International Journal of Physiotherapy and Research,
Int J Physiother Res 2019, Vol 7(4):3173-80. ISSN 2321-1822
DOI: https://dx.doi.org/10.16965/ijpr.2019.147

Original Research Article

PERFORMANCE OF CHILDREN WITH DOWN SYNDROME ON PEDIATRIC CLINICAL TEST OF SENSORY INTERACTION IN BALANCE (P-CTSIB): A DESCRIPTIVE STUDY

Zuhra Farheen *[1], Pallavi Wajapey [2], Pruthviraj. R [3].

[*1] Physiotherapist, RV College of Physiotherapy, Bangalore, Karnataka, India.
[2] Assistant Professor, RV College of Physiotherapy, Bangalore, Karnataka, India.
[3] Principal and Professor, RV College of Physiotherapy, Bangalore, Karnataka, India.

ABSTRACT

Background: Down syndrome is a genetic disorder attributed to chromosomal abnormality. Children with Down syndrome have low score on balance and agility tasks as well as on running speed, strength and visual-motor control. Pediatric clinical test of sensory interaction in balance (P-CTSIB) was used to assess which component amongst visual, vestibular and somatosensory was more involved in causing this imbalance in children. The aim of this study was to determine the effects of individual sensory component on stationary standing posture control and balance using P-CTSIB.

Results: Min and max time required to perform the balance test was noted down with mean SD of max 21.03±1.28 and min 7.32±1.18. ANOVA and Students t test were used for analysing data. It was found that the measure of balance on all 6 conditions of P-CTSIB was better for boys compared to girls and is also better with increase in age. Children with Down syndrome have weak performance when only the vestibular system was available for maintaining balance and the visual and somatosensory systems were compromised.

Conclusion: The findings of the present study concluded that children with Down syndrome performed better in condition1 were all the systems were available to maintain balance and the poor balance was noted in condition 6 were vestibular system was the only available sensory system for maintaining balance. Poor performance was noted at the early stage of life and was slight better as the age advanced with boys performing better than girls. Balance in children with Down syndrome is an important aspect to be considered during rehabilitation. Including the visual, vestibular and somatosensory system individually and in combination during rehabilitation will help improve the balancing skills of patients.

KEY WORDS: Down syndrome, Pediatric clinical test of sensory interaction in balance (P-CTSIB), Balance.

Address for correspondence: Dr. Zuhra Farheen, PT., Physiotherapist, RV College of Physiotherapy, Bangalore, Karnataka, India. **E-Mail:** zuhrafarheen.a@gmail.com

Access this Article online	Journal Information
Quick Response code	**International Journal of Physiotherapy and Research**
	ICV for 2016 86.93
	ISSN (E) 2321-1822 | ISSN (P) 2321-8975
	https://www.ijmhr.org/ijpr.html
	DOI-Prefix: https://dx.doi.org/10.16965/ijpr
DOI: 10.16965/ijpr.2019.147	

Article Information

Received: 26 Apr 2019	Accepted: 09 Jun 2019
Peer Review: 26 Apr 2019	Published (O): 19 Aug 2019
Revised: None	Published (P): 19 Aug 2019

BACKGROUND

Down syndrome (DS) is a genetic disorder attributed to chromosomal abnormality resulting in 47 chromosomes instead of 46 [1-3]. It is commonly called as Trisomy 21 and is one of the most common developmental disability which affects both the gross motor and fine motor skills of children [4,5]. DS is a condition in which extra genetic material causes delays in the way a child develops, and often leads to mental retardation [6]. They have unique physical, neurological, musculoskeletal, sensorimotor, and learning and communication characteristics that can impact each other as well as the individual's ability to develop age appropriate skills.

Individuals with Down syndrome tend to exhibit joint laxity, excessive hip abduction and external rotation, asymmetrical or excessive range of motion and difficulty in initiating movement. They tend to avoid weight bearing, weight shifts and trunk rotation and have difficulty with equilibrium, balance, protective response and graded muscle movement. All of these factors contribute to the use of wide base of support in sitting, standing, balancing and delay in locomotion [7].

In 1866 British physician, John Langdon Down, from whom the syndrome is now named, first described Down syndrome, as "Mongolism". Later in early 1970's the term Down syndrome was accepted. According to WHO the estimated incidence of DS is between 1 in 1,000 to 1 in 1,100 live births worldwide. Each year approximately 3,000 to 5,000 children are born with this chromosome disorder and it is believed there are about 250,000 families in the United States of America who are affected by DS [8]. According to Centre of Medical Genetics, every year between 23,000 and 29,000 children are born in India with DS, which is the highest in the world [9].

Children with DS have low scores on balance and agility tasks as well as on running speed, strength and visual-motor control when compared to children with other mental impairments [10,11]. Balance and postural stability refers to the state of bodily equilibrium or the ability to maintain the Centre of body mass over the base of support [12]. It involves controlling the body's position in space for the purposes of stability limits and orientation and controlling the body's position without change in base of support [13].

The integration of visual, vestibular and somatosensory components is used to maintain one's postural balance. Postural control represents a complex interplay between the sensory systems which involves perceiving environmental stimuli, responding to alterations and maintaining the body's centre of gravity within the base of support [14].

The primary sensory information to maintain postural balance is the visual system. Although the vestibular input is difficult to isolate and has not been studied extensively, it appears to work together with the visual and somatosensory system to maintain postural control [15]. The somatosensory system is also involved in maintaining postural balance by making the body's musculoskeletal framework aware of the spatial and mechanical status regarding sense of position, movement and balance. Therefore it may be interesting to measure these various components interacting to maintain postural balance.

The goal is to identify the effects of individual sensory component on stationary standing posture control using (P-CTSIB) Pediatric Clinical Test of Sensory Interaction in balance. Occurrence of balance and coordination problem in children with Down Syndrome supports the view that a test to determine the effects of sensory system on standing stationary postural control has to be evaluated in order to formulate an inclusive treatment plan concentrating on both motor and sensory aspects of balance.

METHODOLOGY

Place: Special schools and rehabilitation centers located in Bangalore. Fame India special education school, J.S.S Sahana Integrated and special school.

Participants: Sample consists of 50 children with Down syndrome of both genders, age group between 5 years to 15 years. Exclusion criteria was set as children with severe congenital conditions other than Down syndrome, children with ear infection or ear dysfunction, Visually challenged DS children and Children with severe mental retardation.

A written informed consent was obtained from the parents/guardians of included children. The study was approved by the ethical committee of R V College of Physiotherapy® Bangalore.

Study Design: Cross sectional study at selected special schools.

Purpose of the test: This test is designed to assess how well a child is using sensory inputs when one or more sensory systems are compromised. There are 6 conditions listed under the scale and children with DS are made to go through each of these conditions in the order mentioned in Table 1.

Subject preparation: Before starting the test, subject was instructed to take off the shoe and

the demographic data was noted down. Subject was assessed for any other deformities before starting the test to meet the inclusion criteria.

Environment for testing: Environment with limited distractions allowing subject to focus on balance task was used.

Table 1: Sensory system available and compromised in the six conditions of the Pediatric clinical test of sensory interaction for balance (P-CTSIB).

Conditions	Sensory system Available	Sensory system compromised
Condition 1 Firm surface, eyes open	Vision, somatosensory, vestibular	-
Condition 2 Firm surface, eyes closed	Somatosensory, vestibular	Absent vision
Condition 3 Firm surface, visual conflict dome	Somatosensory, vestibular	Inaccurate vision
Condition 4 Foam surface, eyes opened	Vision, vestibular	Inaccurate somatosensory
Condition 5 Foam surface, eyes closed	Vestibular	Absent vision, Inaccurate somatosensory
Condition 6 Foam surface, visual conflict dome	Vestibular	Inaccurate somatosensory and vision

Procedure: subject completed 3 trials of each of the 6 conditions (with hands on hips): stand on firm surface eyes open, stand on firm surface eyes closed, stand on firm surface with visual conflict dome, stand on foam eyes open, stand on foam surface eyes closed, stand on foam with visual conflict dome for a maximum time of 30seconds. The subject completed all 6 conditions in narrow base of support with medial malleoli touching as per protocol.

Statistical analysis: Descriptive and inferential statistical analysis has been carried out in the present study. Results on continuous measurements are presented on Mean ± SD (Min-Max) and results on categorical measurements are presented in Number (%). Significance is assessed at 5 % level of significance. The following assumptions on data is made.

Assumptions: 1. Dependent variables should be normally distributed, 2. Samples drawn from the population should be random, Cases of the samples should be independent.

Analysis of variance (ANOVA) has been used to find the significance of study parameters between three or more groups of patients, Student t test (two tailed, independent) has been used to find the significance of study parameters on continuous scale between two groups.

Inter group analysis on metric parameters, Student t test (two tailed, dependent) has been used to find the significance of study parameters on continuous scale within each group.

Significant figures

+Suggestive significance (P value: 0.05<P<0.10)

*Moderately significant (P value: 0.01<P</=0.05)

**Strongly significant (P value: P</=0.01)

Statistical software: Statistical software: The Statistical software namely SAS 9.2, SPSS 15.0 were used for the analysis of the data and Microsoft word and Excel have been used to generate graphs, tables etc.

RESULT

Data collected for the study were analysed using appropriate statistical test and results are given in terms of test materials, tables and figures.

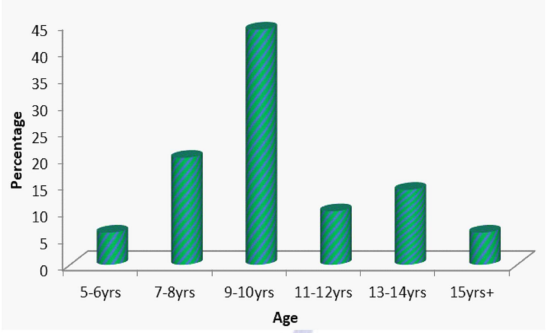
In the present study 50 students (25 boys &25girls) were included based on inclusion and exclusion criteria. The percentage of students was more in the age group of 9-10years i.e. 44%. Balance was measured on all 6 conditions of P-CTSIB and it was found that balance of children with DS was affected in all the conditions with condition6 greatly affected with p value <0.001**. It was found that the measure of balance on condition 6 was better for boys compared to girls and is also better with increase in age.

Table 2: Age distribution of subjects studied.

Age in years	No. of subjects	%
5-6yrs	3	6
7-8yrs	10	20
9-10yrs	22	44
11-12yrs	5	10
13-14yrs	7	14
15yrs+	3	6
Total	50	100

The above table describes the number of subjects in each age category and percentage of each age group.

Fig. 1: Age distribution of subjects studied.



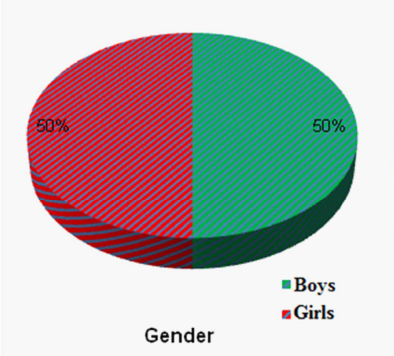
The above fig represents the percentage of subjects in each age group of the study. Highest students being in the age group of 9-10 years

Table 3: Gender distribution of subjects studied.

Gender	No. of subjects	%
Boys	25	50
Girls	25	50
Total	50	100

The above table describe the gender distribution in the study.

Fig. 2: Gender distribution of subjects studied.



The above fig shows the percentage of the gender in the study were 50% is girls and 50% is Boys.

Table 4: Comparison of P-CTSIB pediatric clinical test of sensory interaction on balance (in seconds) in different conditions according to gender.

Condition	Gender		Total	P value
	Boys	Girls		
Condition 1	21.18±1.29	20.88±1.28	21.03±1.28	0.404
Condition 2	20.73±1.33	20.66±1.46	20.70±1.39	0.868
Condition 3	19.73±1.67	20.37±1.57	20.05±1.64	0.17
Condition 4	8.84±1.24	8.50±1.17	8.67±1.20	0.333
Condition 5	8.29±1.15	8.21±1.36	8.25±1.25	0.822
Condition 6	7.32±1.06	7.32±1.32	7.32±1.18	1

The above table describe the performance of boys and girls on the P-TSIB scale.

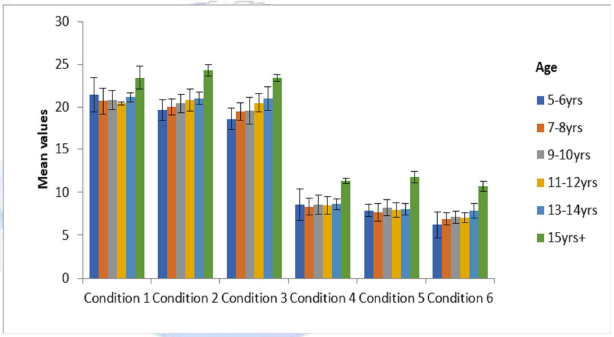
Table 5: Comparison of P-CTSIB (in seconds) in difference conditions according to age in years.

Condition	Age in years						P value
	5-6yrs	7-8yrs	9-10yrs	11-12yrs	13-14yrs	15yrs+	
Condition 1	21.44±2.01	20.73±1.51	20.86±1.10	20.46±0.18	21.19±0.54	23.44±1.34	0.016*
Condition 2	19.66±1.21	20.06±0.94	20.48±1.06	20.86±1.31	21.04±0.71	24.33±0.67	<0.001**
Condition 3	18.66±1.21	19.53±1.00	19.60±1.53	20.53±1.04	21.00±1.36	23.44±0.38	<0.001**
Condition 4	8.55±1.84	8.33±0.96	8.54±1.12	8.46±1.05	8.61±0.59	11.33±0.33	0.003**
Condition 5	7.88±0.69	7.66±0.99	8.22±0.94	7.93±0.83	8.04±0.65	11.78±0.69	<0.001**
Condition 6	6.22±1.50	6.90±0.70	7.09±0.71	7.06±0.60	7.85±0.88	10.66±0.58	<0.001**

The above table explains the performance in each age group of all 6 conditions.

The following set of figures will explain DS children's' responses in each condition on P-CTSIB according to age.

Fig. 3: Comparison of P-CTSIB (in seconds) in different conditions according to age in years.



The above fig represents the performance of all the subjects in all 6 conditions where the performance of subjects (boys and girls) was better in condition1 whereas condition6 was more affected in balance.

Fig. 4: Condition 01.

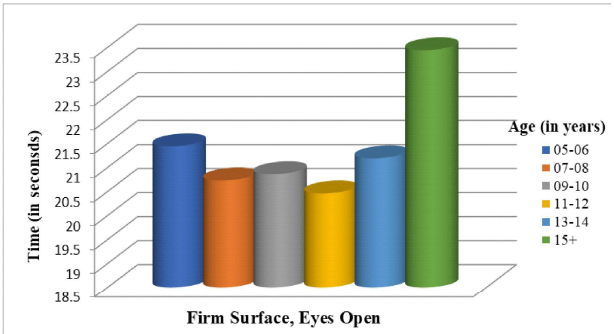
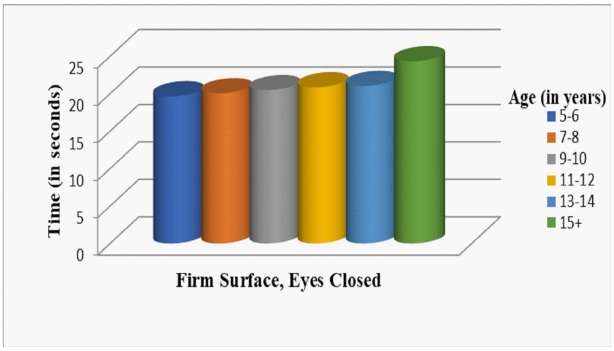


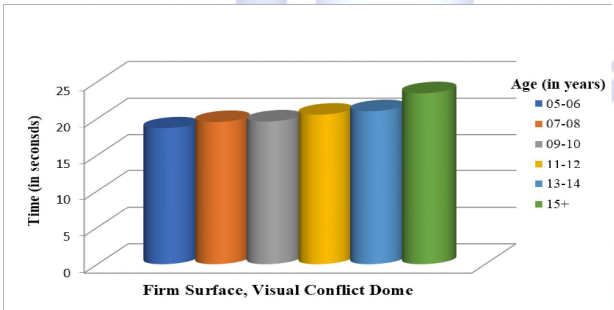
Fig. 5: condition 02.



When Vision, somatosensory and vestibular systems (all 3) were available for maintaining balance subjects of age 11-12years performed poor with mean score of 20.46±0.18 seconds, were as 15year olds performed better than all with mean score of 23.44±1.3.

When somatosensory and vestibular were available for balance and vision is absent, performance of all the children was similar to each other with slight variations, group of 5-6years performed poor with mean score of 19.66±1.21,15 year olds performed better with mean score of 24.33±0.67.

Fig. 6: Condition 03.



When somatosensory, vestibular were available and vision was inaccurate the performance of the subjects was same as in condition 02 with mean score 18.66±1.21 and 23.44±0.38 respectively.

Fig. 7: Condition 04.

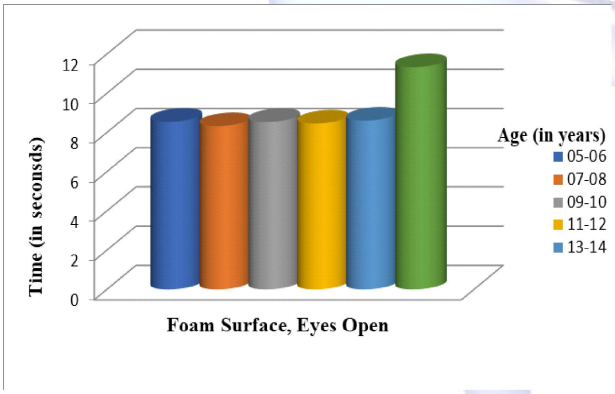
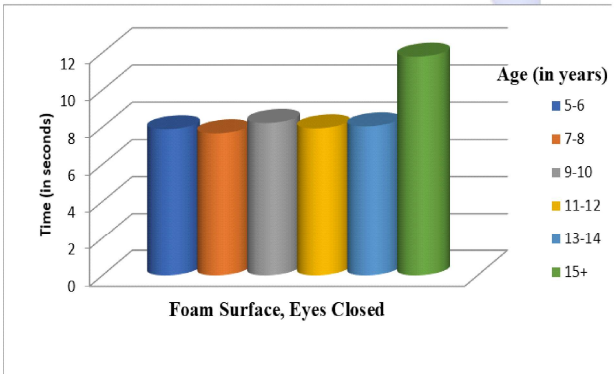


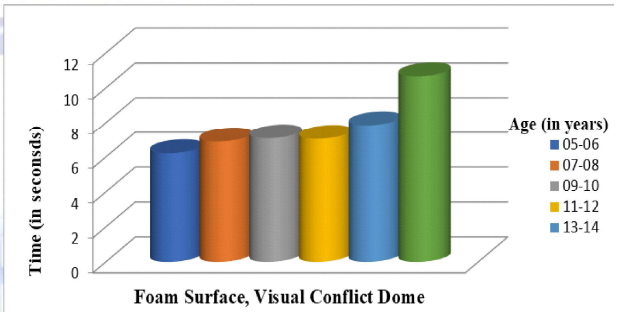
Fig. 8: Condition 05.



When vision and vestibular is available whereas somatosensory system is inaccurate the performance of all age groups were similar with age of 7-8years being the least with mean score of 8.33±0.96 and the better performance was given by those of 15 years with mean score of 11.33±0.33.

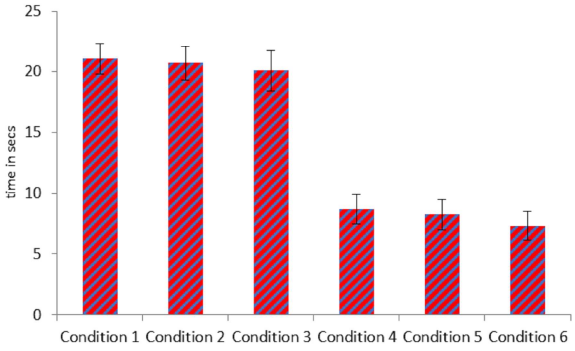
When vestibular system was the only system available for balance where vision was absent and somatosensory system was inaccurate the performance of the DS children was poor in 7-8 years age group with mean score of 7.66±0.99, better performance was given by 15years with mean score of 11.78±0.69.

Fig. 9: Condition 03.



When vestibular system was only available for balance whereas vision and somatosensory system was inaccurate the performance was very poor in all the age groups compared to other conditions. The poorest performance was given by age group of 5-6 years with the mean score of 6.22±1.50 and the better performance was given by 15 year olds with mean score of 10.66±0.58.

Fig. 10: Descriptive statistics of P-CTSIB in seconds.



The above fig explains the time taken by all the subjects (girls and boys) in each condition, were the max time of balance was in condition least balance was maintained in condition 06

Condition 1: Firm surface, eyes open.

Condition 2: Firm surface, eyes closed.

Condition 3: Firm surface visual dome.

Condition 4: Foam surface, eyes open.

Condition 5: Foam surface, eyes closed.

Condition 6: Foam surface visual dome.

DISCUSSION

The present study determined balance performance in the children with Down syndrome aged between 5 years to 15 years using Pediatric clinical test of sensory interaction with balance (P-CTSIB). The three systems in the body i.e.; vision, vestibular and somatosensory systems have direct impact on balance hence, understanding balance in developing children will help to detect any persistence of lack of balance beyond a certain age of development, and also to provide scope for timely intervention to prevent any possible deformities and dysfunction caused by balance issues.

A study conducted by Mohammed T. Ghannoum et al [16] on balance in Down syndrome with middle ear problems concluded that the sensory analysis of balances showed a significant difference in visual and vestibular function, this might lead one to suspect central and proprioceptive causes behind balance problems in Down syndrome, but the was inconclusive and author has recommended further extended studies to confirm this hypothesis. Keeping this in view we have excluded children with middle ear problems so that central causes and proprioceptive causes can be ruled out and do not affect the outcome the present study.

A previous study conducted by Pandian et al [17] on healthy Indian children to find the concurrent validityon P-CTSIB using force plate concluded that the scale is valid to check balance in Indian children, hence this scale was selected for the present study. Sophisticated merchandise like Force plates were not used in this study and can be counted as one of the drawbacks.

Mohamed T. Ghannoum et al [18] conducted study titled "Balance problems in Down syndrome children: various sensory elements and contribution to middle ear problems" where he concluded that the sensory analysis of balance using SOT in DS and an age matched control group showed a significant difference in visual and vestibular function. These two areas were found to be affected in the present study as well, this emphasizes the need to include visual and vestibular training in children in DS to train their balancing abilities.

Balance in DS children improves with the increase in the age as seen in this study. DS children have delayed milestones with poor balance and motor coordination, they tend to walk later than their typical peers, they often lack balance and have low muscle tone and poor postural control which have all contributed to poor posture and balance system as proved by Alberto C. S. Costa [19] in his study titled "altered cerebella is found in those with down syndrome: accounts for poor motor skills, coordination". Our study stratified DS children into different age groups to compare their balance skills as age progressed. The results found that age influences the performances of these children, their scores improved on P-CTSIB as their age advanced. This improved balance can be attributed to building up of tone, improved base of support and improvement in postural control as the child grows older.

In the present study we have used P-CTSIB to evaluate the components of balance in children with DS as there were no previous studies done using this scale in children with DS. The scale identified the effects of individual sensory component on stationary standing posture control and balance. It pointed out that children could perform best when all 3 sensory systems were available to maintain balance. These results were replicated in normal children [17] as well as in those with CP [20], having vision and somatosensory system occluded increased the load on an already compromised vestibular system and caused maximum imbalance in this situation.

Treatment protocols should concentrate on training in all the 3 sensory areas when treating Down syndrome children with balance and postural control issues. Performance of children was highly compromised in the condition 6 where only vestibular system was available, suggesting that visual and somatosensory rehabilitation exercises could bring about improvement in balance functions. Training children on different surfaces with variety of visual exposure should be included as a routine protocol when training children with DS for balance and postural control.

CONCLUSION

The performance of children with Down syndrome on Pediatric clinical test of sensory

interaction for balance P-CTSIB was established, it showed that children performed best when all 3 sensory systems were available for testing balance and performed worst when only vestibular system was available for maintaining balance, occluding visual and somatosensory system.

The study concluded that performance of children with Down syndrome was poor at the early stage of life and improved slightly as the age advanced. It was also concluded in general that boys performed better than girls, although it was not statistically significant. The P-CTSIB is a helpful tool to assess balance in children with DS and can be used as a prognostic tool as well. Planning a treatment including all 3 sensory systems can bring quantitative and qualitative improvement in balance and postural system for children with DS.

Limitations and recommendation: The present study has following limitation and recommendations:

The study was conducted on a small sample size, performing it on larger sample will help to generate age wise data for balance using P-CTSIB which can be used to compare new cases of DS. Degree of sway was not assessed in the present study hence, it is recommended to consider this in further studies for more clear results. Further studies can be conducted for comparison between boys and girls on each condition of P-CTSIB.

Acknowledgement:

I owe my deepest gratitude to all the staffs of RV College of Physiotherapy for their consistent encouragement. .My sincere thanks goes to all the subjects for participating in this study.

Conflicts of interest: **None**

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How to cite this article: Zuhra Farheen, Pallavi Wajapey, Pruthviraj. R. PERFORMANCE OF CHILDREN WITH DOWN SYNDROME ON PEDIATRIC CLINICAL TEST OF SENSORY INTERACTION IN BALANCE (P-CTSIB): A DESCRIPTIVE STUDY. Int J Physiother Res 2019;7(4):3173-3180. **DOI:** 10.16965/ijpr.2019.147