastic diplegia cerebral palsy and comparing it with other traditional methods.

Materials and Methods

A randomized controlled trial (RCT) was conducted from June 2016 to February 2017 at Medical Rehabilitation and Rheumatology Center-Baghdad-Iraq. All the participants recruited for this study who have been diagnosed with spastic diplegia cerebral palsy. Inclusion criteria were as the follows of 4-12 years old, classified within II or III levels of gross motor classification system (GMCS), exclusion criteria included patient who receive treatment with botulinum toxin injections six months before treatment, children didn't have a neurologic disorder other than cerebral palsy, e.g. congenital malformation ,the patient did not had a surgical interference (dorsal rhizotomy and elongation of a tendon) preceding one year and didn't take a medication to relief the spasticity ,e.g. Baclofen, children without visual and hearing impairment, a child who afraid to ride the simulator machine.

The study was briefly explained to the parents or the guardians and if they interested to participate their children in the experiment, consent forms were obtained to them for signing. Thirty children eligible for the trial to participate in the study, considered for randomization process to choose the intervention group, a simple random sampling technique were used to distribute those children into groups of intervention. After randomization, the participants have been distributed into groups, horse riding with strengthening training (H.R.S. and S.T.) (11 children), horse riding with conventional physiotherapy (H.R.S. and Co. Ph.) (11 children) and conventional physiotherapy (Co.Ph.) (8 children), each subject gain 24 sessions three times a week for eight weeks , (Not including holidays). The variables that used to assess the changes in each intervention, Gross Motor Function Measure-66(GMFM-66)(16, 17), pediatric balance scale (PBS)(18), for lower limbs and Modified Modified Ashworth Scale for (Adductor Muscle) (19, 20).

Instrumentation

Horse riding machine (Model Number, TA-022, Wuyi Enpower Fitness Co., LTD, Zhejiang, China Mainland),Electronic stainless steel digital angle ruler for measuring range of motion(Wenzhou Shahe Measuring Instrument Co., Ltd. China Mainland Zhejiang).

Study procedure

For testing the children pre and post each intervention, the pediatric physiotherapist is required for assisting the researcher in this study. In all types of intervention, the children received 24 sessions, the intervention group Horse Riding Simulator and Strengthening Training, the sessions were divided into two stages, the first stage includes 12 sessions of exercises designed for this study performed when the child riding the simulator for 15 minutes followed by 60 minutes of strengthening exercises for abdomen ,back and lower limb muscles , in the other 12 sessions the time specified for riding simulator extended to 20 minutes then continued with strengthening exercises. In the intervention group of Horse Riding Simulator with Conventional Physiotherapy each child performed exactly the same program in the previous intervention especially those related to horse riding simulator program followed by 60 min. of conventional physiotherapy. The last intervention group Conventional Physiotherapy the child only received 60 minutes of conventional physiotherapy.

Statistical analysis

Was carried out by using the statistical package (SPSS) version (16.0). One-way Analysis of Covariance (ANCOVA) was used to comparing the changes across the time and among groups. For comparison the improvement between the groups we used The Post Hoc test that used adjusted P-value in Mann-Whitney's test to compare between the groups.

Result

The distribution of "socio-demographic characteristic" variable of study groups had recorded no significant differences at P>0.05, as shown in Table (1).

Table (1): Socio-demographic characteristic of the participants for each group of the study.

Socio-Demographic Characteristic v.	Classes	No. and %	Groups			Total	C.S. P-value
			(HRS) with strengthening training	(HRS) and conventional physiotherapy	Conventional physiotherapy		
Age Groups Yrs.	4 - 5	number	4	2	2	8	C.C.=0.478 P=0.353
		% Groups	36.4%	18.2%	25.0%	26.7%	
	6 - 7	number	4	6	4	14	
		% Groups	36.4%	54.5%	50.0%	46.7%	
	8 - 9	number	1	0	1	2	
		% Groups	9.1%	0.0%	12.5%	6.7%	
	10 - 11	number	0	3	1	4	
		% Groups	0.0%	27.3%	12.5%	13.3%	
	12 - 13	number	2	0	0	2	
		% Groups	18.2%	0.0%	0.0%	6.7%	
Gender	Male	number	7	6	5	18	C.C.=0.085 P=0.897
		% Groups	63.6%	54.5%	62.5%	60.0%	
	Female	number	4	5	3	12	
		% Groups	36.4%	45.5%	37.5%	40.0%	

[C. C.: Testing based on contingency coefficient test].

The results obtained from the preliminary analysis of (GMFM-66) are presented in (Table 2). There was a significant differences occurred in a group of intervention horse riding simulator and strengthening training (H.R.S. &S.T.) (P=0.021) and horse riding simulator and conventional physiotherapy (H.R.S. & Co. Ph.) (P=0.001).While no significant difference have been noted in group of conventional physiotherapy (P=0.156).

Table (2): Comparison of mean gross motor function measure Gross Motor Function Measure -66 within groups of intervention.

Groups	Gross Motor Function Measure -66								C.S P-value
	Pre intervention				Post intervention				
	Mean	S.E.	95% C.I.		Mean	S.E.	95% C.I.		
			L.B.	U.B.			L.B.	U.B.	
(HRS) with strengthening training	49.95	1.95	45.95	53.94	57.07	1.71	53.58	60.57	0.021
(HRS) and conventional physiotherapy	46.95	1.95	42.95	50.94	51.18	1.71	47.68	54.68	0.001
Conventional physiotherapy	45.48	2.28	40.79	50.16	47.35	2.00	43.25	51.45	0.156

C.S.: Testing based on one-way ANCOVA]; M: Mean,S.E.: Standard error, C.I.: Confidence Interval of mean.

The results in (Table 3) show through applying the suggested program in children with cerebral palsy in light of studied groups, no significant difference was accounted between all probable comparisons for PBS parameters (P>0.05).

Table (3): Descriptive statistics of PBS parameter for studied groups with one-way ACNOVA.

Groups	Pediatric Balance Scale								C.S. P-value
	Pre intervention				Post intervention				
	M.S.	S.E.	95% C.I.		M.S*.	S.E.	95% C.I.		
			L.B.	U.B.			L.B.*	U.B.*	
(HRS)* with strengthening training	13.73	3.56	6.42	21.04	19.73	4.22	11.07	28.38	0.480
(HRS) and conventional physiotherapy	13.46	3.56	6.14	20.77	15.46	4.22	6.80	24.11	0.219
Conventional physiotherapy	10.50	4.18	1.93	19.07	11.50	4.95	1.35	21.65	0.548

C.S.: Testing based on one-way ANCOVA]; **M**: Mean,**S.E.**: Standard error, **C.I.**: Confidence Interval of mean.

As illustrated in (Table 4) indicate that studies groups regarding lower limbs. no significant difference shown in

Table (4): Descriptive statistics of ROM HIP parameters for studied groups with ACNOVA comparisons significant.

Groups	Modified Modified Ashworth Scale Adductor								C.S.* P-value
	Pre intervention				Post intervention				
	M.S.	S.E.	95% C.I.		M.S.	S.E.	95% C.I.		
			L.B.	U.B.			L.B.	U.B.	
Groups	MMASHip Adductors Right Leg								
(HRS) with strengthening training	1.00	0.28	0.42	1.58	1.00	0.25	0.48	1.52	0.052
(HRS) and conventional physiotherapy	1.64	0.28	1.06	2.21	1.73	0.25	1.21	2.25	0.751
Conventional physiotherapy	1.13	0.33	0.45	1.80	1.13	0.30	0.52	1.73	0.135
Groups	MMASHip Adductors Left Leg								
(HRS) with strengthening training	1.00	0.29	0.41	1.59	1.00	0.26	0.47	1.54	0.059
(HRS) and conventional physiotherapy	1.64	0.29	1.05	2.23	1.73	0.26	1.19	2.26	0.224
Conventional physiotherapy	1.50	0.34	0.81	2.19	1.50	0.31	0.87	2.13	0.576

C.S.: Testing based on one-way ANCOVA]; M: Mean,S.E.: Standard error, C.I.: Confidence Interval of mean.

Results from (Table 5) shows that meaningless effects are occurred after applying the suggested program in children with cerebral palsy in light of studied groups, since no significant different are accounted at P>0.05 between all probable comparisons.

Table (5): Descriptive statistics of Modified Modified Ashworth Scale within each group of interventions for Knee Extensor. Groups with ACNOVA comparisons significant.

Groups	MMASKnee Extensor								C.S.* P-value
	Pre intervention				Post intervention				
	M.S	S.E.	95% C.I.		M.S.	S.E.	95% C.I.		
			L.B.	U.B.			L.B.	U.B.	
Groups	MMASKnee Extensor Right Leg								
(HRS) with strengthening training	1.18	0.27	0.63	1.74	1.27	0.28	0.69	1.85	0.183
(HRS) and conventional physiotherapy	1.55	0.27	0.99	2.10	1.82	0.28	1.24	2.40	0.425
Conventional physiotherapy	1.25	0.32	0.60	1.90	1.63	0.33	0.95	2.31	0.661
Groups	MMASKnee Extensor Left Leg								
(HRS) with strengthening training	1.91	0.33	1.24	2.58	1.73	0.33	1.05	2.41	0.848
(HRS) and conventional physiotherapy	2.09	0.33	1.42	2.76	1.64	0.33	0.96	2.32	0.852
Conventional physiotherapy	1.63	0.38	0.84	2.41	1.63	0.39	0.83	2.42	0.101

C.S.: Testing based on one-way ANCOVA]; M: Mean,S.E.: Standard error, C.I.: Confidence Interval of mean.

It is clearly seen from (Table 6) there is no significant differences are accounted between all probable comparisons.

Table (6): Descriptive statistics of Modified Modified Ashworth Scale for Ankle Plantar Flexors for studied groups with one-way ANCOVA comparisons significant .

Groups	MMASAnkle dorsiflexion								C.S. P-value
	Pre intervention				Post intervention				
	M.S	S.E.	95% C.I.		M.S.	S.E.	95% C.I.		
			L.B.	U.B.			L.B.	U.B.	
Groups	MMASAnkle dorsiflexionLeft Leg								
(HRS) with strengthening training	2.27	0.39	1.48	3.07	2.27	0.35	1.55	3.00	0.112
(HRS) and conventional physiotherapy	1.46	0.39	0.66	2.25	1.46	0.35	0.73	2.18	0.918
Conventional physiotherapy	2.38	0.46	1.44	3.31	2.38	0.41	1.53	3.22	0.301
Groups	MMASAnkle dorsiflexionRight Leg								
(HRS) with strengthening training	2.64	0.34	1.93	3.34	2.46	0.35	1.75	3.16	0.050
(HRS) and conventional physiotherapy	1.46	0.34	0.75	2.16	1.46	0.35	0.75	2.16	0.882
Conventional physiotherapy	2.38	0.40	1.55	3.20	2.38	0.40	1.55	3.21	0.095

C.S.: Testing based on one-way ANCOVA]; M: Mean,S.E.: Standard error, C.I.: Confidence Interval of mean.

Table (7) shows the improvement between all the studied groups' parameters, the results have been shown no significant differences were observed except inone variable (the gross motor function measure (GMFM-66). The Post Hoc test that used adjusted P-value in Mann-Whitney shows in gross motor function measure -66 the difference is related to the groups of (horse riding group with strengthening training) and (conventional physiotherapy) p-value =0.000 and the other is not significant.

Table (7): Comparison for improvement in mean and median parameters for studied groups withMann-Whitney test.

Outcome Measure	Mean of horse riding group with strengthening training n=11	Mean of horse riding group with conventional physiotherapy n=11	Mean of conventional physiotherapy n=8	Chi-square	P value
GMFM-66	21.64	14.36	8.62	10.41	0.005
PBS	18.05	15.82	11.56	2.58	0.27
MMAS of hip adductor (right)	15.00	16.36	15.00	0.61	0.73
MMAS of hip adductor (left)	16.45	12.72	18.00	3.44	0.17
MMAS of knee extensor (right)	14.77	14.77	17.50	1.62	0.44
MMAS of knee extensor (left)	15.86	12.95	18.50	3.85	0.14
MMAS of ankle plantar flexor (right)	13.77	16.50	16.50	1.37	0.50
MMAS of ankle plantar flexor (left)	13.77	16.50	16.50	3.57	0.16

Discussion

More recent studies, carried out on children with cerebral palsy to evaluate the effectiveness of a number of therapeutic interventions were used in their rehabilitation and to obtain a more comprehensive understanding of the feasibility of these approaches. Few studies have been done on horse riding simulator in children with cerebral palsy and they have demonstrated that this intervention can improve the controlling on postural and promote their motor function ability [12]. Enhance the

ability to sit[13], reinforce equilibrium [21]. On the other hand, treatment with strengthening exercise have been reported an improvement in motor function, the activity of muscles, walking ability, control spasticity, and ambulatory function after participating in intensive training exercises [14][15][22][23][24]. The characteristic and benefits form this equipment motivated me to use it in this study in comparison with other routinely interventions that used in rehabilitation, horse riding simulator is inexpensive , mimic the horse movements, easy to handle ,not affected by weather and we can use it indoor [12]. Therefore, the objectives of the current study were to estimate the influence of using horse riding simulator and strengthening training program and comparison with conventional physiotherapy in the rehabilitation of cerebral palsy children. The socio-demographic characteristic in (Table 1) shows no significant differences have been found between studied group at $p>0.05$, and that is more reliable for this study, since any improvements may occur should be interpreting due to the effectiveness of applying for the suggested training program in children with spastic diplegic Cerebral Palsy.

The study findings indicate, groups of intervention (horse riding simulator with strengthening training and horse riding simulator with conventional physiotherapy) shows that significant improvement occurred in (GMFM-66),the gross motor function measure scores reflect a children performance of complicated motion patterns which include stability of the trunk and coordination in addition to strength and mobility [15][25]. All these factors that may be improved by horse riding simulator with strengthening training program. While, no significant differences have been seen in conventional physiotherapy group. This finding is consistent with past studies [26-28]. Which demonstrate that horse riding have a beneficial effect with respect on (GMFM).One unanticipated finding was that pediatric balance scale in all intervention groups did not show any significant difference was noted in spite of the improvement occurred in the mean of scores pre and post intervention in each group, (HRS and ST) group showed an increased about 6 points, (HRS and Co.Ph.) group showed an increased about 2 points and group of conventional physiotherapy showed increase 1 point, This results is in agreement with Herreroet al. (2012) findings [16] and Purohitet al.[29]. Which showed that no significant differences were found in pediatric balance scales in children with cerebral palsy. Balance Scale measure the standing balance and doesn't measure the balance in sitting, the children shows an improvement in postural control, balance, coordination and well response when using hands while riding the simulator.

In this study the level of spasticity was evaluated by Modified Modified Ashworth Scale and the results obtained from the (Table 4) for hip adductor muscle shows that too small value close to the significant levels have been reported in group of (HRS and ST) intervention in right and left leg, whereas, no significant difference shown in other studies groups. These values support the authors' study and match those observed in the earlier studies by Purohit et al.[29]. And Yokoyama et al. which suggested that horse riding significantly decrease the muscle hypertonia in children with cerebral palsy [30].

In the current study, the other important finding that the muscle tone in the knee extensor and ankle planter flexors in modified modified ashworth scale was not significantly improved between all interventions groups,

except to small value of moral close to the significant level have been reported in ankle plantar flexors for right leg in group of horse riding with strengthening exercise (P=0.050). The data obtained from this research describe for the first time the effect of new approaches of treatment on children with cerebral palsy, the response of those patients for treatment differs from child to another depending on the level of disability and severity for each child, also The proper position that the child must maintain while riding the simulator, the hip at 90˚and knee at 90˚,this position induce reduction in muscle tone and spasticity of the rider, Children with cerebral palsy often cannot maintain this position during riding the device and some of them they have a short legs, and maintaining the appropriate posture plays an important role in reducing the spasticity, therefore, the non-significant differences that appeared in the results for modified modified ashworth scale may be attributed to those reasons.

In conclusion, the main finding from this study was enhancing our understanding about the influence of horse riding simulator with strengthening training program on children with cerebral palsy, the positive improvement that occurred in gross motor function measure and reduces muscle spasticity in hip adductors and ankle plantar flexors with small values of significantly, also the changes to better in balance scales, all These findings suggest that this approach of treatment could be more beneficial in rehabilitation of children with diplegiccerebral palsy and the horse riding simulator could be a successful alternative if real horses unavailable.

We recommend using horseback riding simulator as an alternative to the real horse if it is not available and increase the sample size to determine the impact of the proposed program. Otherexercises can be designed and performed on a simulator which concentrates on certain aspects of rehabilitation such as proprioception and neuromuscular coordination.

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