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Utility of the items of the paediatric balance scale to assess postural control in children from 3 to 10 years of age

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Abstract

Purpose: The purpose of the study was to find out the utility of the items of Paediatric Balance Scale to assess the development of postural control in children from the age group of 3 to 10 years of age.
Relevance: Despite the importance of Postural Control Development we don't have established measures for evaluating postural control for school- aged children in our country.
Participants: This study included 160 school-aged children from the age of 3 to 10 years. The children were divided in 7 groups each of 20 children, 10 Male and 10 Female.
Methods: The above study was an experimental design and correlational study for school children of age group of 3 to 10 years of age who were able to walk and stand independently without support. The children below 3 years and above 10 years and all the children who cannot maintain standing independently and have any abnormal disease process were excluded from the study.
Analysis: The data was analysed using the Mann- Whitney Test and Ordinal Regression Analysis
Results: Mann- Whitney Test and showed a significant progressive increase in Paediatric Berg Balance Scale Scores as age advances from 3 to 10 years of age. Ordinal Regression Analysis revealed that Item no 6,7,8,9,11,14 were found to be more sensitive out of the 14 items. There was a significant difference in males and females in 8 and 9 years of age.
Conclusion: There was a positive correlation between Paediatric Balance Scores and Age. Six items were found to sensitive in evaluating development of postural control in children
Implications: For assessing the postural control development, introduction of Paediatric Balance Scale in our school settings which are less time consumable and easy to administer is a must.

Keywords: Paediatric balance scale, postural control, school children

Introduction

Ever since a child is born, the parents are concerned about his development. All of the milestones achieved by the child- rolling, prone lying, crawling, standing is monitored, even celebrated [4].

The developmental progression to bipedal stance is usually accomplished during the 1st year of life and is one of the major milestones of motor development [4]. There are however many changes that continue in dynamics of posture through ontogeny in part due to the individual attempting to realize new task goals. The age range of 3 to 6 years has been identified as one of the critical periods of postural development with significant changes in child's postural development with significant changes in child's postural control [20]. Thus postural development and motor development are inextricably linked.

Postural Control requires the development of both muscle strength that allows for antigravity movements and proximal-axial muscle control which results in dynamic patterns of co-contraction and mature equilibrium responses [18]. In the past, the therapists conceptualized postural and motor development as a hierarchy in which high level brain structures (i.e. the cortex) control and mediate the functions of lower level brain structures (i.e. the brain stem). Under the hierarchic model of neuromotor control, postural and motor development was thought to be determined by maturation of the nervous system, resulting in emergence of increasing advanced reflex patterns and eventually voluntary movement as higher levels of the nervous system developed [20].

In addition, postural control was considered to mirror motor development and proceed in cephalocaudal and proximodistal manner [3].

Recent research suggests the 1) an interplay between higher and lower system control 2) control of complex movements not just reflexes at lower levels of the nervous system 3) an overlap in the emergence of proximal versus distal model. All these contradict the hierarchic model. Furthermore, the hierarchic model of motor control does not adequately explain the higher level of variability in child development (e.g. why some babies roll at 4 months and others at 6 months or why some babies roll leading with their head and others leading with their legs) [19].

Recently system theories of motor control have been used to explain motor development, influencing the way that therapists view development. Systems theories recognize that postural and motor development results from more that maturation of a hierarchically organized nervous system. These theories acknowledge the importance of muscle strength, body mass, sensory system function, behavioural systems and environmental constraints on motor and postural development.

Despite the importance of postural control development, we don't have established measures or standards for postural control for school-age children in our country. The causes for this are in school children more emphasis is placed on academics and psychosocial. This necessitates the introduction of a standardized battery of tests that can be administered with ease in our school settings, are economic in terms of the time taken for testing and are understood by both the test administrators and the students.

Need for study

Examination of postural control is thus an important element of a physical therapy evaluation for a school age child. The clinician must predict the ability of the child to safely and independently function in a variety of environments (i.e. Home, school and community). Valid and reliable functional balance measures are of critical importance if the paediatric physical therapist is to justify that the intervention is warranted and demonstrate that improved balance function has occurred as a result of intervention.

Functional balance for the purpose of this study has been defined as the element of postural control that allows a child to safely perform everyday tasks. A child of school age is expected to function independently within his/her home & school environment while performing ADL, Locomotor and gross motor activites including recreational activities/play [19].

Thus balance is an important aspect of motor activities and impairments of balance can cause many functional difficulties. The consequence of balance impairments occurs not only in adults but also paediatric population [5]. Children between 8-12 years are in the process of learning skills to increase their independence in daily tasks and any impairment in gross motor skills can impede independence [13].

Evaluation of standing balance have begun to examine the functioning of sensory systems, associated with balance function, the development of appropriate muscle synergies in response to perturbations and the development of stability under testing conditions [12].

The quantitative analysis of postural control is generally based on date acquired by a force plate that allows one to determine the instantaneous position of the Ground Reaction Force Application Point, which is referred to as Center of Pressure (COP). Quantitative Posturography can thus be applied to obtain functional markers on fine competencies and their development. For instance, a perturbation in posture with challenges such as a compliant surface, or a concurrent cognitive task, can help to enlighten possible adjustment strategies or deficiencies, or to monitor balance control variations with age. But this equipment is very expensive [18].

So Paediatric Balance Scale was devised to assess the development of postural control. The equipment required can be easily obtainable to be used in school settings. The Berg Balance Scale has the potential to be used with paediatric population [5]. Berg (1989) states that the scale can be applied to any population with balance impairments [6]. By the age of 10, children's balance skills have achieved adult like qualities. It has simple format based on the functional balance skills required for ADL. Therefore, it can be used to assess development of postural control in children [11].

Aim and Objectives

Aim

The aim was to stress on the need for a standardized screening tools for students to select candidates for any sport/other activity based on development of postural control.

Objectives

The objectives were laid down as follows

- To assess the use of items of Paediatric Balance Scale to assess the postural control in children between 3 to 10 years.
- To determine the most effective predictors of Peadiatric Balance Scale.
- To assess the co-relation of various items of Peadiatric Balance Scale.
- To assess the age wise developmental differences in postural control of normal school children using Paediatric Balance Scale.
- To determine is any gender differences exist among school children in scores of Paediatric Balance Scale.

Hypothesis

- There would be a significant positive correlation between age and PBS Scores.
- The total score of 56 would be achieved by all children by 10 years of age.
- PBS scores would be better in Females than in Males.

Methodology

This section describes the study design, the sample selection process, the inclusion and exclusion criteria, the materials used for the collection of the data and the methods employed to do the same.

Study Design: Experimental Design, Correlational study

Subjects: This study included 160 school aged children from the age of 3 to 10 years. The children were from Kendriya Vidyalaya School and Bombay Cambridge School from Mumbai, Maharashtra, India. The children were divided in 7 groups each of 20 children, 10 Male and 10 Female. An informed consent was obtained from the parents of the children included in the study. The following inclusion and exclusion criteria were applied to the study for inclusion in the study.

Inclusion Criteria
1. Children between 3 to 10 years of age.
2. Normal school going children who were able to stand and walk independently without support.

Exclusion Criteria
1. Children below 3 years of age and above 10 years of age.
2. Children who cannot maintain standing independently.
3. Children having any abnormal disease process:

a) Delayed Milestones
b) Cerebral Palsy
c) Learning Disability
d) Undernourishment
e) Mental Retardation
f) Illness
g) Any neuromuscular disease or disorder due to disease/ infection
h) Developmental Disorders

Evaluation
The subjects thus selected underwent examination as indicated in the patient assessment sheet. The subjects were then assessed through the Paediatric Balance Scale. PBS was used to assess functional balance which consists of 14 tasks similar to ADL. The items are scored on a five-point scale (0, 1, 2, 3 or 4), zero when unable to perform the activity without assistance and four when able to perform the task with complete independence. The score is based on the time for which a position can be maintained, the distance to which the upper limb is capable of reaching in front of the body, and the time needed to complete the task. The maximum score is 56 points.

Statistical Analysis
The data was analysed using the Mann- Whitney Test to check whether there was a significant difference in performance among children when compared to adults. Ordinal Regression Analysis was done to find out the most sensitive items of PBS. Gender wise correlation was done among various age groups using Mann- Whitney Test. The Mean and Standard Deviation was found out for the Total Score of all the ages.

Table 1: Comparisons of Total Score

Ages	Mean	Standard Deviation
3 Years	47.06	1.36
4 Years	48.37	2.56
5 Years	53.03	0.73
6 Years	53.75	1.05
7 Years	54.03	0.83
8 Years	54.92	0.53
9 Years	55.42	0.39
10 Years	56	0.00

Table 2: The Total Score of Ages between 3 to 10 years was compared with Adults using Mann Whitney Test

Ages	Mean	Standard Deviation	Adults	Mann Whitney Test	
				Z	P- Value (2Tailed)
3 Years	47.06	1.36	56	-5.803	0.00E-01
4 Years	48.37	2.56	56	-5.704	0.00E-01
5 Years	53.03	0.73	56	-5.800	0.00E-01
6 Years	53.75	1.05	56	-5.811	0.00E-01
7 Years	54.03	0.83	56	-5.791	0.00E-01
8 Years	54.92	0.53	56	-5.567	0.00E-01
9 Years	55.42	0.39	56	-4.900	0.00E-01
10 Years	56	0.00	56	0.000	1.000

The analysis of performance on this test showed that there was a significant difference in performance of total score among all age groups when compared to adults. The difference was not significant only at 10 years of age. There was a significant increase in the total score from 4 to 5 years according to the graph.

Table 3: The Ordinal Regression Analysis was done to find out the most sensitive items of PBS

Sr. No	Items	Estimate	Standard Error	Wald	Degree of Freedom	Significance	95% Confidence Interval	
							Lower Bound	Upper Bound
1	Sitting to Standing	0(a)			0			
2	Standing to Sitting	0(a)			0			
3	Transfers	0(a)			0			
4	Standing Unsupported	0(a)			0			
5	Sitting Unsupported	0(a)			0			
6	Standing with Eyes Closed	4.214	0.746	31.912	1	0.00E-01	2.752	5.676
7	Standing with Feet Together	4.175	0.722	33.44	1	0.00E-01	2.76	5.59
8	Standing with one foot in front	4.363	0.489	79.49	1	0.00E-01	3.404	5.322
9	Standing on One Foot	4.299	0.559	59.104	1	0.00E-01	3.203	5.395
10	Turning 360 Degree	0(a)			0			
11	Turning to look behind	2.7	0.572	22.318	1	0.00E-01	1.58	3.82
12	Retrieving Object from the Floor	0(a)			0			
13	Placing Alternate Foot on Stool	0(a)			0			
14	Reaching Forward with Outstretched Hand	4.422	0.539	67.367	1	0.00E-01	3.366	5.478

From this table, it is seen that the following six items of PBS are found to be major determinants of development of Postural Control out of the 14 Items.

- Standing with Eyes Closed
- Standing with Feet Together
- Standing with One Foot in Front
- Standing on One Foot
- Turning to Look Behind
- Reaching Forward with Outstretched Hand

And any difference in the scores of these items would in turn affect the total score of PBS.

Table 4: Significant difference in Males and Females between 8 and 9 Years of Age. The Myelination of the Corpus Callosum takes place faster in Females than Males

Ages	Gender	Mean	SD	Mann Whitney Test	
				Z	P- Value (2 Tailed)
All Ages	Male	52.83	3.22	-0.455	0.649
	Female	52.81	3.43	Difference is not significant	
3 Years	Male	47.50	1.81	-0.576	0.564
	Female	46.61	0.42	Difference is not significant	
4 Years	Male	48.39	2.87	-0.114	0.910
	Female	48.34	2.37	Difference is not significant	
5 Years	Male	53.33	0.65	-2.122	0.034
	Female	52.72	0.69	Difference is not significant	
6 Years	Male	53.62	0.96	-0.391	0.695
	Female	53.87	1.17	Difference is not significant	
7 Years	Male	53.89	0.78		
	Female	54.16	0.91	Difference is not significant	
8 Years	Male	54.68	0.42		
	Female	55.16	0.53	Difference is significant	
9 Years	Male	55.24	0.30	-2.316	0.021
	Female	55.60	0.39	Difference is significant	
10 Years	Male	56.00	.0000(a)	0.000	1.000
	Female	56.00	.0000(a)	No Difference	

The analysis of performance on this test showed that there was a difference in performance between Males and Females, Females having better Postural Control than Males. However, this difference is more significant between 8 and 9 Years of Age.

Discussion

In our study "Utility of the Items of PBS was used to assess the Postural Control in Children between the ages of 3 to 10 Years "we have administered PBS to 160 school children.
The Paediatric Balance Scale consists of 14 items. The PBS incorporates a 0 to 4 grading scale to assess performance [1]. The scoring criterion within an item incorporates qualitative and quantitative measures that allow for normal variability in performance. This aspect of grading scale is extremely important, in that variability is a hallmark of typical motor performance. PBS Item 8- "Standing on one Foot in Front" illustrates the use of qualitative measures, quantitative measures and variability within the scoring criteria of a single item [15]. This item examines a child's ability to assume and maintain a tandem posture. To obtain the maximal score of four, the child must be able to independently assume a tandem foot placement position and maintain it for 30 seconds. A lesser score is earned if the child requires assistance to step, can maintain a stride stance but not tandem stance or maintains the tandem posture for 30 seconds. Extreme care was taken during the modification process of the BBS to ensure that the intent of the task was not altered [11].
The reduction in time parameters for static balance in BBS Items 2,3, and 7 was necessary to ensure the measure of elements of Postural Control Vs Attention Span. The reduction to 30 Seconds may limit the ability of this tool to assess the underlying element of Muscle Strength/Postural Stability as a component of Functional Balance. Verbal, Visual and Tactile Feedback for each item was provided during test session one and two during the practice trial only [15]. Qualitative Performance Feedback, Positive or Negative, was not provided during test administration and/or scoring. Additional Feedback relative to individual item(s) or overall test performance was not provided [11].
Table No 1 shows the Mean and Standard Deviation of all Ages from 3 to 10 Years.
Table No 2 shows that there is a significant increase in Total Score as the Age Increases. Also there is a steep increase in curve from 3 to 6 years. The reasons for this may be that the children from 3 to 6 years of age, adopted head stabilization in space strategy. When the level of equilibrium difficulty increases, these children show an increase in the head- trunk stiffness, particularly in 6-year-old children. This suggests an en bloc operation of the head- trunk unit [13]. Only a minority of the 3-year-old children introduced compensatory motion of the torso and limbs to minimize postural sway under the different task conditions [8]. The most common strategy in the 3 year old group was to freeze the majority of the biomechanical degrees of freedom by stiffening the torso, leg and arm joints have them operate as in effect, a single degree of freedom inverted pendulum [17]. Furthermore, in freezing the degrees of freedom, a few 3-year-old subjects mimicked a tonic neck reflex organization of the posture of the head and arms to satisfy the task constraints in the more difficult single-leg condition. The 5-year-old group showed more activity in these biomechanical degrees of freedom and greater systemization in the way in which the torso and limbs were being organized to satisfy the postural task constraints [7]. The results confirm that at around the age of 6 a turning point appears in the development of equilibrium control as already reported [12].

The children from 7 to 8 who become able to adopt the head stabilization in space even when balance difficulty increases, for example while walking on narrow supports. This improvement is associated with a large decrease in the correlations calculated between the head and the trunk movements of rotation, consistent with an articulated operation of the head- trunk unit [10]. This reacquired mastery of the degrees of freedom of the neck joint involves taking into account the orientation of the head on the trunk as a means of accurately interpreting the visual and vestibular messages relating to equilibrium control [20]. Lastly from 10 years onwards to adult, involves an articulated operation of the head- trunk unit and a selective control of the degrees of freedom at the neck level, presumably depending upon the task [3].

Table No 3 Suggests that the Following 6 items on PBS Was Found to be more sensitive.

- Standing with Eyes Closed
- Standing with Feet Together
- Standing with One Foot in Front
- Standing on One Foot
- Turning to Look Behind
- Reaching Forward with Outstretched Hand The various reasons for this are:
- Assainante *et al*. have reported that the influence of peripheral visual cues on locomotor equilibrium didn't vary monotonically with age. The peripheral visual contribution to dynamic balance control increased from 3 to 6 years of age with a maximum in 6-year-old children. And from 7-year-old there is actually a transient predominance of the dynamic vestibular contribution to balance control. Indeed, the head stabilization in space strategy mainly requiring the contribution of vestibular cues, associated seemingly with a transient lowering of the visual contribution to locomotor balance, it is reasonable to postulate a transient predominance of those vestibular cues also the functional efficiency of the vestibular system in children between 7 and 10 years of age may still be developing [2].
- There is an ascending organization of balance control from either the hip or the foot to the head, may also correspond to an ascending progression with age of the ability to control several body segments at once during stance or locomotion [9]. We would also suggest that the angular stabilization of the hip during locomotion may occur before that of the shoulder which will eventually be followed after 7 years up to the adulthood by that of the head. Our data also suggest that under difficult equilibrium conditions, the simplest strategy, in this period, is likely to consist of blocking the head on the trunk, with the en bloc mode of operation in order to minimize the number of degrees of freedom to be controlled simultaneously during the movement. They are both characterized by a return to an articulated mode of head- trunk operation as a means of stabilizing the head in space [3].
- There were no differences between the postural muscle activity of the 4 and 5-year-old children. Meanwhile the 10 and 11 year of children with their increased tolerance to imbalance appear to use a strategy more focussed on efficiency [8]. The first is that the younger children are using the same strategy and therefore there is very little variation within the young group, the 4 and 5-year-old children use the same postural muscle sequence as the older, but with less consistency is also typical of feedback postural development [16].

Table No 4 Suggests that the there is a significant difference in Males and Females between 8 and 9 Years of Age. The Myelination of the Corpus Callosum takes place faster in Females than Males [14].

Conclusions

The PBS Scores showed a positive correlation as age advances. By the age of 10, children achieved the maximum score of 56 compared to adult. Out of the 14 items of PBS, 6 Items were major determinants of Postural Control E.g. Item No 6,7,8,9, 11,14. Postural Control was better in girls than in boys significantly different at 8 and 9 years of age.

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