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RESEARCH ARTICLE

EFFECT OF ARM MOVEMENT WITHOUT SPECIFIC BALANCE CONTROL TRAINING TO IMPROVE TRUNK POSTURAL CONTROL IN CHILDREN WITH SPASTIC DIPLEGIC CEREBRAL PALSY

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ABSTRACT

Introduction: One of the key features of children with Cerebral palsy (CP) is deficient postural control. Poor postural control significantly affects activities of daily living. It has been hypothesized that training focused on task completion with no explicit instructions provides better postural alignment, weight shift and balance. The aim of the study was to evaluate the effect of arm training without specific balance control training in improving trunk postural control in children with spastic diplegic cerebral palsy (SDCP).
Methods: 32 children with a mean age 6.11 years were randomized into two groups each with 6 subjects in experimental group (mean age 5.69) and control group (mean age 6.56). All children underwent an initial baseline assessment of trunk control measurement scale (TCMS) and GMFM-66 (Dimension-D). Both groups received conventional exercises. The experimental group in addition received arm training in diagonal pattern using elastic tube in sitting and standing positions. The intervention period was of 6 weeks duration, 5 days/week. Post-test measurement were assessed after 6 weeks
Statistical Analysis: Data was analyzed using non parametric Mann Whitney U test.
Results: The overall results of the study showed improvement in the trunk control measurement scale (TCMS) for trunk postural control and Gross Motor Function Measure (GMFM-66) dimension-D i.e. standing at the end of 6 weeks of treatment in both, experimental and control groups. However, the experimental group showed a significant more improvement in both trunk control measurement scale (TCMS) and Gross Motor Function Measurement (GMFM-66) dimension-D.
Conclusion: It can be concluded that arm training without using specific balance training could be used as an effective method for improving trunk postural control for children with SDCP.

INTRODUCTION

Postural control involves controlling the body's position in space for the purposes of stability and orientation and emerges from the interaction of multiple systems that are organized around a task and constrained by the environment (Shumway-Cook and Woollacott, 2001). Given that postural control is an integral part of all motor skills, postural problem interfere significantly with activities of daily living (van der Heide and Hadders-Algra, 2005). It has been also suggested that many of these delays in developing complex motor skills such as independent stance and walking are due to poor balance control (Bleck, 1994). The trunk, center of our body, plays a crucial role in postural control and the organization of balance reaction (van der Heide *et al*., 2004) and consequently is of the great importance for successful execution of functional activities. More specifically, trunk control is necessary to provide a stable base of support during execution of upper and lower limb movements, but it also includes active participation of the trunk during reaching and walking (Mayston, 2001: Prosser, Lee, Van Sant, Barbe, and Lauer, 2010: Saavedra, Joshi, Woollacott, and van Donkelaar, 2009). One of the key features of children with Cerebral palsy (CP) is deficient postural control (Brogren, Hadders-Algra, and forssberg, 1998; Liu, Zaino, and MaCoy, 2007: van der Heide *et al*., 2004). CP is the most common neuromuscular disorder in children with an increasing prevalence (Blair and Stanley, 1997; Odding *et al*., 2006; Yeargin-Allsopp, 2007) having high economic cost and negative impact on quality of life (Livingston *et al*., 2007; Majnemer *et al*., 2007). During sitting and standing humans voluntarily move their arm; the postural muscles of the lower limbs and trunk that control posture are activated in advance of the focal muscles that move the arm voluntarily (Belen'kiiˇ *et al*. 1967; Massion 1992; Hodges, Paul W.*et al*, 1999). This type of postural control, known as anticipatory postural adjustment (APA), is believed to reduce the effects of forthcoming perturbations caused by voluntary movement on posture and equilibrium (Bouisset and Zattara 1981; Friedli *et al*. 1984; Horak *et al*. 1984). APAs thus probably play an important role in adequately performing various voluntary movements while standing (Bouisset and Do

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2008; Massion 1992). This `anticipatory' contraction of the abdominal muscles is thought to contribute to preparatory stabilization of the spine against reactive forces resulting from the limb movement (Bouisset, S. and Zattara, M 1981; Hodges, P.W. and Richardson, C.A 1997). Numerous studies on several hundred subjects have investigated the possibility of improving posture with a variety of modaliting including biofeedback, orthotic or seating device, electrical stimulation and exercises both classical and NDT (Anttila H *et al*., 2008, Frederick B. Palmer *et al*., 1988). Despite the presence of multifactorial deficits, in the literature, the majority of interventions in cerebral plasy typically target isolated impairments or functional limitations.

For example, arm training approaches are conducted in the seated position. Likewise, postural training studies, while conducted in standing, rarely include concurrent functional arm training or manipulatory tasks in children with spastic diplegic cerebral palsy. Studies by Combs *et al*., 2010 and Sandy MacCombe Waller *et al*., 2012, report an arm training program that has a component of task oriented skills training in patients with post stroke but without specific quantification of postural control outcomes and with specific quantification of postural control outcomes respectively, but no Studies reported in cerebral palsy children. In standing to perform any functional task, it requires anticipatory postural control which helps to achieve their functions. Anticipatory postural control and voluntary arm movement are thought to be controlled by different, but parallel descending pathways. These parallel control mechanisms need to be integrated for effective activity completion without loss of postural control or a fall. Hence, reach training should be carried out in the context of the task demands (pull, push and transfer object) and may be essential for the implicit engagement of the underlying neural control networks for integration of the different mechanical, sensory, motor and goal oriented systems that contribute to arm function and postural regulation.

Combining explicit cues for both arm function as well as postural control, however, would constitute a dual task situation that individuals with spastic diplegic cerebral palsy would find quite difficult. In this study we propose the use of explicit cues only for the arm during training in sitting and standing with no cueing for postural control to facilitate an implicit learning process for the latter. Up to date there is no as such study which defines the postural control improvement by using arm function which includes pulling and pushing activities involving diagonal movement and functional task (diagonal and forceful movements similar to activities of daily living and sport) in children with spastic diplegic cerebral palsy. So we want to find the effects of arm training in trunk control in sitting and standing in children with cerebral palsy.

MATERIALS AND METHODS

32 children within age group of 4-10 years with a mean age 6.11 years were randomized into two groups with 16 subjects each in experimental group (mean age 5.69 years) and control group (mean age 6.56 years). To be eligible for the study, the children with CP met the following criteria: a medical diagnosis of spastic diplegic cerebral palsy without any fixed hip, knee and ankle deformity, Gross Motor Function Classification of III or IV (children who can stand with or without the use of an assistive device), Gross Motor Function Measure (GMFM) 66 under dimension B score at least 30 out of 45, no surgical or Botox interventions for 6 months prior to enrollment and the ability to understand procedures and follow directions. All participants were recruited following procedures approved by the Swami Vivekanand National Institute of Training and Research (SVNIRTAR). Parental consent was obtained. The children with CP were recruited from the pediatric section of Physiotherapy department of SVNIRTAR.

Procedure

All children with spastic diplegic cerebral plasy underwent an initial baseline assessment of trunk control measurement scale (TCMS) and GMFM-66 (Dimension-D). Gross motor function measure (GMFM), a standardized observational instrument, valid and reliable to be used for measuring change in gross motor function abilities in cerebral palsy children. Trunk control measure scale (TCMS), a recent observational scale developed to measure the static as well as dynamic trunk control in spastic cerebral palsy children. The children who met the inclusion, exclusion criteria were randomly distributed into 2 groups. Both groups received conventional exercises like trunk stabilization exercises for the trunk in the various positions, i.e. prone, supine, quadruped, kneeling and sitting. All the exercises were performed till hold of 10 seconds for 2 minutes each. The experimental group in addition received arm training.

Exercise protocol for the arm training group

Children were seated on a stool without a back or arm supports and also in standing with foot in correct alignment at a distance of his/her arm-length. Training focused on task completion with no explicit instructions provided for postural alignment, weight shift or balance strategy.

Task 1: The child lift his/her right hand forward just above the shoulder and deviated 40^0 laterally from sagittal plane to point of maximum efficiency without loss of balance to hold the elastic band and pull toward the left side downward diagonally and then repeat the whole process with the left hand. 15 repetitions from each side were given, both in stilling and standing.

Task 2: The child lean forward and deviated 40^0 laterally towards right side from sagittal plane to point of maximum efficiency without loss of balance to hold the elastic band with right hand from down and pull it upward towards the left side diagonally and then repeat the whole process with the left hand. 15 repetitions from each side were given, both in stilling and standing. The intervention period was of 6 weeks duration, 5 days/week. Follow-up was assessed at 6 weeks

Data Collection and Data Analysis

GMFM and TCMS scores were recorded prior to (pre-test) the intervention and after completion of 6 weeks intervention (post-test).

Wilcoxon Signed Rank test was used to know the difference within the groups, 0.05 level of significance was used for hypothesis testing. Analysis was performed using SPSS versions 16.0 package.

RESULTS

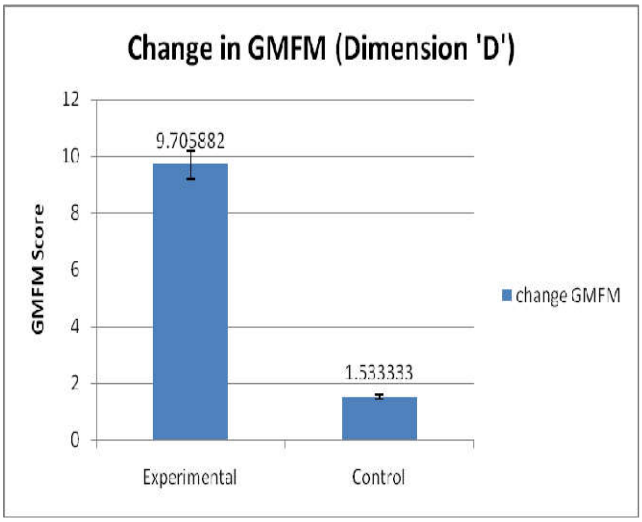
The overall results of the study showed improvement in the trunk control measurement scale (TCMS) for trunk postural control and Gross Motor Function Measure (GMFM-66) dimension-D i.e. standing at the end of 6 weeks of treatment in both, experimental and control groups. However, the experimental group showed a significantly more improvement in both trunk control measurement scale (TCMS) and Gross Motor Function Measurement (GMFM-66) dimension-D.

Gross Motor Function Measure (GMFM)

The graph 1 shows there was a significant change in GMFM score in both the groups with interventions, however experimental group showed significantly more change as compared to control group after 6 weeks of intervention.

Trunk Control Measurement Scale (TCMS)

The graph 2 shows there was a significant change in total TCMS in both the groups with interventions, however experimental group showed significantly more change as compared to control group after 6 weeks of intervention.



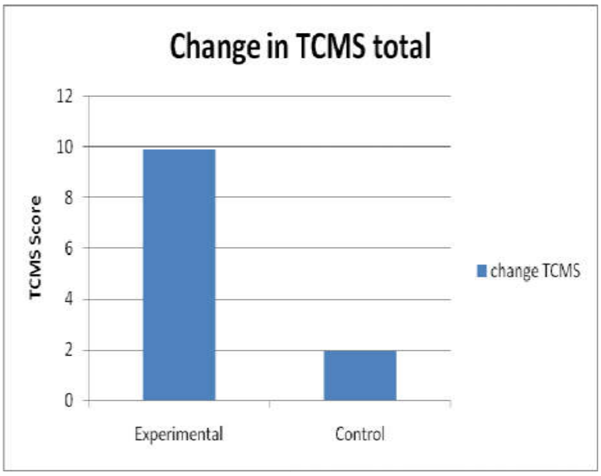
Graph 1.

TCMS subgroup "A" static control

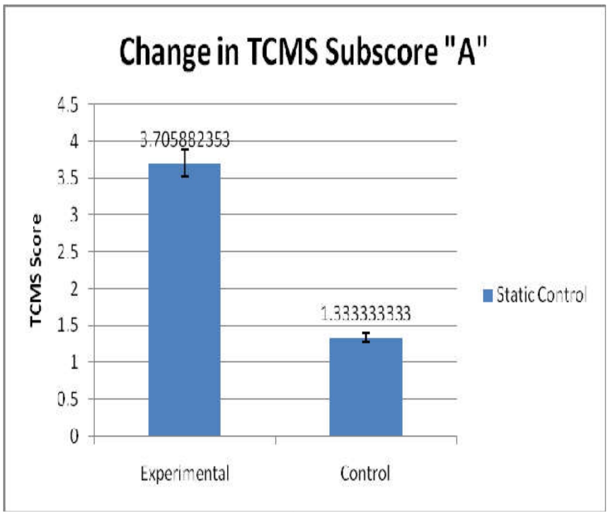
The graph 3 shows there was a significant change in TCMS subgroup 'A' (static control) score in both the groups with interventions, however experimental group showed significantly more change as compared to control group.

TCMS subgroup "B" selective control

The graph 4 shows there was a significant change in TCMS subgroup 'B' (selective control) score in both the groups with intervention, however experimental group showed significantly more change as compared to control group.



Graph 2.



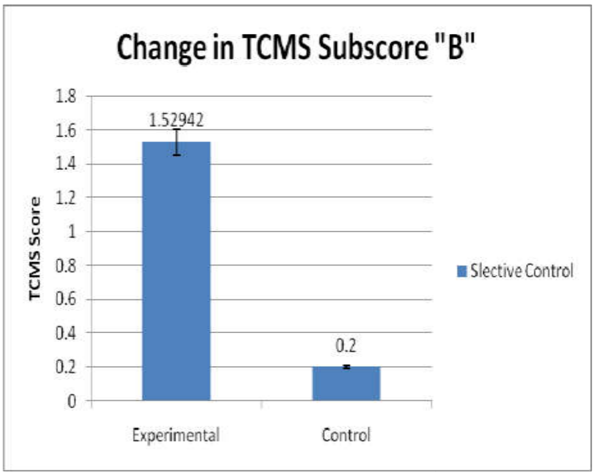
Graph 3.

TCMS subgroup "C" dynamic reaching

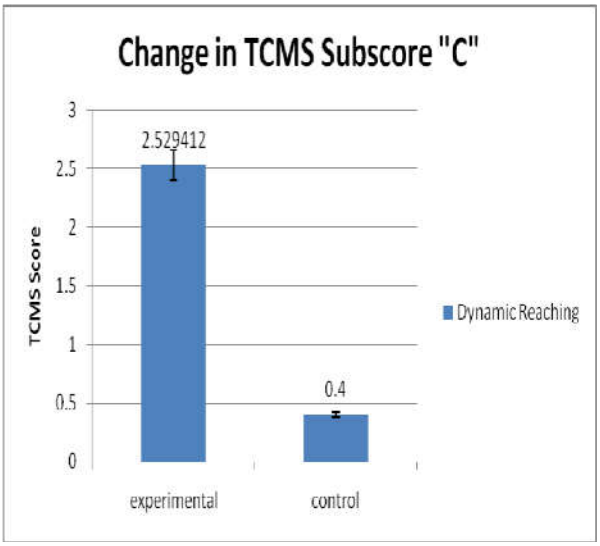
The graph 5 shows there was a significant change in TCMS subgroup 'C' (dynamic reaching) score in both the groups with intervention, however experimental group showed significantly more change as compared to control group.

DISCUSSION

The overall results of the study showed that after 6 weeks of intervention, both the groups showed significant improvement in trunk control measurement scale (TCMS) and gross motor function measure (GMFM). The experimental group who were given feed forward arm training in diagonal pattern using elastic band in sitting and standing along with trunk stabilization exercise showed significantly better improvement than control group who were given only trunk stabilization exercises. Trunk control as measured through TCMS improved significantly in both the groups of children, however the improvement in experimental group was greater. Improvement in function was measured using Gross Motor Function Measure (GMFM) under dimension D i.e. standing; both the groups improved significantly with experimental group showing more improvement as compared to the control group.



Graph 4.



Graph 5.

Trunk Control Measurement Scale (TCMS)

The improvement in TCMS score in control group can be attributed to the performance of trunk control exercises in variety of positions i.e. supine, prone, quadruped, kneeling and sitting, which could have improved core muscle recruitment. EMG studies performed on normal individuals (Richard A Erkstrom 2007) and low back patients (Kavcic N Grenier S, 2004) have established that core muscles can be strengthened by appropriate strengthening strategies in a wide array of positions. Performance of core stabilization exercises in various positions could have given on opportunity to CP children to develop the movement transitions in these positions which they normally lack (Suzanne Campbell 1990).

Cerebral palsy children lack the ability to distribute the load (body weight) appropriately during static balance and transfer the body weight adequately from one supporting ring to another during dynamic balance task. Also evidence exists regarding delayed trunk muscle recruitment with predictable and non predictable challenges to spinal stability in stroke patients (Eun-Jung Chung *et al*., 2013). Mahboobeh Kiani *et al*., 2014 has shown an improvement in postural control parameters with core stability training in children with cerebral palsy probably due to the efficient changes related to load transfer and weight distribution pattern. Similar effects of core stabilization could have brought about improvement in TCMS scores in our cerebral plasy patients. In this study a variety of spinal stabilization exercises on mat (stable surface) while transitioning for attaining, maintaining, weight shifting were performed. This might have lead to learning and retention as the environment and the order in which the activity was performed are varied. Thus an improvement in TCMS score can be attributed to the increase stabilization effect on core muscle during sitting as these muscle challenges in the therapeutic exercise program and led to their conditioning.

The superior results seen in the experimental group may be attributed to the motor learning and postural control development associated with feed forward training. There was significantly greater improvement in TCMS scores in experimental group to whom resisted arm training were given in addition to trunk postural control exercises. Recently, investigators (McGill SM *et al*., 2009; Willardson JM, 2007) identified muscular power as a critical element in the development and evaluation of proximal stability for dynamic trunk activity. Power movements, such as lifting a heavy bag, pulling and pushing, or throwing or kicking a ball, rely on a proximal foundation, (Kibler WB *et al*., 2006; Kibler WB *et al*., 2000; McMullen J, 2000). Some researchers (Voss DE, 1967; Voight ML, 2008) consider diagonal and forceful movement patterns that simulate motions associated with activities of daily living or sports to be more functionallys appropriate in assessing the capabilities of the trunk stabilizers.

Diagonal movements used in the study mimic chop and lift; these are likely to promote sequential muscle activation on multiple planes between the proximal and distal body segments. Thus, diagonal movement patterns of the extremities may have promoted a comprehensive integration of active trunk stability on multiple planes i.e. diagonal and forceful movements similar to activities of daily living and sports. Improvement in TCMS score also suggested by Putnam CA, 1993 and Zattara M, 1988; with an approach to trunk stabilization exercise that integrates the kinetic link model and normal synergistic muscle-activation patterns with proprioceptive neuromuscular facilitation (PNF) principles.

This approach focuses on rehabilitating the entire neuromuscular system by integrating multiple body segments throughout the process. The segmental integration follows the proximal-to-distal movement and muscle-activation sequence consistent with biomechanical upper extremity function. Trunk stabilization exercise programs incorporate with PNF techniques to stimulate synergistic patterns of movement. Close kinetic chain exercises incorporate 5 important PNF concepts. The first is that motor behavior is a sequence of total patterns incorporating the head, neck, trunk, and extremities. This is true whether the movement is unilateral, bilateral, or reciprocal (Voss DE, 1967). Second, normal goal-directed movement and posture depend on synergies to balance muscular activity between antagonists. Third, normal motor development occurs in a proximal-to-distal direction. Fourth, in movement patterns, stronger component patterns augment weaker components by the irradiation reflex, (Voss DE, 1967; Voss DE 1968) which suggests that as the intensity of an applied stimulus increases, the area of response increases (Sherrington CS, 1906). Fifth, the child learn the normal movement patterns by selecting and applying appropriate stimuli such as positioning, manual contact, or resistance.

Facilitation of the core stabilizer due to concurrent resisted arm movement can be postulated as the bringing about more improvement in trunk control in experimental group. Predictable disturbances to balance caused by voluntary movement, such as rising of the arms (Cordo and Nashner 1982) or forward displacement of a mass (Wing *et al*. 1997), are associated with anticipatory postural adjustments. One of the main goals of these anticipatory adjustments is to maintain equilibrium as suggested by Hess (1943) and Martin (1967) and has stabilization of the position of given segment such as the head, trunk or limbs during movement performance. Anticipatory control production of force prior to the intended movement is crucial to setting the posture to maintain the body upright against the force of gravity, while allowing task to be accomplished in an efficient, coordinated manner within an environmental context, (Eliasson *et al*, 1999) this is imperative for postural control; an improvement in core stability could have ultimately led to improvement in postural alignment.

Thus an improvement in TCMS score can be attributed to the increase stabilization effect on core muscle during sitting and standing as these muscle challenges in the therapeutic exercise program and led to their conditioning. As the child actively move arm and upper trunk beyond the stability limit of the base of support during goal oriented specific reaching and grasping the elastic band from target 1 to target 2 task i.e. movement of arm in diagonal pattern requiring forward, lateral and combination of rotation and lateral displacement of the trunk while performing the direction specific goal oriented task. Improvement in motor behavior towards expected perturbation while feed forward arm training can be postulated as another factor bringing about improvement in TCMS score.

Gross motor function measure

The performance of core stabilization exercise to improve the trunk control as evident by the improvement in TCMS scores with time, so it can be postulated that improvement trunk control could be responsible for an improvement in GMFM score. The dimension D i.e. standing were used to measure the improvement in function. The dimension of D requires the child to attain weight shift, unilateral limb lifts in the same position, attain kneeling; standing with support, standing without supports, etc. All of these activities require control of the trunk and pelvis segments in space, and require trunk to act as a stable base upon which activities of limbs can be performed. Another factor responsible for improvement in GMFM score could be the practice of functional activities like reaching in various directions while sitting upright, kneel sitting to kneeling, sit to stand with support, etc. have the potential to train aspects of muscle performance such as coordination, strength, endurance, physical conditioning (Shumway Cook, 2001) as well as motor learning as all of these tasks resembled the items of GMFM scale. Since the exercises simulated the goal movement and context of movement, neuromuscular organization to movement occurs (Lederman E 2010).

Thus, this can be transformed as an improved performance on GMFM score. Studies of Curtis DJ *et al*. 2015 suggest strong association of improvement in gross motor function, and mobility and segmental level of trunk control. Experimental group has show, a significantly better improvement in function than control group possibly due to upper limb movements like reaching, pulling, pushing and transfer of object, which are more functional and execution of purposeful movement typically requires that postural components are effectively coordinated with the intended action. Anticipatory postural adjustments (APAs), constituting a general form of postural accompaniment, act to stabilize posture and equilibrium before the initiation of a voluntary movement (APAs; reviewed in Massion 1992).

Upper limb diagonal and forceful movement patterns that simulate motions associated with activities of daily living or sports to be more functionally appropriate in assessing the capabilities of the trunk stabilizers. Upper limb movements used in the study mimic chop and lift; these are likely to promote sequential muscle activation on multiple planes between the proximal and distal body segments. Thus, diagonal movement patterns of the extremities may have promoted a comprehensive integration of active trunk stability on multiple planes i.e. diagonal and forceful movements similar to activities of daily living and sports. Executing trunk rotation while reaching and power movements produce more challenging on postural control in children with cerebral palsy (Ju, Hwang, and Cherng, 2012; Ju, You, Cherng, 2010).

Conclusion

Clinician may consider using arm training without explicit instruction in the improvement of trunk control in children with spastic cerebral palsy. It is a cost effective and simple exercise which can be used in home setup as well as institutional setup to improve trunk control and gross motor function.

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