Research Article

Effects of Therapeutic Dosing through Enriched Environment on Gross Motor Function in Spastic Quadriplegic Cerebral Palsy

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Abstract

Background: Cerebral palsy differs in every child in terms of impairments, activity limitations and participation restrictions, so intervention should be designed in a way which is specific to every child and is constantly adjusted according to the needs of the child. Level appropriate selection of dosage (frequency, type, time, intensity) of treatment plays a vital role in treatment efficacy.

Objective: To investigate the effects of therapeutic dosing through age-appropriate enriched environment on gross motor function in spastic quadriplegic cerebral palsy.

Methods: In this RCT, 82 spastic cerebral palsy children were randomly allocated to two groups. Group A received level appropriate enriched environmental inputs consisting of motor and sensory enriched play environment with therapeutic dosing (20-25 minutes intermittently, 5 hours per day, 5 days a week for 24 weeks) along with Neurodevelopmental Technique. The goal was to promote participant's self-generated movements, exploration of the environment and successful task completion. Group B received clinical based regular physical therapy consisting of NDT. Guidance was given to parents on how to carry out a home program. Data was collected at the end of 5 months on GMFM scale to check improvement in gross motor function.

Results: The data was analyzed using Mann Whitney U test. There was statistically significant difference between the two groups. Group A showed improvement in gross motor function (p value<0.05) whereas improvement in group B was not as significant (p-value>0.05).

Conclusion: This study concluded that optimal dosage of an intervention along with parent/caregiver education started at an early age resulted in significant functional improvements in spastic quadriplegic cerebral palsy children. These improvements were observed not only in body functions but also in active involvement and participation of the child.

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Introduction

Cerebral palsy (CP) consists of number of developmental disorders related to movement and posture which are permanent but non-progressive and causes activity limitations.[1]

Motor disorders in CP often present with disturbances of sensations which affect perception, cognition, behavior, and communication and result in activity limitations and participation restrictions.[2,3] Sensory exploration leads towards motor execution.[4] As there is restriction of movement in CP due to abnormal muscle tone and

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asymmetrical posture, a CP child cannot explore the environment on his own. This hinders with the motor planning and motor learning of the child.[5] Since brain damage is irreversible in CP, so current interventions which only focus on motor disabilities are insufficient to improve these patients' activity level and participation and, therefore, their quality of life.[6]

Multidisciplinary approach which is child centered and holistic in nature encourages the training of care-giver/ parents to help them achieve the full potential of the child. In general, intervention should be focused on the intrinsic activity of the child to achieve functional improvement.[7]

Environment plays a vital role in the motor behavior of the child.[8] Infant Environmental Enrichment is defined as the intervention focused on parent-infant interaction. In this program, parents are guided on how to adapt and enrich physical and playful environment that leads to promote skill development of the child through active motor learning.[9] It creates an environment which optimizes motor learning through goal-oriented activities which are task specific and repetitive in nature. This program is based on the motor learning principles and focuses on the activity and participation restriction domain though environment context and task practicability.[10]

CP differs in every child in terms of impairments, activity limitations and participation restrictions.[(11)] Intervention should be designed in a way which is specific to every child and is constantly adjusted according to the needs of the child over the years.[7] Moreover, studies indicate that dosage (frequency, time, type, intensity) of treatment plays a vital role in treatment efficacy.[11] Little is known about the minimum dosage required to produce changes across the domains of ICF in different disabilities.[12]

In general opinion, it is believed that high dosing interventions would give better outcomes. But these high dosing protocol impose difficulties in executing them in clinical set ups like service constraints, increased time consumption and increased cost demands. CP children often present with multiple comorbid conditions that requires continuous health care, education and multidisciplinary training further contributing to financial constraints, ultimately leading towards decreased compliance from families. One way to overcome this obstacle is to find a minimum dosage regime which would provide the desired outcomes.[13]

In the recent decade the term "dosage" has been used to define the intensity, frequency, type and time of the intervention given in the rehabilitation setup.[12] In this framework, frequency is characterized by "how often" the treatment is given per day. Intensity is providing intervention at an amount greater than standard care (typically defined as 2X/week) or number of repetitions in each session per day. Time is for "how long" the session was carried out and type is the specific intervention given.[11,14] Optimal dosages may vary with the type of intervention used.

With the heterogeneity of the impairments presents in CP, it is still not clear about that what dosage would be appropriate to use in the rehabilitation of these children to provide functional benefits and reduce participation restrictions.[11,15]

There is still a blurred area regarding dosage parameter in cerebral palsy rehabilitation. In this study it is hypothesized that level appropriate selection of time, type, frequency, and intensity of intervention (sensory and motor) plays a very vital role in developing gross motor functions. The secondary purpose of this study is to establish the impact of enriched environmental inputs and foster parent capacity as an early intervention taking into account CP specific positioning and handling along with level appropriate sensory inputs.

Methods

This randomized controlled trial was conducted in University of Lahore Teaching Hospital. 92 participants were selected on the basis of non-probability purposive sampling technique. Out of these, 5 participants refused to take part in study due to insufficient time to carry out home program, 3 participants were dropped out due to not following instructions and 2 participants relocated to another city. After excluding dropout 82 participants were included in the study then randomly allocated into either experimental group or control group. Consent was taken from the parents of the participants. Inclusion criteria of the study were age (7 months-5 years), spastic quadriplegia, level IV and V of Gross Motor Function Classification System (GMFCS), level 1 and 2 of Modified Ashworth scale and both genders.

However, if the participant had any history of fits, dislocation/fracture, visual/auditory impairment, repeated infections, cognition delay, medications or if participant was taking therapy from multiple places, they were excluded from the study. This study was a single blinded study where assessor was blinded. Approval was taken from the Ethics Committee of University of Lahore prior to data collection. Group A (experimental group) received level appropriate enriched environmental inputs with therapeutic dosing along with Neuro Developmental Technique (NDT). Group B (control group) received clinical based regular physical therapy consisting of NDT.

Enriched Environment (EE) was designed in way that it consisted of age-appropriate motor and sensory enriched play environment. The goal was to promote participant's self-generated movements, exploration of the environment and successful task completion. EE also contained guidance to parents regarding reflex inhibiting postures and maximum exposure to age and level appropriate sensory activities leading to motor execution. Primary Investigator provided visual stimulus via colorful toys and auditory stimulus via musical toys in the midline to promote midline orientation, which is an important prerequisite for gross motor function. He encouraged focusing and tracking through 180 degrees to promote reach, grasp and bimanual activities of the participant. Tactile stimulus was provided via different textures (soft, hard, rough, carpet etc). Level appropriate vestibular stimulus was also provided via gentle rocking initially or swing in later stages that led to encourage transitions and level appropriate mobility like creeping and crawling. Gym ball was also used to encourage core muscle stability, neck on trunk balance and trunk on pelvis balance. Dosing of sensory inputs was done throughout the therapy. The Primary Investigator adapted the multisensory (auditory-tactile-visual-vestibular) stimuli according to the behavior and physiologic cues of the participant. If the participant showed any negative response in the form of irritation, crying or extensor thrust, that part of stimulus was skipped and next stimulus was initiated. Intervention was given for 20 to 25 minutes intermittently for period of 5 hours per day, 5 days a week for the total duration of 24 weeks. These dosing parameters have been pilot tested in a study in CP rehabilitation.[16] Intensity of the intervention was not included. Guidance was given to parents on how to carry out a home program. Parents were instructed to document the number and length of the sessions they conducted on a logbook. They were also instructed to document the time they spent carrying out instructions given by the therapist at home. Daily feedback was taken from parents along with video presentations. The outcomes were measured on GMFM scale after 5 months.

Results

Total 96 participants were approached to participate in the study. Out of these 96, 11 did not meet the inclusion criteria and 3 declined to participate due to insufficient time to carry out home programs. Total 82 participants were randomized into 2 groups. 41 participants were allocated into Group A (experimental) and Group B (control) each.

Data was analyzed using SPSS ver.3.0. Normality of data was tested by using Kolmogorov-Smirnova and Shapiro-Wilk test. Normality of data was tested across all domains of GMFM at baseline and after getting treatment for 5 months. The results showed that data was not normally distributed as indicated by the p-value which was less significant. ($p<0.05$). Descriptive data was calculated for age and categorical variables gender and GFMCS level of classification.

Descriptive statistics of age showed that mean age of Group A (experimental group) and Group B (control group) was 3.796 and 4.166 respectively. Standard deviation was found to be ±1.2165 and ±1.1403 for Group A and Group B respectively. Descriptive statistics of gender and GMFCS level are shown in table 1. Descriptive statistics of level of spasticity showed that out of 41 participants, there 8 participants were at level 1 and 33 participants were at level 2 of MAS in experimental group. In control group, out of 41 participants, 5 participants were at level 1 and 36 participants were at level 2 of MAS.

Since the data was not normally distributed, non-parametric statistical tests were applied to analyze data. Mann Whitney U-test was applied to compare both groups at baseline. Results indicated that both groups were similar at baseline (p-value <0.05)

Comparison of each variable of GMFM scale (lying and rolling, sitting, crawling and kneeling, standing,

and walking and jumping) before treatment and at 5 months, after giving therapy. Mean ranks were calculated and significance of data was found was p-values. Results are summarized in table 2 (baseline) and table 3 (after 5 months).

Wilcoxon Signed Rank test was used to perform within the group analysis. Results of this test showed that there was improvement in all the variables like lying and rolling, sitting, crawling and kneeling, standing, walking and running and total GFMF score at baseline and after 5 months of assessment. These results were statistically significant shown by the p-value (<0.05).

Table 1: *Demographic Data*

			Frequency	Percentage
Gender	Group A	Female	16	39.0
		Male	25	61.0
		Total	41	100.0
	Group B	Female	16	39.0
		Male	25	61.0
		Total	**41**	**100.0**
GMFCS Level	Group A	Level 4	29	70.7
		Level 5	12	29.3
		Total	41	100.0
	Group B	Level 4	29	70.7
		Level 5	12	29.3
		Total	**41**	**100.0**

Discussion

Therapeutic interventions used in the management of CP ranges from conventional approaches like neuro-developmental techniques, occupational therapy, hippo therapy etc. to the continuous emergence of new techniques like virtual reality, GAME, COPCA, H-HABIT etc.[17,18] Present study focuses on one such technique called Environmental Enrichment (EE) program which includes specifically designed interventions to change any aspect of an environment to make it favorable for the infant to achieve a certain goal. It could be related to motor, cognitive or social aspect of the environment of the child. One of the key features of this program is that it encourages the interaction between an infant and the caregiver/parent.[9]

Morgan et al. conducted a study in which they concluded that the interventions focusing on environmental enrichment and motor learning in infants who were at risk of developing CP, produces significant motor and cognitive gains when compare with standard care.[19] Their findings were consistent with the present study which hypothesized that along with the conventional physical therapy techniques, interventions with the focus on enriching environment if started at early age can produce significant improvement in gross motor functions of the child.

The efficacy of EE program has been demonstrated in several animal studies[20] and among other disorders

Table 2: *Mean Rank at Baseline*

Variables	Mean Rank		Sum of ranks		Mean		St. deviation		p-value
	Group A	Group B	Group A	Group B	Group A	Group B	Group A	Group B	
Lying and rolling	42.28	40.72	1733.50	1669.50	55.2993	54.2749	38.24604	38.15310	.766
Sitting	42.62	40.38	1747.50	1655.50	27.3288	26.3776	25.43766	25.28498	.669
Crawling and kneeling	42.80	40.20	1755.00	1648.00	12.8663	12.0766	13.69606	13.45348	.617
Standing	44.02	38.98	1805.00	1598.00	7.2366	4.6322	11.37410	9.29062	.266
Walking and jumping	46.76	36.24	1917.00	1486.00	3.3780	1.2027	4.39115	2.85852	.113
Total Score of GMFM	43.22	39.78	1772.00	1631.00	21.2218	19.7128	17.40771	16.09230	.513

Table 3: *Mean rank after 5 Months of Treatment*

Variables	Mean Rank		Sum of ranks		Mean		ST		p-value
	Group A	Group B	Group A	Group B	Group A	Group B	Group A	Group B	
Lying and rolling	49.61	33.39	2034.00	1369.00	85.1276	65.6556	16.15611	29.00336	.002
Sitting	47.70	35.30	1955.50	1447.50	47.3761	35.9739	22.25373	22.46620	.018
Crawling and kneeling	47.70	35.30	1955.50	1447.50	31.8446	18.7702	28.12965	17.05252	.017
Standing	46.20	36.80	1894.00	1509.00	18.7029	5.5890	22.72735	9.99145	.039
Walking and jumping	47.95	35.05	1966.00	1437.00	9.1476	1.3220	11.36078	3.09512	.002
Total Score of GMFM	50.95	32.05	2089.00	1314.00	38.4398	25.4621	18.91532	14.77120	.000

like autism,[21] ADHD[22] etc. The current studies have been utilizing EE in the rehabilitation of cerebral palsy children and the finding suggests promising results. The current study utilized this technique in addition of the conventional physiotherapy and found significant improvement in the gross motor functions of the participants.

In an overview of systematic reviews Diane et al in his study stated that techniques like passive ROM's. passive stretching, excessive facilitation from external factors, or too much physical guidance while the child is learning how to move might produce more negative than beneficial results. This is consisting with the present study which emphasized on the importance of designing interventions in such a way which facilitates the intrinsic drive of the child to complete a task. This can be done through motor learning principles by incorporating goal-oriented and task specific activities. And by altering any aspect of the environment, or breaking the task into small simple tasks to make it possible for the child to complete it.[23]

A thorough review of literature showed that noticeable developmental changes occur in cerebellum in the preterm period and during the first-year post term making early diagnosis. If treatment is started during this period, plastic changes in the brain may help the infant to grow out of the dysfunctions present at an early age. Because neuroplasticity is at peak during first three years of life.[24] Many studies reported the use of neuro-imaging and general movement assessment scale for an early diagnosis of cerebral palsy.[25] The present study also emphasizes the role of early intervention in the treatment of cerebral palsy. It hypothesizes that if diagnostic specific intervention is started at an early age, it results in the better development.

Literature review shows that focus of intervention is greatly influenced by the involvement of caregivers/parents. The perception of family and therapist in regarding the important elements of intervention maybe different, so their collaborative efforts in identifying areas of restriction and goal setting is one of the key elements which makes the treatment successful.[18] One of the key features of environmental enrichment program is the family coaching. The current study uses this feature in the form of parental education. Intervention was designed in a way which was child focused and task-oriented with the collaborative efforts of parents and therapist.

Mary E. Gannotti et al. submitted research proceedings discussing the parameters of therapeutic dosing. They reviewed several studies on CIMT which reported 6 hours of therapy/day for 15 consecutive days gave good outcomes in hemiplegic children. Another study reported that just 3 hours/day for 15 days of therapy would produce similar results. In another study it was reported that if the number of days were reduced to 10 rather than 15, it'd produce the similar outcomes. However, the casting of the less affected limb was done all day. They concluded that dosing of an intervention is as important as the intervention given itself, and it plays a vital role in treatment efficacy.[12] The primary goal of present study was to establish an optimal dosage of the intervention to be given. In general opinion it is believed that high dosage intervention would produce better outcomes. This study hypothesized that optimal dosage of an intervention along with parent/caregiver education would yield better results.

Multiple health complications in individual are an important factor, which is not considered in this study. This study did not consider intensity of the treatment while designing the program. As intervention should be designed in a way which is individualized to every child, ideally dosage of the treatment should be child specific as well. Structural/behavioral- coordination was not considered while designing the intervention as it needs interdisciplinary approach. Further researches are requested to couple dosing parameters with selected interventions. Reconciliation between capacity and performance needs further research. Long term effects of enriched environment with care givers support need further research. Stratification by the level of severity, age and type of cerebral palsy is required.

Conclusion

This study concluded that optimal dosage of an intervention along with family centered program and parent/caregiver education started at an early age resulted in significant functional improvements in spastic quadriplegic cerebral palsy children. These improvements were observed not only in body functions but also in active involvement and participation of the child. One

of the most efficient ways found to provide level appropriate dosage therapy was individually designed program along with proper guidance to family to incorporate it in daily life for maximum hours.

Ethical Approval: The Research Ethical Committee, the University of Lahore approved the study vide letter Ref No: REC-UOL/74-03/2022.

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Authors' Contribution:

SS: Conception & design, data collection, drafting of article

SS: Analysis & interpretation of data, critical revision for important intellectual content, final approval

MAR: Analysis & interpretation of data, critical revision for important intellectual content, drafting article

KH: Acquisition of data, analysis & interpretation of data

SA: Critical revision for important intellectual content, final approval

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