Original Article

HIPPOTHERAPY SIMULATOR AS ALTERNATIVE METHOD FOR HIPPOTHERAPY TREATMENT IN HEMIPLEGIC CHILDREN

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ABSTRACT

Background: Hippotherapy considered as worldwide techniques used in rehabilitation of children with neurological disorders as it improved gait pattern, balance, postural control, strengthen, range of motion and gross and fine motor skills development but it encounter some technical problems.
Purpose: The purpose of the current study was to compare between hippotherapy and hippotherapy simulators effect on back geometry and balance in hemiplegic children.
Materials and Methods: Thirty ambulant hemiplegic children, their age ranges from four to six years old participated in this study. They were randomly divided into two matched groups (control and study). The control group treated with hippotherapy for half hour in addition to the selected physical therapy program, while the study group treated with hippotherapy simulators for half hour in addition to the selected physical therapy program also. All children received the treatment three times weekly for three successive months. Spinal geometry were evaluated by Formatric instrumentation systems and balance were evaluated by pediatric balance scale before and after treatment
Results: There was significant improvement in all the measured variables for both groups after comparing of their pre and post-treatment mean values with non-significant difference between both groups post treatment.
Conclusion: Hippotherapy simulators is an alternative method for hippotherapy could be used for modulation of back geometry and for improving balance in hemiplegic children.
Brief summary and potential implication: Hippotherapy simulator was used in treatment of back geometry and balance in hemiplegic children, all the measurements were compared with hippotherapy. The results were nearly the same in both groups.
KEYWORDS: Hippotherapy, Postural Disorders, Back Geometry.

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Access this Article online

Quick Response code

International Journal of Physiotherapy and Research
ISSN 2321- 1822
www.ijmhr.org/ijpr.html

Received: 07-02-2014 Accepted: 25-02-2014
Peer Review: 07-02-2014 Published: 11-04-2014

INTRODUCTION

Hemiplegic cerebral palsied (CP) children characterized by unilateral paresis with upper limb more severely affected than the lower limb due to larger cortical representation of the hand and the arm. [1,2,3] The Prevalence of spastic hemiplegia accounted for about 0.6 per 1000 live births. Hemiplegic children account more than 38 % of CP children. [4, 5] Spinal deformities such as scoliosis, kyphosis was commonly associated with CP children and lead to serious problems. The overall frequency of scoliosis in CP is 25%. Hemiplegic children suffered from loss of dissociation between lower limb movement and less weight bearing on the affected side, affecting the ability to maintain an upright standing and gait. [7, 8] A symmetrical weight-bearing distribution between legs result in spinal deformity in hemiplegic children. [9] Hemiplegic children depend on unaffected side for weight support.[10] Based on the weight bearing between the affected and unaffected body sides and the characteristic relationship between the shoulder and pelvis, two types of asymmetrical postural pat-

terns were described: the pro gravitational postural pattern, with shifting weight over the affected side, and the ant gravitational postural pattern, with shift body weight over un affected side.[11]

Hippotherapy improved posture, strength trunk muscles and stimulated vestibular, tactile, visual, and postural senses.[12] The horse's pelvic movement similar to human pelvic movement thus, providing efficient proprioceptive stimulation.[13] Horse's gait provides a precise, the horse rhythmic and repetitive movement similar human walking pattern.[14]

Hippotherapy improved postural control.[15] Hippotherapy inhibited sustained pathological reflexes and correct abnormal muscle tone.[16] Hippotherapy improved gross motor development in CP children. [17] Hippotherapy improved balance in CP children.[18] Reduced spasticity in patients with spinal cord injuries and multiple sclerosis.[19, 20] Improved back geometry in spastic diplegic children.[21] Improved coordination and balance. [22] stimulating righting and equilibrium responses. [22, 23] There is different designs to assimilate horse riding as Karakuri type structured to give sensation of hippotherapy[24] structured trotting providing combination of forward-backward and up-and-down oscillating movements. [25]

This study included treatment of back geometry and balance in hemiplegic children using hipptherapy simulator and comparison of its results with hippotherapy.

METHODS

Subjects, Instrumentations and Procedures:

The study design was randomized controlled trials. the procedures followed were in accordance with the ethical standards and after approval of the children families.

Subjects: Thirty spastic hemiplegic CP children participated in this study. Their ages ranges from four to six years old. They were selected from the Outpatient Clinic of the Faculty of Physical Therapy, Cairo University. They were divided randomly into two groups of equal number, control group consists of fifteen hemiplegic children (nine female and six male) and study group consists also of fifteen hemiplegic children (seven female and eight male).

Inclusive criteria: All children were ambulant hemiplegic children and had spasticity grade1 and 1+ according to modified ashworth scale and could follow orders. Exclusive criteria: Children were excluded if they had hip dislocation, structured scoliosis, fixed contractures or deformity and uncontrolled convulsions, visual, auditory and vestibular disorders.

Instrumentation:

For Evaluations:

For metric instrumentation system (AESCULAP-MEDITEC GMBH, Holland): This system serves for determining spinal geometry of the human being based on non-contact three dimensional scan and spatial reconstruction of the spine derived from it by means of a specific mathematical model. The For metric instrument system contains the following major subassemblies a- Scan system b- Computer c- Black background screen. d- Laser printer.

The Pediatric Berg Balance Scale (BBS): This scale was developed to measure balance among children with impairment in balance function by assessing the performance of functional tasks. It is a valid instrument used for evaluating effectiveness of interventions and quantitative descriptions of function in clinical practice and research. Equipment needed for this scale is: Ruler, two standard chairs (one with arm rests, one without), footstool or step, stopwatch or wristwatch, 15 ft walkway.

For Treatment:

Well trained horse was selected walking with speed 6.4 km/h, during each session the horse walk in rectangular shape around the treatment arena in clock wise and anti-clock wise direction, directed by the handler who rides another horse walked in front of the child horse, holding the two rein lines together to direct the horses. The horse saddle in training consists of leather seat, stirrups, leather flaps, panel, or padding, surcingle, monkey grip, D shape ring and Safety helmets.

The hippotherapy simulators is an electronic horse provides rocking movement in anteroposterior, lateral directions and combination of both directions. It was equipped with two three phase motor (code COSQ 0.72), its speed 1500 cycle / sec. and 1.8 amps made in Italy. Industrial invertors (code VF-NC1) made

in Japan used to control the three phase inductive motors speed and transfer electricity from interrupted to direct current for the motors. The horse body made from fiber glass reinforced by iron at the base to be strongly attached to the main machine, the horse is equipped with handle for grasp and foot rest. The horse perform rocking movement in anteroposterior direction at 10,20,30 degree from the vertical line and 5,10,15 degree in lateral directions from the vertical line. The horse is covered by heat bearable leather. The saddle equipped by four small two phase motors producing low frequency vibration (50-60 HZ) and equipped by electrical heating pad that, raise the saddle temperature up to (40-44C°). (figure 1).

Physical therapy equipment including balance board, bounce board, parallel bars, wedges and rolls of different sizes.

Fig 1: Hippotherapy simulators.

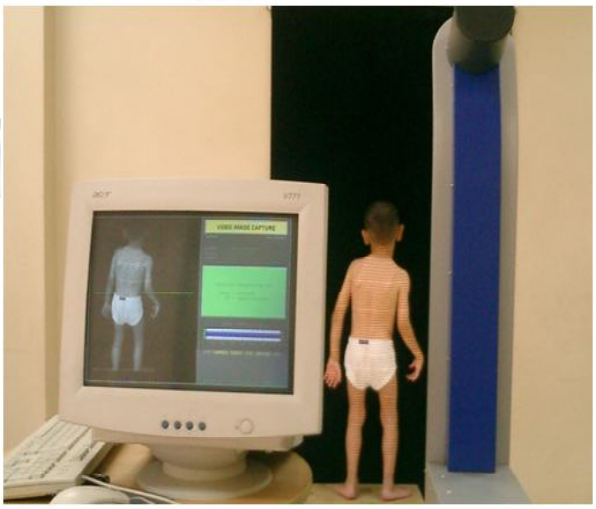
An electronic horse provides rocking movement in anteroposterior, lateral directions and combination of both directions. The horse was equipped with two three phase motor (code COSQ 0.72), speed 1500 cycle / sec, 1.8 amps. The industrial invertors (code VF-NC1) controls the three phase inductive motors speed and transfer electricity to direct current.

Procedures:

For Evaluation:

For metric instrumentation system: Each child in both groups was evaluated in a warm and quite room before and after three months of treatment using For metric instrument system to measure back geometry. Child data were entered to the computer and the child was asked to stand facing the black back ground screen at a distance of 2 m away from the scan system either on the ground or on the blocks (according to his/her height). The horizontal line of scan system should lie below the inferior angles of scapulae. It is important that the child's back (including buttocks) was completely bare to avoid disturbed image structures. Each child was asked to assume the usual natural standing attitude with chin in to improve the presentation of the vertebral prominence. The child was also asked to keep his/ her both upper extremities freely extended beside the body as much as possible. Height adjustment of the optical column was done before capturing to obtain the suitable image. When the camera was ready for image recording, a green horizontal line appeared on the computer screen and the projector lamp was automatically switched. During capture, the child was asked to hold on breath. Full back shape three-dimensional analysis was recorded and printed out for each child. Through one capture, the following parameters were measured trunk imbalance vertebral prominence (VP) –dimples mid points (DM) , pelvic tilt VP-DM, pelvic torsion dimple right (DL) – dimple left (DR), surface rotation maximum (max) and lateral deviation (max) for all children of both groups. (Figure 2)

Fig 2. Formetric instrumentation system.



Pediatric Balance Scale: Fourteen item scales designed to measure balance before and after treatment for both groups. The child instructed to maintain his balance while attempting the following tasks: sitting to standing, standing to sitting, transfer, standing unsupported, transfer, sitting unsupported, standing with eye closed, standing with feet together, standing with one foot in front, standing on one foot, turning 360 degrees, turning to lock behind, retrieving object from floor, placing alternate foot on stool,

reaching forward with outstretched arm, The choices of which leg to stand on or how far to reach are left to the child, the scale scoring, ranging from 0-4. "0" indicates the lowest level of function and "4" the highest level of function.

For Treatment:

The control group treated with hippotherapy for three times weekly for three successive months in addition to the selected physical program, the first session is a preparatory session for the child and his parents. The child sit on the horse alone during treatment, the horse walks in rectangular shape around the treatment arena in clock and anti-clock wise direction, directed by the handler who rides another horse walked in front of the child horse, holding the two rein lines together to direct the horses.[21] The horse's legs moves in this pattern left hind leg left front leg, right hind leg, right front leg [26] The horse speed was 55 walking steps per minute. [12] The physical therapist walked beside of the horse to ensure child safety and to give verbal guide to the child to maintain proper upright posture and prevent child falling. [27, 28] The child allowed to had 10 min rest during the session.

The study group treated with hippotherapy simulators three times weekly for three successive months in addition to the selected physical program also. The first session is a preparatory session for the child and his parents, the child sits on the horse holding the handle the hip joint flexed, abducted and externally rotated and feet hold in dorsiflexion during treatment by belt. Each child rode the simulators for 30 min with 10 minutes rest in between, the Child exposed to the rocking movement by the simulators in the anteroposterior direction 20 degree from the vertical for 10 minutes and to both sides for 15 degree from the vertical for10 minutes and combination of both directions for another 10 minutes, the low frequency mechanical vibration and heating applied during treatment. The child allowed to having 10 min rest during the session.

The selected physical therapy program conducted for an hour for each groups, including postural correction exercise, correction of abnormal gait pattern via task analysis technique, trunk control exercise, stretching exercises for tight muscles and strengthening exercise for weak muscle.

Statistical analysis: Chi- squared was conducted to ensure equivalence of both groups. T-test was conducted to compare the differences between both groups pre and post treatment. Paired t test was conducted to compare between pre and post treatment measurements within each group. The level of significance for all statistical tests was set at $p < 0.05$. Non parametric analysis was carried out post treatment for both groups by Wilcoxon Signed Ranks Test . All statistical measures were performed through the statistical package for social studies (SPSS) version 19 for windows.

RESULTS AND TABLES

The demographic and other baseline characteristics:

There was no significant difference between both groups in their age, height, gender, affected side and spasticity as illustrated in Table 1-2.

Table 1: Comparison between both groups in mean age and height.

Variable	Control group $\bar{x}$ ±SD	Study group $\bar{x}$ ±SD	t- value	p-value
Age	4.84 ± 0.58	4.98 ± 0.75	-0.14	0.55*
Height	120.93 ± 5.67	122.4 ± 6.54	-0.65	0.51*

$\bar{x}$ ±SD: mean ± standard deviation p: level of significant
*: non significant

Table 2: Comparison between both groups in gender, affected side and spasticity grade.

Variable		Control group	Study group	X^2 value	p-value
Gender	Male	(6) 40%	(8) 53.3 %	0.6	0.43*
	Female	(9) 60%	(7) 46.7%		
Affected side	Right	(7) 46.7%	(6) 40%	0.67	0.79*
	Left	(8) 53.3 %	(9) 60%		
Spasticity	Grade 1	(7) 46.7%	(8) 53.3 %	0.13	0.71*
	Grade 1+	(8) 53.3 %	(7) 46.7%		

X^2: Chi-squared value *: non significant

Pre treatment statistics for both groups (Table 3): There was no significant difference between both groups in all measured variables pre treatment as illustrated in Table 3.

Table 3: Comparison between pretreatment mean values for both groups.

Variable	Control group $\bar{X}$±SD	Study group $\bar{X}$±SD	t- value	p-value
Trunk imbalance VP-DM (mm)	9.06 ± 1.75	9.46 ±1.99	-0.58	0.56*
Pelvic tilt DL-DR (mm)	7.26± 1.9	7.53±1.55	-0.42	0.67*
Pelvic torsion DL-DR (degree)	5.26 ± 1.03	5.33±1.49	-0.14	0.88*
Surface rotation (max) (degree)	5.66 ± 1.44	5.93± 1.48	-0.49	0.62*
Lateral deviation (max) (mm)	4.46 ±1.06	4.7± 1.08	-0.59	0.55*
Berg balance test	28 ±2.2	28.33 ±2.35	-0.4	0.69*

$\bar{x}$ ±SD:mean±standard deviation p: level of significant
*:non significant

Pre and Post Treatment statistics for control group:

There was a significant decrease in post treatment mean value for control group as illustrated in Table 4.

Table 4: Comparison between pre and post treatment mean values for control group.

Variable	$\bar{x}$ ±SD Pre	Post	t- value	p-value
Trunk imbalance VP-DM (mm)	9.06± 1.75	6.26±1.66	12.58	0.0001*
Pelvic tilt DL-DR (mm)	7.26± 1.9	4.76±1.49	8.91	0.0001*
Pelvic torsion DL-DR (degree)	5.26± 1.03	2.86±0.83	12.61	0.0001*
Surface rotation (max) (degree)	5.66± 1.44	3.43±1.27	12.29	0.0001*
Lateral deviation (max) (mm)	4.46 ±1.06	2.4±1.05	13.48	0.0001*
Berg balance test	28 ±2.2	31.93±2.78	-17.23	0.0001*

$\bar{x}$ ± SD: mean ± standard deviation
p: level of significant *: significant

Pre and Post Treatment statistics for study group:

There was a significant decrease in post treatment mean value for study group as illustrated in Table 5.

Table 5: Comparison between pre and post treatment mean values for study group.

Variable	$\bar{X}$ ±SD Pre	Post	t- value	p-value
Trunk imbalance VP-DM (mm)	9.46 ±1.99	6.73±1.79	10.25	0.0001*
Pelvic tilt DL-DR (mm)	7.53±1.55	5±1.41	19	0.0001*
Pelvic torsion DL-DR (degree)	5.33±1.49	3±.94	10.27	0.0001*
Surface rotation (max) (degree)	5.93± 1.48	3.8±1.29	16	0.0001*
Lateral deviation (max) (mm)	4.7± 1.08	2.63±1.04	16.16	0.0001*
Berg balance test	28.33 ±2.35	33.13±2.85	-18.33	0.0001*

$\bar{x}$ ± SD: mean ± standard deviation
p: level of significant *: significant

Post treatment statistics for both groups:

There was no significant difference between both groups in all measured variables post treatment as illustrated in Table 6.

Table 6: Comparison between post treatment mean values for both groups.

Variable	Control group $\bar{X}$±SD	Study group $\bar{X}$±SD	t- value	p-value
Trunk imbalance VP-DM (mm)	6.26±1.66	6.73±1.79	-0.73	0.46*
Pelvic tilt DL-DR (mm)	4.76±1.49	5±1.41	-0.43	0.66*
Pelvic torsion DL-DR (degree)	2.86±0.83	3±.94	-0.41	0.68*
Surface rotation (max) (degree)	3.43±1.27	3.8±1.29	-0.78	0.44*
Lateral deviation (max) (mm)	2.4±1.05	2.63±1.04	-0.6	0.54*
Berg balance test	31.93 ±2.78	33.13 ±2.85	-1.16	0.25*

$\bar{x}$ ±SD: mean ± standard deviation
p: level of significant *: non significant.

Non parametric analysis for both groups post treatment:

Six variables were tested forboth groups post treatment.The results seem to indicate that the after the measurements there was no increase and no decrease (average rank of zero vs. average rank of zero). The Wilcoxon signed rank test shows that the observed difference between both measurements is not significant. The test statistics assume that the novel method is the same like the control method and no significant differences as illustrated in Table 7-8.

Table 7: Wilcoxon signed ranks test. Ranks.

		N	Mean rank	Sum of ranks
Study- control	Negative ranks	0[a]	0	0
	Positive ranks	0[b]	3.5	21
	Ties	0[c]		
	Total	6		

a. Study < control b. study > control c. study= control

Table 8: Wilcoxon signed ranks test. Test statistics.

Test statistics[b]	
	Study- control
Z	-2.201[a]
Asymp.sig.(2 tail)	0,028

a. Based on negative ranks
b. Wilcoxon Signed Ranks Test

DISCUSSION

Hippotherapy is effective method used in CP children rehabilitation but it is limited in clinical practice for various reasons such as fear, difficulty of mounting a horse, climate, financial considerations[2] and require huge space.Therape- utic result obtained from hippotherapy treatmets has encouraged research into developing an advanced hippotherapy simulators that "imitate" the horse movement.[29]

The purpose of this study was to investigate the efficacy of a new designed hippotherapy simulators on spinal geometry and determine its effect on balance in hemiplegic children by comparing it's effect with hippotherapy.

The result of the study showed significant improvement in the spinal geometry and balance in the study groups and this could be attributed to hippotherapy simulators is design to assimi-

-late pelvic movement of the horse, stimulating trunk and pelvis proprioceptors and correct abnormal pelvic tilting posture. The heating pad and the low frequency vibration in the saddle and with hip adductors stretching during sitting on the simulators leading to damping lower extremities spasticity correcting abnormal pelvic tilting, improving trunk proprioceptive function and improving balance and spinal geometry.

The hippotherapy simulators perform rocking movement in separate and in combined way not as life horse riding but this way was effective and improved balance and back geometry this due to the rocking movement stimulated trunk and pelvic proprioceptive function and stimulating the vestibular system in linear and rotatory directions. Cerebral palsied children treated with mechanical saddle, replicating horse riding, significantly increased their passive range of antero-posterior pelvic tilt and hinder hypertonia compared to those who sit on a static saddle. Sitting positioned with the hips abducted reduces electromyography (EMG) activity in the hip adductors, knee extensors, plantar flexors and back extensors. [30]

The saddle was equipped with heating pad to prevent decreased lower extremity temperature and damp spasticity. Zurekiet., al. [31] concluded that mechanical horse riding, causes a sustained lowering of skin temperature in children with spastic cerebral palsy, indicating acutely diminished skin blood flow; a liable effect of intensified vasoconstriction. Tillman [32] stated that therapeutic heating increased nerve conduction velocity type II fibers, decreased latency time for both sensory and motor nerves and decreased firing rate of type II muscle spindle afferents and gamma efferent. The hippotherapy simulators is equipped with low frequency vibration to damp spasticity in cerebral palsied children. Hebert [33] stated low frequency mechanical vibration reduced H- reflex leading to muscle relaxation.

The post treatment statistic was performed with T test demonstrated no significant difference between both groups and the non parametric test also showed that there is no significant difference between the results of both groups.

The study limitation includes small number of available hemiplegic CP children and high cost of the Hydraulic design of the control unit of the simulators, so the mechanical design was used. The knowledge acquired during the development of the project would lead to further lines of research in very important areas such as effect of the simulator on gross motor development and other pediatric disorders. The opportunity of offering new evidence based treatments for physical disabled child was of great interest at a social level not only for the benefits derived from the therapy but also for the recreational character of the activity and the possibility of combining with other types of therapy.

CONCLUSION

Hippotherapy simulators showed results that make it an efficient alternative method for hippotherapy and could be used in modulation of back geometry and treatment of balance disorders in hemiplegic children.

List of abbreviations:

BBS- Berg Balance Scale
CP- Cerebral palsy
DL- Dimple Left
DM- Dimples Mid point
DR- Dimple Right
EMG- Electromyography
Max- Maximum
SPSS- statistical package for social studies
VP- Vertebral prominence

Conflicts of interest: None

Source of funding: None

ACKNOWLEDGEMENT:

I am so sincere gratitude grateful to Dr. Rana Elmarzouki physiotherapist in Mit- Ghamer hospital for her participation in this study and support to complete this work, I am also grateful to engineering Mohamed elshreef for designing the hippotherpay simulator unit. Finally, I cannot find words to express my deep thanks to all children who participated in this study.

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How to cite this article:

Mohamed Ali Elshafey. HIPPOTHERAPY SIMULATOR AS ALTERNATIVE METHOD FOR HIPPOTHERAPY TREATMENT IN HEMIPLEGIC CHILDREN. Int J Physiother Res 2014;2(2):435-41.