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Original Article

Physiotherapy Section

Relationship Between Trunk Control and Balance in Children with Spastic Cerebral Palsy: A Cross-Sectional Study

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ABSTRACT

Introduction: Trunk control is impaired in children with Cerebral Palsy (CP) thus influencing their functional balance. However, there is a paucity of literature determining the relationship between trunk control and balance in children with CP.

Aim: To find the relationship between trunk control and balance by means of Trunk Control Measurement Scale (TCMS) and Paediatric Balance Scale (PBS).

Materials and Methods: Twenty four children {age range 8-14 years, Gross Motor Function Classification System (GMFCS) Level I-III} with spastic CP were recruited and evaluated using TCMS and PBS. The results were expressed as summary measures median (M) and Inter-Quartile Range (IQR). The correlation of TCMS and PBS were done using Spearman's correlation coefficient. A p-value <0.05 was considered statistically significant.

Results: The children obtained a median score of 52 out of 58 on the TCMS and 50 out of 56 on PBS. There was a significantly strong correlation with r_s=0.77 and p<0.01. A strong correlation (p<0.01) was seen between static, dynamic and total components of TCMS and PBS. The median scores of TCMS and PBS had a strong correlation for boys with r_s=0.74 and very strong correlation for girls with r_s=0.84. Based on the type of spastic CP, diplegics had a very strong correlation with r_s=0.85. While based on GMFCS levels, Level II and Level III had a very strong correlation (For level II rs=0.81 and level III rs=0.86) and weak correlation for level I (rs=0.27).

Conclusion: Based on gender, topography and severity of the motor impairment both trunk control and balance are impaired to a different degree in children with CP. The findings of this study showed a high positive correlation between trunk control and balance in children with spastic CP.

Keywords: Evaluation, Functional balance, Paediatric balance scale, Postural control, Measurement scale

INTRODUCTION

The neuromuscular impairments in children with CP are manifested in abnormal posture and loss of selective motor control, poor trunk control and balance which contributes to poor postural control with significant limitations in their activities of daily living [1]. Balance and upright postural control are fundamental components of movement which plays a major role in maintaining the body in equilibrium in a given sensory environment, with anticipatory and automatic postural adjustments [2,3]. Postural control development during early life is a complex and long term process [4]. During this process of development, the postural control mechanism provides a vertical posture of stabilizing head and trunk against gravity to allow a proper base for performing adequate activities like sitting, reaching, standing and walking [5]. The trunk plays a key role in maintaining the postural control mechanism and also in the organization of balance reactions in this developmental process. The trunk control is also required for a stable base of support which is necessary to execute functional activities for limb movements [6].

One of the key fundamentals of children with CP is a deficient postural control mechanism and it is necessary for the therapist to evaluate trunk impairments and to improve the functional performance of such children. Currently, there are many clinical tools to measure trunk control which is found to be reliable and valid methods to assess trunk control in children with CP. These methods include Seated Postural Control Measure (SPCM), the Sitting Assessment for Children with Neuromotor Dysfunction (SACND), the Spinal Alignment and Range of Motion Measure (SAROMM), Segmental Assessment of Trunk Control (SATCo), Trunk Impairment Scale (TIS) and Trunk Control Measurement Scale (TCMS) [4-6].

TCMS (58 total score) is the only scale that measures the two most important components of trunk control during functional activities: (a) the trunk as a stable base of support and (b) the trunk as an actively moving body segment. TCMS was employed to assess children with spastic CP and found to have excellent psychometric properties i.e., Intra-Class Correlation Coefficients (ICC) ranged from 0.91 to 0.99 for Inter-rater and test-retest reliability; Cronbach's alpha coefficients ranged from 0.82 to 0.94; Spearman's rank correlation with GMFM was 0.88 for construct validity allowing clinicians greater specificity in assessing trunk control [7].

Functional balance is a component of postural control which helps a child in executing basic activities of daily, social and recreational activities independently at home, school and in the community [8,9]. Functional balance in children with CP is impaired by the poor postural control mechanism. Earlier studies on balance have found that children with CP had poor static and dynamic balance reactions than, those of typically developing children [2,3]. These balance problems increased the risk of falls which further affected children with CP in performance of Activities of Daily Living (ADL), mobility and participation [9].

Currently, tools that measure balance in children with CP are the Gross Motor Function Measure (GMFM), Paediatric Reach Test (PRT) and PBS [10]. The PBS is easy and may be a less expensive alternative to be used in clinical practice. It is a reliable and valid tool for children with CP and can be used to evaluate balance and detect small changes in their functional balance. It has 14 items and a total score of 56. A previous study done using PBS on children with CP demonstrated that, it had high to very high relative reliability and that absolute reliability was satisfactory for inter-rater (Intra-class correlation coefficient=0.901) and intra-rater (Intra-class correlation coefficient–0.988) and test-retest reliability (Intraclass correlation coefficient–0.958). The concurrent validity (p<0.01) of PBS with GMFM-66 at baseline (r=0.92-0.95) and follow up (r=0.89-0.91) was excellent; and with Wee-FIM at baseline (r=0.47-0.78) and follow up (r=0.44-0.87) was moderate to good [9-11].

Available literature suggests that trunk control and balance are impaired in children with CP [7,8,12] and the present study was addressed to evaluate the relationship between TCMS (measuring trunk control) and PBS (measuring functional balance) among them.

MATERIALS AND METHODS

This cross-sectional study was conducted from March 2014 – March 2015 at Neuro-Sensory Paediatric Rehabilitation Centre, Department of Physiotherapy, Kasturba Medical College, Manipal University, Mangaluru and Chetana Special School, Mangaluru, Karnataka, India. The study protocol was approved by the Institutional Ethical Committee (IEC KMC MLR 11–13/266) and also permission from the concerned authoritarians from the special school.

A purposive sampling method and sample size was calculated using the below formula, $n = \frac{2(z\alpha + z\beta)^2}{c^2}$ which includes Zα=1.96, Zβ= 0.84 and $c=0.5 \times \ln\left[\frac{1+r}{1-r}\right]$ where r=0.7 [7]. A sample size of 24 was obtained which includes 20% of non responsive error of the study samples.

Children were examined by qualified paediatric physical therapist to find out whether, they met inclusion criteria for the study: Children of 8 to 14 years of age, afflicted with spastic cerebral palsy, GMFS levels I, II and III, afflicted children able to understand the test instructions, able to sit without trunk and feet support for at least 30 minutes and able to stand independently without upper extremity support for four seconds. Exclusion criteria were afflicted children who had undergone spinal surgeries, botulinum toxin prescribed in the last six months, intrathecal baclofen pump implantation, history of injury to spine and pelvis, on medication like antiepileptic and anti-spastic drugs, progressive neurological disorder, genetic or metabolic disorder and severe concurrent illness or disease not typically associated with CP (e.g., traumatic brain injury or acute pneumonia). Consent forms that explained the study purpose and test procedures were provided to parents and all twenty-four participants and were signed.

TCMS measures trunk as a stable base of support and as an actively moving body segment which are the two most important components of trunk control. TCMS had 15 items and a total score of 58 and evaluates both the static (total score of 20) and dynamic (total score of 38) aspects of trunk control. The subscale static component evaluated static trunk control during movements of the upper and lower limbs. The dynamic part was further divided into two subscales: selective movement control (score of 28) which measure targeted trunk movements in three planes (flexion/extension, lateral flexion, rotation) within the base of support and dynamic reaching (score of 10) which evaluated the performance during three reaching tasks, requiring active trunk movements beyond the base of support [7].

Trunk control was assessed with TCMS for static and for dynamic components. During testing no orthoses, shoes and/trunk brace was worn. Each item was commenced with the child seated on a bench without back, arm and feet support and with the trunk in its most upright position with thighs making full contact with the bench. Scoring was based on the best of three performances. In static sitting balance, the child was allowed single arm support with the hand flat on the bench without grasping. The functional balance was assessed with the PBS which has a total of 14 items for static and dynamic components in sitting and standing [8]. After the demonstration and a practice trial of each item, scoring was done utilizing 0-4 scale where the best performance was taken into account after multiple trials. All the selected children were then randomly tested for trunk control and balance using TCMS and PBS scales. A rest period of 15 minutes was given to the children between the test procedures.

STATISTICAL ANALYSIS

The collected data were coded and entered into a Statistical Package for the Social Sciences (SPSS) version 16.0 for Windows. The results were expressed as summary measures median (M) and Interquartile Range (IQR) and proportions using appropriate tables and figures. The correlation of TCMS and PBS was done using Spearman's correlation coefficient. A p-value <0.05 was considered as statistically significant.

RESULTS

Total twenty four children participated with a mean age was 126±21.9 (months). The study group consisted of 16 (66.7%) boys and 8 (33.3%) girls. Children demographic data was summarized in [Table/Fig-1].

Age (Months) (Mean ± SD)		126 ± 21.9
Gender	Boys	16 (66.7%)
	Girls	8 (33.3%)
Type of Spastic CP	Hemiplegia Boys (n=1) Girls (n=1)	2 (8.3%)
	Diplegia Boys (n=14) Girls (n=7)	21 (87.5%)
	Triplegia Boys (n=1)	1 (4.2%)
GMFCS Level	I Boys (n=10) Girls (n=5)	15 (62.5%)
	II Boys (n=4) Girls (n=2)	6 (25%)
	III Boys (n=2) Girls (n=1)	3 (12.5%)

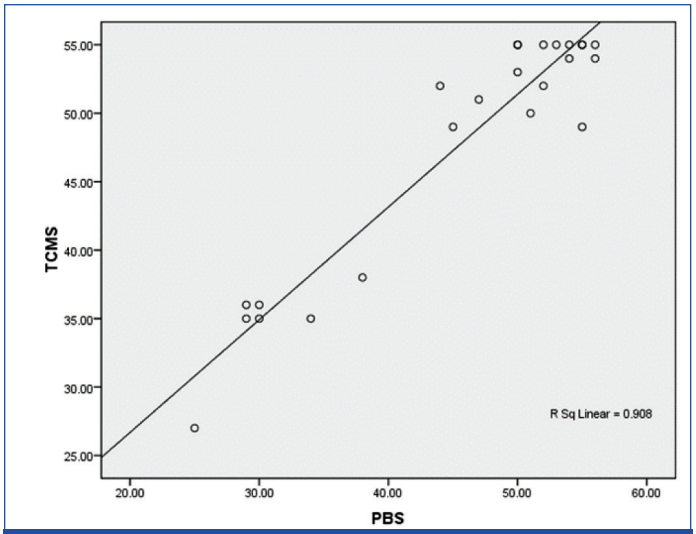
[Table/Fig-1]: Demographic characteristics of children with spastic cerebral palsy. n= 24 (100%)

Overall, the median total score of TCMS was 52 (27-55), and PBS was 50 (25-56). Spearman's correlation (r_s) was used to determine the relationship between TCMS and PBS. There was a significantly strong correlation with r_s=0.77 and p<0.01. The correlation between the subscales of TCMS and PBS was analysed through Spearman's correlation (r_s). A strong correlation (p<0.01) was seen between static, dynamic and total components of TCMS and PBS. There was a very strong correlation (p<0.01) present for static part of TCMS with the dynamic and total components of PBS as shown in [Table/Fig-2,3].

r_s=0.77		Paediatric Balance Scale (PBS)		
Trunk Control Measurement Scale (TCMS)		Static M 21.5 IQR (10-24)	Dynamic 28 (13-32)	Total 50 (25-56)
n = 24 p≤0.01	Static M 19 IQR (12-20)	0.74*	0.84**	0.80**
	Dynamic M 34 IQR (14-35)	0.66*	0.70*	0.67*
	Total M 52 IQR (27-55)	0.74*	0.82**	0.77*

[Table/Fig-2]: Total scores and Correlation between TCMS and PBS and their subscales.
M-Median, IQR-Inter quartile range; r_s-Spearman's correlation
*Strong correlation; **Very strong correlation.

The descriptive analysis (median) were used to report total TCMS, total PBS and their subscale scores of children with spastic CP based on gender, type of CP and GMFCS levels [Table/Fig-4]. The median total TCMS scores for boys and girls were 52 (35-55) and 53.5 (27-55) and for PBS it was 49.5 (29-56) and 50 (25-56) respectively. Based on the topographic classification, the median total TCMS and PBS scores for children with hemiplegia were 55 and 54 (52-56), for diplegia was 52 (27-55) and 49 (25-56) and for triplegia was 49 and 55 respectively. Based on GMFCS level, the



[Table/Fig-3]: Scatter plots of total scores of TCMS and PBS.

median total TCMS scores were 55 (49-55) in level I, 39.5 (35-50) in level II, 33 (27-35) in level III and the median total PBS scores were 54 (44-56) in level I, 37.5 (29-51) in level II and 29 (25-30) in level III as presented in [Table/Fig-4].

Gender-based correlation, TCMS, and PBS had a strong correlation for boys with r_s = 0.74 and very strong correlation for girls with r_s = 0.84. Based on the type of spastic CP, diplegics had a very strong correlation with r_s = 0.85. While based on GMFCS levels, level II and III had very strong correlation (For level II rs = 0.81 and level III rs = 0.86) and weak correlation for level I (rs = 0.27) as depicted in [Table/Fig-5].

n=24		Correlation between TCMS total and PBS total (r_s)	p-value
Gender	Boys (n=16)	0.74**	≤0.05
	Girls (n=8)	0.84***	
Type of Spastic Cerebral Palsy	Diplegia (n=21)	0.85***	
GMFCS Level	I (n=15)	0.27*	
	II (n=6)	0.81***	
	III (n=3)	0.86***	

[Table/Fig-5]: Correlation of TCMS and PBS with respect to Gender, Type of Spastic CP, GMFCS levels.
Correlation - *weak, ** strong, *** very strong.

DISCUSSION

In this study, 24 children with spastic CP were included, of which a majority were spastic diplegics. Most participants had GMFCS Level-I and many of them were boys. The median total scores for TCMS and PBS were 52 and 50, respectively, corresponding to 89.65% of maximum scores of TCMS and 89.28% of PBS. The children in our study performed well on the static components of TCMS and PBS. However, they had limited difficulty in the performance of dynamic components for both the scales which has also been observed in previous studies on trunk control and balance [4,7,11].

The result of our study showed a strong significant correlation between the total components and also for subscale components of trunk control (TCMS) and balance (PBS). The findings also indicated a very strong correlation between the static components of TCMS with dynamic elements of PBS. The results of the current study show that children with spastic CP with good sitting trunk control will have a better functional balance in standing. According to neurodevelopmental principles, movements of extremities are controlled in proximodistal fashion with the trunk, where trunk has a vital role in movement control of the extremities and further development of balance and functional mobility [13,14].

In our study, for gender, girls had a relatively higher total TCMS median score (92.2%) and performed better in the dynamic component (90.7%) compared to boys (TCMS Total-88.7% and TCMS dynamic–86.8%). However, differences were non significant in the median scores of PBS total for both girls and boys. There was a significant correlation of between TCMS and PBS, but girls are found to have a better correlation than boys. For topography, the median total scores of TCMS and PBS in spastic diplegics were lower when compared to the total scores of spastic hemiplegics. Children with spastic diplegia demonstrated difficulties in performing lateral trunk displacements that would have resulted in low scores [15].

Earlier studies reported that total and subscale total scores of TCMS were clearly decreased from Level I to Level IV. It has been indicated that the primary factor in classifying gross motor function in children with CP was maintaining a static postural balance while executing dynamic activities which was 67% remaining 33% by other factors such as muscle force and muscle tone. Present study about the severity of motor involvement marked differences were

Demographic variables		Trunk Control Measurement Scale (n=24)			Paediatric Balance Scale (n=24)		
		Static	Dynamic	Total	Static	Dynamic	Total
Gender							
Boys	M IQR	19 (12-20)	33 (19-35)	52 (35-55)	21 (13-24)	28.5 (13-32)	49.5 (29-56)
Girls	M IQR	19 (13-20)	34.5 (14-35)	53.5 (27-55)	22 (10-24)	28 (15-32)	50 (25-56)
Type of Spastic Cerebral Palsy							
Hemiplegia	M IQR	20 20	35 35	55 55	22.5 (21-24)	31.5 (31-32)	54 (52-56)
Diplegia	M IQR	18 (12-20)	34 (14-35)	52 (27-55)	21 (10-24)	28 (13-32)	49 (25-56)
Triplegia	M IQR	18 18	31 31	49 49	24 24	31 31	55 55
GMFCS Levels							
I	M IQR	20 (16-20)	35 (31-35)	55 (49-55)	23 (20-24)	31 (23-32)	54 (44-56)
II	M IQR	17 (12-20)	22.5 (18-33)	39.5 (35-50)	16.5 (10-21)	21 (13-30)	37.5 (29-51)
III	M IQR	14 (13-16)	19 (14-21)	33 (27-35)	13 (10-13)	16 (15-17)	29 (25-30)

[Table/Fig-4]: Descriptive statistics of TCMS and PBS with respect to gender, type of spastic CP and GMFCS levels.
M-Median, IQR- Inter quartile range

noted in total and subscales scores for both TCMS and PBS for all GMFCS levels. From Level I to Level III there was a decrease in total and subscale scores of TCMS and PBS which denoted that Level I children have better functional abilities. GMFCS Level I had capacities to balance and move intentionally and independently but not at Level II. Level I children can perform better in complex motor tasks such as running, jumping, keeping balance when standing without support and walking long distances. Thus, Level I children can achieve more efficiently the components of PBS which may be attributed to a weak correlation between trunk control and balance [16].

Correlation of both TCMS and PBS was higher for GMFCS levels II and III which implies that impaired trunk control in both static and dynamic components will influence their functional abilities [5,10,11]. These findings suggest that trunk control and balance are essential elements of the functional abilities of children with CP. Only two TCMS items (static and total) were very strongly correlated whereas the dynamic component of TCMS was strongly correlated with all PBS items. The ability to perform functional activities is dependent on the stability of the trunk to carry out the movements of upper and lower extremities. Therefore, it is assumed that trunk targeted interventions for improvement of TCMS scores increases gross motor function and thus performance on PBS.

LIMITATION

Limitations of the study were exclusion of severely disabled CP children and children with other forms of CP.

CONCLUSION

The present study which was aimed to find the relationship between TCMS (trunk control) and PBS (functional balance) concluded that there was a strong positive correlation found between TCMS and PBS in children with spastic CP.

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