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ORIGINAL ARTICLE

Effect of Trunk Stabilization Exercises on Static and Dynamic Sitting Balance among Children with Cerebral Palsy: A Randomized Control Trial

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ABSTRACT

Aim: To evaluate the effectiveness of trunk stabilization exercises on Static and Dynamic Sitting Balance among Children with Cerebral Palsy

Method: This randomized controlled trail was conducted at physiotherapy department, Mayo hospital, Lahore. 38 children were with cerebral palsy were enrolled in this study via non-probability purposive sampling technique which later on randomized and allocated to two equal groups. Group A received specific core stability training while group B received conventional physical therapy treatment. Written informed consent was procured from every participant or their guardian through signed consent forms. Questionnaire used for data collection was Gross Motor Function Measure (GMFM-88) also used for assessment of sitting balance.

Results: Descriptive statistics showed participants were having mean age of6.00 ±2.00 for group A and 5.52±.1.80 for Group B**.** Participants who received trunk stabilization exercises showed marked improvement as compared to group B. There was a statistically significant improvement in all measured variables following the intervention (P<0.05). Pre-treatment sitting GMFM mean score in group A was 27.54 ± 3.61, while in group B was 26.48 ± 4.64. After 3 week treatment mean score in group A was 30.04 ± 3.81 and in group B was 27.43 ± 4.36 and post treatment mean score in group A was 32.80 ± 3.54 and in group B was 29.46 ±4.36.

Practical Implication: This research would lay another evidence highlighting the effectiveness of trunk stability exercises to not only improve sitting balance among cerebral palsy patients but also the quality of life among them.

Conclusion: It was concluded from the study that trunk stabilization exercises showed significant improvement in static and dynamic sitting balance scale among cerebral palsy children. The children when treated with trunk stabilization exercises showed a significant treatment outcome when analyzed on Gross Motor Function Measure GMFM-88.

Keywords: Cerebral Palsy, Trunk control, Static sitting Balance, Dynamic sitting balance, GMFM-88.

INTRODUCTION

Cerebral Palsy includes permanent neurological disorders that lead to motor, sensory, cognitive issues and ultimately activity limitations. Such neurological problems are associated with non-progressive abnormalities or lesions occurred in early stages of brain development[1]. Optimal trunk stability is considered vital to help execute basic functional activities of daily life like sitting and reaching. Impaired trunk control is a characteristic hallmark which often exists among patients of cerebral palsy but there is deficient evidence about the extent of impairment in static and dynamic trunk stability in moderate to severe cases of cerebral palsy[2].

The trunk's insufficient function is a very important factor that render difficulties not only in basic activities of daily living like sitting, playing and gross movements but also in performing complex functional daily living tasks such as moving in a wheelchair[3]. Voluntary control of the trunk usually used to represent an important stage in development of function and for some children it may leads to independent activity in sitting, so that independent sitting balance without specialized seating may be achieved[4]. The trunk muscle strengthening exercise is considered effective to improve the functional gross movement and the balance in children having spastic cerebral palsy [5]. The management and improvement of the core muscles strength, coordination and balance have also enhanced overall efficacy in functions of kinetic chains of upper and lower extremities. Reciprocally, inefficient core stability could have been considered to correspond to decreased functional capabilities hence affecting gross motor skills in CP child[6,7]. Muscle strengthening is considered very effective in improving sitting posture, gross motor function and the functional independence. Muscle strengthening has shown positive effects on the postural stability in sitting[8].

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Postural control is being achieved by subconscious coordinated muscle activity in space to stabilize the body's position or optimize postural alignment .Postural control usually plays a primary role during functional movements and the daily tasks[9]. Therefore, it is considered very necessary to evaluate the trunk control ability in these positions. Trunk sway is being correlated with the functional activities in children with cerebral palsy[10].

Postural stability along with reaching movements are usually considered dependent on the extent of segmental trunk control that is acquired during sitting[11].Trunk training mostly targets activation of core and lower extremity muscles increasing their strength, improve balance as well as gait problems[12]. The Muscle activation showed increased in the bilateral erector spine, rectus abdominal muscles in the left RA, bilateral RF, gastrocnemius, and left TA. Trunk Training is being considered safely and effectively maintains and improves physical performance and mostly can be included in the rehabilitation programs[13].

Spinal sagittal alignment activation is associated with the improvement in the functional outcomes and with the reduced complications rates. That's why trunk instability had led to deforming forces on the spine and ultimately scoliosis[14]. Treatment usually necessitates a cautious risk-benefit analysis. Therefore it is considered imperative to have in-depth indulgence in patients' medical history and post-morbid functional status[15].

Neck and trunk stabilization exercises had shown a positive impact on static sitting balance, movement control and dynamic sitting balance[16].

The rationale of this study lies in the focus on trunk stabilization exercises and the development of an intervention protocol to benefit patients and to prove that trunk stabilization exercises would improve not only trunk function but also static and dynamic sitting balance, to a greater extent than seen with a conventional comprehensive rehabilitation. This study helped to justify that how strongly trunk musculature is linked with balanced movement of extremities in children with cerebral palsy.

MATERIALS & METHODS

Present study was chosen to be a randomized controlled trial. After approval from ethical committee of Mayo Hospital, the study procedures were conducted at school of physiotherapy, Mayo hospital. Informed consent had been taken from all participants and their caregivers through signed consent forms. Thirty-eight children with spastic paraplegic CP were selected. The patients were aged 3–10 years. There was random manual assignment of patients to either group; an intervention group or a control group.

Sample size was calculated by employing G*POWER(version 3.1.9.4.) statistical tool. The estimated sample size was found to be 19 participants in each group. Calculations were assumed using α=0.05, Effect size d = 1.1043153, power =0.95. To overcome dropout ratio, sample size was increased. Mean of group A is 0.4 and mean of group B is 0.45. Standard deviation of group 1 is 0.04 and standard deviation of group 2 is 0.05 [17].

Inclusive criteria for the study was Spastic CP with paraplegia and impaired trunk control. Participants aged (3 to 10) years with mild degree of spasticity (grade 1 to 1+ according to Modified Ashwarth Scale), Level II or III of the Gross Motor Function Classification system GMFCS were included.

The exclusive criteria for the study were participants aged more than 10 years, having sitting position already intact, any Co morbidities affecting motor performance.

Treatment interventions: Performa was collected and participants were received an informed consent. Questionnaire used to record assessment data was GMFM-88 which was used for assessment of sitting balanceGroup A received Trunk Stabilization Exercises (Figure 1) along with conventional Physiotherapy three times/week for total six weeksand Group-B received Conventional Physiotherapy, three times/week for total six weeks treatment duration.

One group was assigned as intervention or Group A, whose participants were treated with trunk stabilization training with each single session lasting for about forty five minutes. Standard exercise protocol designed by Jeffreys[18], which was incorporated in this group included three levels. First two levels included static and dynamic balance exercises in a stable environment whereas, third level comprised of dynamic and resistive exercise training amongst unstable environment as discussed in Figure 1, along with conventional physiotherapy treatment and other group was treated with only the conventional rehabilitation program. In this study hot pack was applied to all of patients in every treatment session[19]. General muscle stretching exercises for upper and lower limb (typically for calf muscles by pulling the toes down toward the floor and lifting the heel off the ground, other muscles like adductor muscles and muscles of the arm) provided to the patients of both groups as conventional physiotherapy treatment. The patients were treated 6 weeks duration (3 times per week) each treatment session lasted for 25 min.

Assessment of the participants were done at baseline (pretreatment), mid-treatment and post-treatment following six weeks of intervention. The assessor was taken on board who was not directly involved in treatment provision and was also kept blind to the allocation of each child to their respective group. The assessor was a practicing, qualified and an experienced pediatric physical therapist as well as an efficient administrator of GMFM. Though special training WAS not necessary to administer the tool, researches recommend that the administrator must be familiar with assessment of children motor skills and the general GMFM administration protocol[20].The patients were re-evaluated by the same assessor at the end of the treatment.

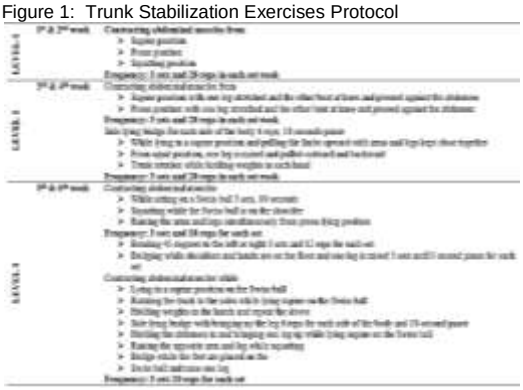
Outcome Measures:

GMFM-88 (Gross Motor Function Measure-88): Outcome measure, used in this study, has been considered as being fantastic tool for approaching an initial assessment. We have used GMFCS to determine Gross Motor skills and to find how severe a given case of cerebral palsy was. This scoring system might helped in taking consideration of limb control , movement, shifting position , use of assistive devices and many other factors[21]. Gross Motor Function Measure scale has been the gold standard outcome measure to assess the level of gross motor skills and functioning among patients with cerebral palsy at clinical and as well as research settings[22]. It has exhibited well-established and excellent psychometric properties for the population having cerebral palsy in children (age< 15 years) and has also been validated against other populations as well. As this is an assessment tool, could be effectively applied to record change in motor abilities and functions over time as well as to reflect the efficacy of interventions devised to improve gross motor skills[23].

Static and Dynamic Sitting Balance: Static balance, when defined, is the capability of child to uphold the body at rest while being in any stable or fixed posture and to carry postural alignment in coordinated and stabilized way keeping center of mass within base of support[24].On the other hand, dynamic posture has been quiet challenging for children with cerebral palsy, capability to fluctuate the center of gravity within vertical projection around line of gravity and base of support. In short, to maintain body posture with well oriented balance and coordination keeping it within base of support while it is in motion, is referred to as dynamic balance[25].

Statistical analysis: Using SPSS 23, data analysis was executed. Demographic data was computed using mean and standard deviation to interpret the descriptive statistics. For quantitative data, mean and standard deviation were preferred execution while qualitative categorical data has been presented in the form of percentage or frequency table if applicable. Shapiro-wilk test has been used to assume normal distribution of data. After assuming normality, parametric hypothesis testing was considered and independent sample t test was used to assess mean difference between groups while within subject variance, time effect and interaction effect, repeated measure ANOVA test was used. P-value<0.05 was considered significant to reject null hypothesis.

Figure 1: Trunk Stabilization Exercises Protocol



RESULTS

Participants were evaluated at the time of enrollment for eligibility and baseline assessment; 46 children, fulfilling the inclusion criteria,were randomly allocated to two equal groups (Figure 2: CONSORT flow diagram). Eight patients did not complied with the study protocols due to unavoidable reasons (mentioned in Figure 2). Hence, 38 participants' data were analyzed statistically.

Table 1 shows that out of 19 (100%) subjects, 8 were male and 11 were female in group A. In Group B out of 19 (100%) subjects, 14 were male and 5 were female. mean age in group 1= 6.00 ± 2.00 and in group 2 = 5.52 ± 1.80. Distribution of cases according to socioeconomic status has showed out of 19 (100%) subjects; 14 belong to middle class and 5 belong to lower class. In Group II out of 19 (100%) subjects; 16 belong to middle class and 3 belong to lower class.

Baseline or Pre-treatment Mean Difference: Baseline assessment indicatedthat both groups, intervention and control, showed no significant difference in any of the concerned outcome variables (P>0.05).

Pre-treatment, mid-assessment & post-intervention comparison in group A: Pre-treatment sitting GMFM mean score was 27.54±3.61. After 3 week treatment mean score was 30.04±3.81 and post treatment mean score was 32.80±3.54.

Pre-treatment, mid-assessment and post-intervention comparison in group B: Pre-treatment sitting GMFM mean score was 26.48±4.64. After 3 week treatment mean score was 27.43±4.36 and post treatment mean score was 29.46±4.36.

Pre-treatment, mid-assessment and post-intervention comparison for both groups: Pre-treatment sitting GMFM mean score in group A was 27.54 ± 3.61 and in group B was 26.48 ± 4.64. After 3 week treatment mean score in group A was 30.04 ± 3.81 and in group B was 27.43 ± 4.36 and post treatment mean score in group A was 32.80 ± 3.54 and in group B was 29.46 ±4.36 as shown in Table 2. Hence, supported with mean difference over time indicated a significant improvement in static and dynamic sitting balance post intervention (P<0.05).

Table 1: Sociodemographic Characteristics of Participants

Age of patients (Years)		
Treatment Group	Mean	6.00
	Std. Deviation	2.00
	Minimum	3.0
	Maximum	9.0
Control Group	Mean	5.52
	Std. Deviation	1.80
	Minimum	3.0
	Maximum	9.0
Gender		
Female Male		22(57.89%) 16(42.10%)
Socioeconomic status Lower class Middle class		 8(21.01%) 30(78.94%)

Shapiro wilk test of normality has shown that p-value for most of the variables in group 1 and 2 were more than 0.05, showing that data was normally distributed (Table 3). Thus, between group analysis, independent T, P value for pretreatment or baseline p = 0.44 (non-significant) showing variables were similar at baseline. Mid treatment p value = 0.57 (non-significant). Post Treatment p = 0.014 (Significant) showing treatments A were more effective than treatment B in improving the sitting balance in CP child. As it is clear that the post-assessment results showed p value significant (Table 4)

Table 5 shows multivariate analysis interpreting repeated measure ANOVA to observe time effect, within subject and between subjects comparison, results turned out to be significant (*p value<0.05).*

Table 2: Pre and Post treatment comparison in Group A and B

Group	**N**	**Mean**	**Std. Deviation**	**Std. ErrorMean**
Pretreatment GMFM score				
Group A	19	27.54	3.61	0.83
Group B	19	26.48	4.64	1.06
After 3 week treatment GMFM score				
Group A	19	30.04	3.81	0.87
Group B	19	27.43	4.36	1.00
Post treatment GMFM score				
Group A	19	32.80	3.54	0.81
Group B	19	29.46	4.36	1. 00

Table3: Test of Normality (as n<50, Shapiro-wilk was used to assume normality of data)

	Sig.
Pre Treatment sitting GMFM score Group A	.412
After 3 week Treatment sitting GMFM Group A	.835
Post treatment sitting GMFM score Group A	.545
Pre Treatment sitting GMFM score in Group B	.516
After 3 weeks sitting GMFM score in Group B	.341
Post Treatment sitting GMFM score in Group B	.821

Table 4: Independent Samples Test

	Independent t-test		
	t	**Df**	**Sig. (2tailed)**
Pre Treatment sitting GMFM score	78	36	.44
After 3 week sitting GMFM score	1.96	36	.05
Post treatment sitting GMFM score	2.58	36	.01

Table 5: Multivariate Test

GMFM Effect	**Value**	**F**	**Sig.**
Pillai's Trace	.908	172.71	.000
Wilks' Lambda	.092	172.71	.000
Hotelling's Trace	9.869	172.71	.000
Roy's Largest Root	9.869	172.71	.000

Table 5.1: Tests of Within-Subjects Effects

GMFM	**Type III Sum of Squares**	**df**	**Mean Square**	**F**	**Sig.**
Sphericity Assumed	325.568	2	162.784	263.906	.000
Greenhouse-Geisser	325.568	1.615	201.647	263.906	.000
Huynh-Feldt	325.568	1.726	188.615	263.906	.000
Lower-bound	325.568	1.000	325.568	263.906	.000

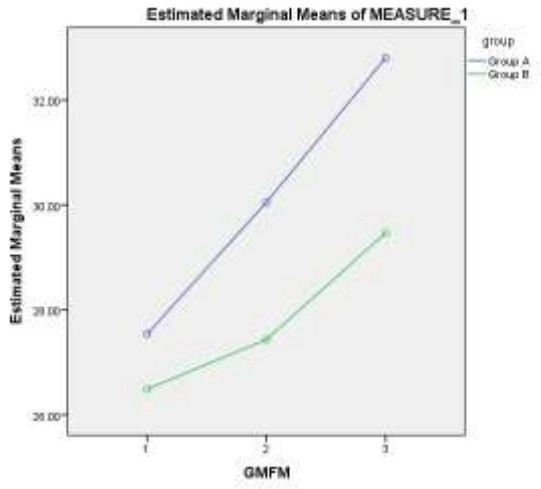
Table 5.2: Tests of Within-Subjects Contrasts

Source	**GMFM**	**Type III Sum of Squares**	**df**	**Mean Square**	**F**	**Sig.**
GMFM	Linear	322.761	1	322.761	355.174	.000
	Quadratic	2.807	1	2.807	8.641	.006

Table 5.3 Tests of Between-Subjects Effects

Source	**Type III Sum of Squares**	**df**	**Mean Square**	**F**	**Sig.**
Intercept	95634.61	1	95634.61	1964.10	.000

Figure 2: Time & Interaction effect (Mixed Factorial Analysis)



DISCUSSION

In this randomized controlled trial, two groups of patients each group having 19 patients. One group of patients was treated with trunk stabilization training along with conventional physiotherapy treatment and other group was treated with only the conventional rehabilitation program[26]. General muscle stretching exercises for upper and lower limb (typically for calf muscles by pulling the toes down toward the floor and lifting the heel off the ground, other muscles like adductor muscles and muscles of the arm) provided to the patients of both groups as conventional physiotherapy treatment. The patients were treated 6 weeks duration (3 times per week) each treatment session lasted for 25 min. The progress of patients was assessed at the end of treatment. There was notable improvement observed in outcome variable, as of both static and dynamic balance during sitting poture following the intervention protocol. The static and dynamic sitting balance was assessed by GMFM-88 (Gross Motor Function Measure)scale[27].

Group A of this study who received trunk stabilization training, mean pre-treatment sitting GMFM mean score was 27.54 ± 3.61. After 3 week treatment mean score was 30.04 ± 3.81 and post treatment mean score was 32.80 ± 3.54.

Group B who received conventional physiotherapy treatment, mean Pre-treatment sitting GMFM mean score was 26.48 ± 4.64. After 3 week treatment mean score was 27.43 ± 4.36 and post treatment mean score was 29.46 ± 4.36. The significantly notable improvement being gained in Gross motor function measure in participants of intervention group at the end of treatment regimen which had been entirely designed considering neurodevelopmental therapy principles aiming to facilitate the normal patterns[28]. Moreover, the post treatment results also showed remarkable improvement in patients in the control group, being comparable with the results of study of Dodd et al[28].

Improvement of gross motor function activities and balance have been supported by the findings of the study by Davis & Verheyden et al which concluded that the stability of trunk is a significant core element of balance and coordination, thus helps expedite to accomplish advance motor skills. Another research by Mudie et al concluded that kinesthetic and proprioceptive training of trunk in the patient with cerebral palsy had produced better weight distribution and balance[29, 30]. The ultimate enhancement of trunk control happens as stabilization training is primarily comprised of certain trunk movements aimed to cause the strengthening of trunk musculature[31].The remarkable positivity in post intervention results in experimental group is due to marked improvement in abdominal and back muscle strength as well as proprioception of trunk as the treatment protocol majorly involved specific activities and training, engaging the core muscles in a static and perturbed environments[32, 33]. This study helped to find that the CP children with good trunk control seemed more active in static and dynamic balanced sitting. Thus it stated the importance to determine the trunk control required for the improvement of sitting balance both in static and dynamic perspective in children with cerebral palsy. Children with insufficient trunk control failed to achieve effective sitting balance that affected the functional independence.

CONCLUSION

Post assessment of patients on GMFM-88 scale indicated that the use of trunk stability exercise regimen has produced effective and better outcomes than the routine physiotherapy program alone. The comparison of results on data analysis in my study showed that the trunk stabilization exercises along with conventional physical therapy rehabilitation program is effective in Cerebral Palsy.

Limitations: The major limitation of this study was poor compliance by the participants and it took longer than expected to complete the estimated sample size. Moreover, this study compared one intervention with the conventional therapy; results would have been different if compared with some other advance techniques. Sample size was not enough to produce generalizability of the results.

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Conflict of interest: Nil

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