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Original Article

TO STUDY THE EFFECTS OF VESTIBULAR STIMULATION USING THE VESTIBULATOR ON THE MUSCLE TONE AND REFLEX RESPONSES IN CHILDREN WITH CEREBRAL PALSY

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ABSTRACT

The present study was carried out to give preliminary data on positive effects of vestibulator on different types of cerebral palsy children using Vestibulator to see the effect of controlled vestibular stimulation on muscle tone, reflex responses and the ability to balance at Posat foundation rehabilitation centre during December 2017 to March 2018. Clinical trial was carried out with 24 sessions on vestibulator and the results were statistically analysed.

KEYWORDS: Cerebral Palsy, Vestibulator & Vestibular Stimulation

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INTRODUCTION

Vestibular System includes Central and Peripheral system. The Central Vestibular System comprises of relaying nuclei and pathways passing through and entering the brainstem at the ponto-medullary junction.1 Peripheral Vestibular System comprises of five end organs placed within the labyrinth of the inner ear and the vestibular portion of the vestibule-cochlear nerve (Jonas 2009). Cerebral palsy is the leading cause of childhood disability affecting function and development. (Jones.2007) This disorder affects the development of movement and posture that is believed to arise from non-progressive disturbances in the developing fetal or infant brain. In addition to the motor disorders that characterize cerebral palsy, which may limit a patient's activities, individuals with cerebral palsy often display epilepsy, secondary musculoskeletal problems, and disturbances of sensation, perception, cognition, communication, and behavior (Bax, 2005). Vestibulator is a therapeutic device designed at industrial research centre IIT and co patented by Transpact Enterprises. The machine has the facility of providing vestibular stimulation in different positions of the child with required speed and desired velocity depending upon the therapeutic need of a particular child. Child is properly supported on the machine in every position e.g. lying down, sitting, kneel standing or standing considering all the safety measures.

Objective

The purpose of the clinical trial is to provide the enhance treatment beneficial long term positive effects and overall review of vestibulator therapeutic device designed by Industrial research Center of IIT Mumbai and co patented by Transpact Enterprises Private Limited. 2. Role of vestibulator stimulation to subject affected by Cerebral palsy,

Autism and ADHD. 3. Response of subjects to movement of muscles and balance support. 4. Subject response to vestibulator and its statistical analysis. 5. Some important observation during the sessions.

METHODOLOGY

The Vestibulator is a patented scientific therapeutic device invented by Industrial research Center of IIT Mumbai and co patented by Transpact Enterprises Private Limited. It aims to provide vestibular stimulation to pediatric population affected by conditions like cerebral palsy, autism and ADHD. It can provide the following movements:

- Anteroposterior tilts – the client can be moved through a maximum of 30 degrees from the horizontal both in anterior as well as posterior directions. The client can be given treatment to focus on both tilts simultaneously or only in one direction.
- Lateral tilts - The client can be moved 30 degrees to the right and left or either one depending on the requirement.
- Rotations – The client can be provided clock wise as well as anti clockwise rotations
- Horizontal accelerations– The client can be provided a maximum of 280 mm of movement in a sliding motion (forward and backward)
- Vertical accelerations – The client is provided with an up and down movement to a maximum of 140 mm.

The speed of these movements as well as the number of cycles can be modified depending on the requirement. The client can be provided these movements in a variety of positions – supine, prone, chair sitting, long- sitting, cross legged sitting, kneeling, crawling as well as standing. Personalized treatment combinations can be stored as patient data for purpose of monitoring and comparing. 5 point harnessing system and emergency stop switches are provided to ensure safety of the client.

Subjects: (Inclusion Criteria)

- Children between 3-11 years of age
- Confirmed diagnosis of cerebral palsy
- Children with active epileptic episodes were not taken in the study
- Children with severely impaired cognitive abilities were also excluded from the study

Number of Children: A target of 30 children was set, however only 24 children were finally enrolled. Over the course of the trial, 3 children opted out due to various reasons bringing the final number of children to 21.

Duration: The duration of the study is 3 months which consists of 24 session's i.e. two session /week. Each session lasts for 30 minutes.

Population Characteristics: Spastic quadriplegia – 4, Spastic diplegia – 6, Hypotonia- 4, Hemiplegia- 3, Ataxia- 3, Athetoid – 1

Gender ratio: Girls to boys = 8:13

Process of Consent: A meeting was held before the trail with the parents of the participating children to explain the nature of the clinical trial, the product that was going to be investigated and how it was likely to impact their children. All questions pertaining to the same were answered to the parents' satisfaction. A video of the product was also shown at

the time. The parental consent form was signed after one trial session as per the parent's request.

Assessment Protocol: The physiotherapist involved in the clinical trial used the following standardized tests to measure the outcomes –

- **Modified Tardieu Scale**– it has been found to be a valid, reliable and sensitive abridged version of the Tardieu Scale. The angle of catch at most rapid velocity (R1) and the joint angle when muscle length is maximum (R2) when moved using slow passive movement. The difference in degrees between R2 and R1 is referred to as the dynamic component of spasticity.
- **Early Clinical Assessment of Balance**– It quantifies deficits in balance that may be present in specific pediatric populations.
- **Pediatric Balance Scale** – It examines functional balance in the context of everyday tasks in the pediatric population. Steady state and anticipatory balance activities are performed with and without visual inputs

These assessments were done at the beginning of treatment and repeated after the 12^{th} and 24^{th} session.

The respective therapists were also provided with an assessment form to be filled at the beginning of the clinical trial, after 12 sessions and at the end of 24 sessions.

Treatment Protocol

- **Frequency of Sessions:** Treatment sessions were provided twice a week for 3 months. thus making a total of 24 sessions
- **Position of the Child:** The position of the child was progressed from postures with wide base of support – for example, sitting and crawling to those with narrow base of support like kneeling and standing
- **Support:** The support provided to the children was gradually decreased as treatment progressed - for example, standing with support to the back was progressed to standing without support at the back.
- **Range of Motion:** The treatment began with small magnitude and was gradually progressed depending on the response of the child.
- *Speed of the vestibular stimulation* also progressed appropriate to response of the child.
- **Reducing Visual Stimuli:** The children were also provided treatment with their eyes closed, once they had responded well with their eyes open.
- *Assistive devices* like AFOs, pedi wraps, shoes with compensation were used depending on the need of the child during the treatment session.
- A questionnaire was provided to the parents at the end of each session to document the safety of the machine and any adverse reactions that may have occurred during the treatment.

RESULTS

Tone

Cerebral palsy is classified into four broad categories -- spastic, athetoid, ataxic, and mixed forms -- in accordance with the

type of movement disturbance. In spastic cerebral palsy, the muscles are stiff and permanently contracted. Athetoid, or dyskinetic, cerebral palsy is characterized by uncontrolled, slow, writhing movements which affect the hands, feet, arms, or legs and, in some cases, the muscles of the face and tongue, causing grimacing or drooling. Ataxic cerebral palsy affects the sense of balance and depth perception. Affected persons often have poor coordination; walk unsteadily with a wide-based gait, placing their feet unusually far apart and experience difficulty when attempting quick or precise movements, such as writing or buttoning a shirt. It is common for patients to have symptoms of more than one of the previous three forms. The most common mixed form may include spasticity and athetoid movements.

Spasticity develops when an imbalance occurs in the excitatory and inhibitory input to alpha motor neurons which is caused by damage to the spinal cord and/or central nervous system. Ataxia is an outcome of damage to the cerebellum or its connections while athetoid cerebral palsy results from damage to the basal ganglia. (Lewis, 2001)

As mentioned earlier, the Modified Tardieu scale measures the dynamic component of spasticity. The post test results of the Modified Tardieu Scale have shown a decrease in the dynamic component in the hamstrings as well as TA in most children (highlighted in red)as compared to the dynamic component present before the trial .

It is to be noted that children with no change in dynamic component (highlighted in blue) fell under 2 categories– those whose passive Range of Motion had increased or those whose muscles were already in contracture.

It is also to be noted that 2 children showed an increase in the dynamic component of the hamstrings on one side while 1 showed an increase in the dynamic component of the TA also on one side. (highlighted in green). Both children had missed considerable sessions on the Vestibulator as well as with their respective therapist.

DISCUSSIONS

The Vestibulator allowed providing graded and consistent changes in the support surface. The therapist provided tactile as well as verbal inputs to the child regarding appropriate response which was correctly learned over a period of a time. The child was weaned off these inputs slowly till he/she was able to make these adjustments more automatically. In order to allow for more vestibular and somato sensory feedback to make these postural adjustments, the child was blindfolded, thus cutting off all visual input.

Children with cerebral palsy have an exaggerated reaction to gravity resulting in spasticity. This results in abnormal feedback from the muscles as well as joints. This combined with abnormal patterns of activation result in poor postural control, thus making the child a victim of gravity. It could be thus hypothesized that learning the correct response by providing consistent and graded input would break the cycle and thus normalize the tone.

The MTS – Muscle (Lt Hamstring)

Table 1.1: Pre-Test (R1, R2) and Post Test (R1, R2) MTS – Muscle (Lt Hamstring)

Sl. No.	Name	Muscle	Pre Test R2	Post Test R2	Pre Test R1	Post Test R1	Pre Test R2-R1	Post Test R2-R1
1	faizan	Lt hamstrings	120	130	100	130	20	0
2	vihang	Lt hamstrings	110	125	90	115	30	10
3	raunak	Lt hamstrings	140	130	90	115	50	15

4	sansiya	Lt hamstrings	140	170	120	170	20	0
5	soham	Lt hamstrings	120	120	120	105	0	15
6	atharva	Lt hamstrings	90	150	75	150	15	0
7	Sadaf	Lt hamstrings	125	140	65	135	60	5
8	astha	Lt hamstrings	160	150	160	125	0	25
9	Sarthak r	Lt hamstrings	120	130	90	110	30	20
10	jhanvi	Lt hamstrings	90	150	90	150	0	0
11	krishna	Lt hamstrings	120	170	100	170	20	0
12	samiksha	Lt hamstrings	NA					
	Mean		121.3636	142.2727	100	134.0909		
	Standard deviation		20.7474	17.22841	25.78759	23.11041		
	Standard error		5.989258	4.973414	7.444237	6.6714		

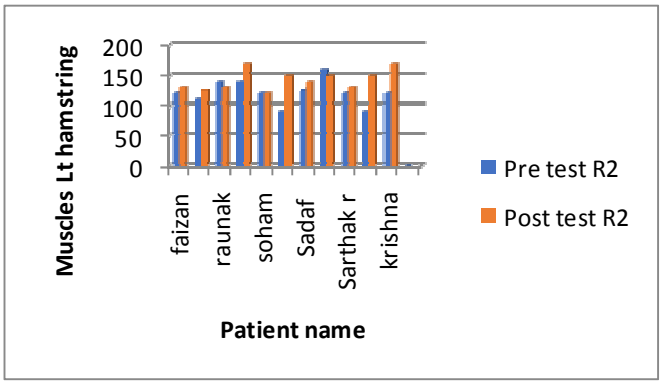

Figure 1.1: Multiple Bar showing the variation of Pre Test R2 and Post Test R2 (MTS – Muscle (Lt hamstring)).

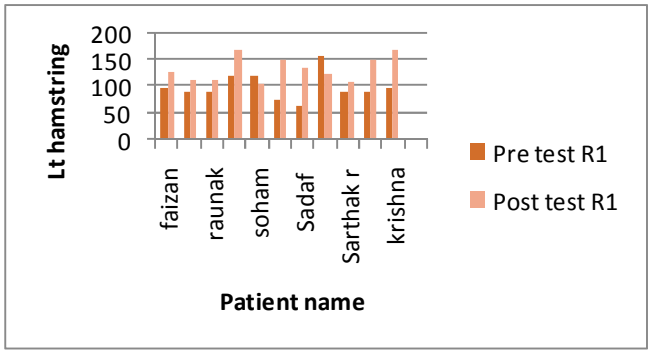

Figure 1.2: Multiple Bar showing the Variation of Pre Test R1 and Post Test R1 (MTS – Muscle (Lt hamstring)).

Table 1.2: Coefficient Correlation of Pre Test and Post Test of R1 and R2.

	Pre Test R1	Post Test R1		Pre Test R2	Post Test R2		Post Test R1	Post Test R2
Pre Test R1	1		Pre test R2	1		Post test R1	1	
Post Test R1	-0.06292	1	Post test R2	0.08838	1	Post test R2	0.934993	1

Discussion: Unayik & Kahiyan (2011) in his article ―Down Syndrome: Sensory Integration, Vestibular Stimulation and Neuro developmental Therapy Approaches for Children‖ described that the role of vestibular system is important in the achievement of normal motor development and coordination (Shumway & and Cook, 1992). The vestibulator of IIT is designed to improvise the development and coordination of muscles. Table 1.1 showing left muscle hamstring pre test R2 and Post test R2 there is improvement in each subject. Mean of Post R2 is 142.2727 and is greater than pre test R2 (121.3636) whilst comparing the standard deviation, it is spread out in graph. Both the multiple bar diagram depicts each subjects improvement after undergoing vestibulator treatment. The coefficient correlation table 1.2 of post treatment of R1 and R2 (0.934993), A perfect linear relationship is obtained and clearly shows how strongly and effectively the vestibulator is working and improving the development and coordination in each subject.

The MTS – hamstrings (RT hamstring)

Table 2.1: Pre-Test (R1, R2) and Post Test (R1, R2) MTS – Muscle (Rt Hamstring)

Sl. No.	Name	Muscle	Pre Test R2	Post Test R2	Pre Test R1	Post Test R1	Pre Test R2-R1	Post Test R2-R1
1	faizan	Rt hamstrings	120	150	100	150	20	0
2	vihang	Rt hamstrings	120	135	90	125	30	10
3	raunak	Rt hamstrings	140	110	120	110	20	0
4	sansiya	Rt hamstrings	140	170	110	170	30	0
5	soham	Rt hamstrings	130	110	90	90	40	20
6	atharva	Rt hamstrings	75	130	75	130	0	0
7	Sadaf	Rt hamstrings	95	120	60	110	30	10
8	astha	Rt hamstrimgs	120	150	90	125	30	25
9	Sarthak r	Rt hamstrings	130	135	110	120	20	15
10	jhanvi	Rt hamstrings	130	170	130	170	0	0
11	krishna	Rt hamstrings	NA					
12	samiksha	Rt hamstings	130	150	130	150	0	0
	Mean		120.909091	139.090909	100.454545	131.818182		
	Standard deviation		19.5982374	21.0734646	22.1872199	25.5218267		
	Standard error		5.65752382	6.08338522	6.40489869	7.36751675		

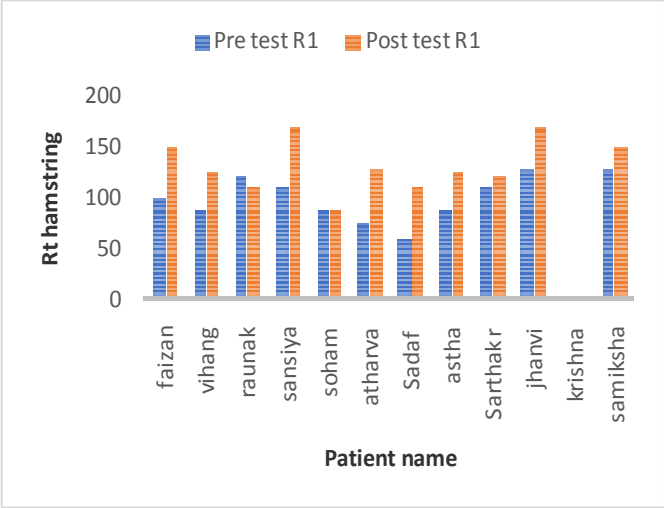

Figure 2.1: Multiple Bar Showing the Variation of Pre Test R1 and Post Test R1(MTS – Muscle (Rt Hamstring)).

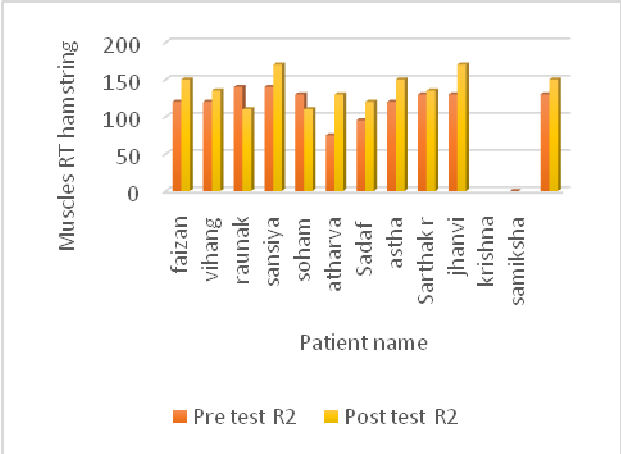

Figure 2.2: Multiple Bar Showing the Variation of Pre Test R2 and Post Test R2 (MTS – Muscle (Rt Hamstring)).

Table 2.2 Showing Coefficient Correlation of Pre Test and Post Test of R1 and R2

	Pre Test R1	Post Test R1		Pre Test R2	Post Test R2		Post Test R1	Post Test R2
Pre Test R1	1		Pre test R2	1		Post test R1	1	
Post Test R1	0.52818	1	Post test R2	0.24433	1	Post test R2	0.937685	1

DISCUSSIONS

Vestibular system when stimulated elicits responses that facilitate, muscles, to evoke movements of head, trunk and limbs to compensate for postural sway. The cerebellum with input from the vestibular system provides balance, orientation & coordination (Ottenbacher K, 1983). The vestibulator which is used for treatment of subjects is to evoke movements of rights muscles hamstring so as to provide balance and orientation. Table 2.1 showing right muscle hamstring pre test R2 and Post test R2, there is positive progress in each subject. Mean of Post R2 is 139.090909 and is greater than pre test R2

(120.909091) whilst comparing the standard deviation, it is spread out in graph. Both the multiple bar diagram depicts each subjects development after undergoing vestibulator treatment. The coefficient correlation table 2.2 of post treatment of R1 and R2 (0.93785), A perfect linear relationship is obtained and evidently shows how strappingly and successfully the vestibulator is functioning and improving the development and coordination in all subject. All the coefficient correlation data was showing a strong positive relationship.

The MTS -plantar flexors (TA) (Lt Hamstring)

Table 3.1: Showing Pre-Test (R1, R2) and Post Test (R1, R2) The MTS -Plantar Flexors (TA) (Lt Hamstring).

Sl. No.	Name	Muscle	Pre Test R2	Post Test R2	Pre Test R1	Post Test R1	Pre Test R2-R1	Post Test R2-R1
1	faizan	Lt TA	100	120	90	120	10	0
2	vihang	Lt TA	110	120	90	120	20	0
3	raunak	Lt TA	90	110	90	110	0	0
4	sansiya	Lt TA	100	110	80	110	20	0
5	soham	Lt TA	90	110	90	110	0	0
6	atharva	Lt TA	90	90	70	90	20	0
7	Sadaf	Lt TA	90	90	70	90	20	0
8	astha	Lt TA	110	120	90	120	20	0
9	Sarthak r	Lt TA	90	90	70	70	20	20
10	jhanvi	Lt TA	90	110	90	90	0	20
11	krishna	Lt TA	90	110	90	110	0	0
12	samiksha	Lt TA	NA					
13	twisha	Lt TA	NA					
14	arnica	Lt TA	NA					
15	aaricia	Lt TA	NA					
	Mean		95.45454545	107.2727273	83.63636364	103.6363636		
	Std dev		8.201995323	11.90874392	9.244162777	16.29277587		
	SE		2.192075456	3.18274569	2.470606424	4.354427512		

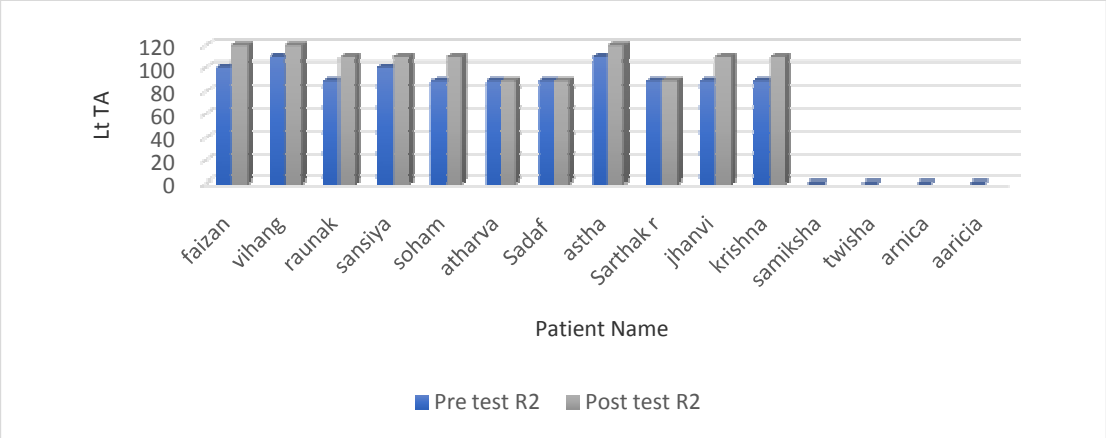

Figure 3.1: Multiple Bar Showing the Variation of Pre Test R2 and Post Test R2 The MTS -Plantar Flexors (TA) (Lt Hamstring)

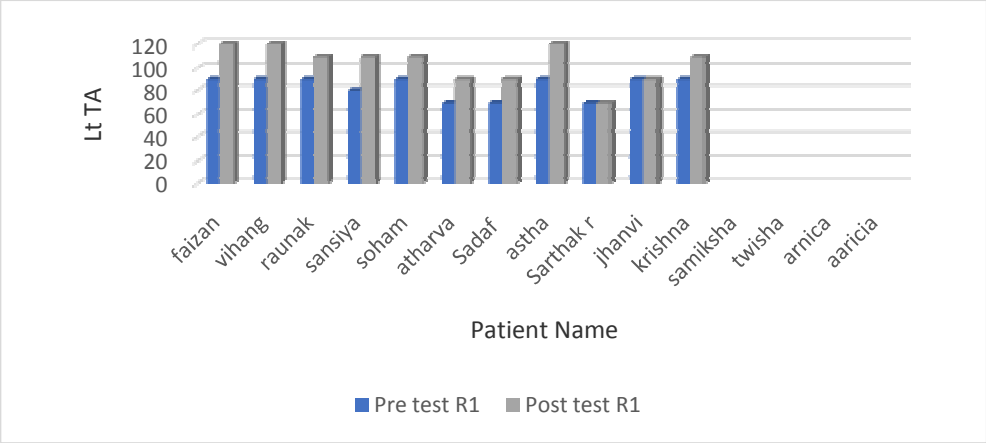

Figure 3.2: Multiple Bar Showing the Variation of Pre Test R1 and Post Test R1 The MTS -Plantar Flexors (TA) (Lt Hamstring).

Table 3.2: Showing Coefficient Correlation of Pre Test and Post Test of R1 and R2

	Pre Test R1	Post Test R1		Pre Test R2	Post Test R2		Post Test R1	Post Test R2
Pre Test R1	1		Pre test R2	1		Post test R1	1	
Post Test R1	0.766564	1	Post test R2	0.67943	1	Post test R2	0.880854	1

The MTS -Plantar Flexors (TA)(RT)

Table 4.1: Pre-Test (R1, R2) and Post Test (R1, R2) The MTS -Plantar Flexors (TA) (Rt Hamstring)

Sl. No.	Name	Muscle	Pre Test R2	Post Test R2	Pre Test R1	Post Test R1	Pre Test R2-R1	Post Test R2-R1
1	faizan	Rt TA	100	120	90	120	10	0
2	vihang	Rt TA	90	120	70	120	20	0
3	raunak	Rt TA	90	90	90	90	0	0
4	sansiya	Rt TA	110	110	90	110	20	0
5	soham	Rt TA	90	110	90	110	0	0
6	atharva	Rt TA	90	90	70	90	20	0
7	Sadaf	Rt TA	90	115	40	115	50	0
8	astha	Rt TA	110	110	90	110	20	0
9	Sarthak r	Rt TA	90	70	90	70	0	0
10	jhanvi	Rt TA	90	110	90	110	0	0
11	krishna	Rt TA	NA					
12	samiksha	Rt TA	90	110	90	110	0	0
13	twisha	Rt TA	110	110	90	110	20	0
14	arnica	Rt TA	110	110	110	110	0	0
15	aaricia	Rt TA	90	120	90	120	0	0
	Mean		96.4285714	106.785714	85	106.785714		
	SD		9.28782732	14.0886128	16.0527975	14.0886128		
	SE		2.3981067	3.63766419	4.14481449	3.63766419		

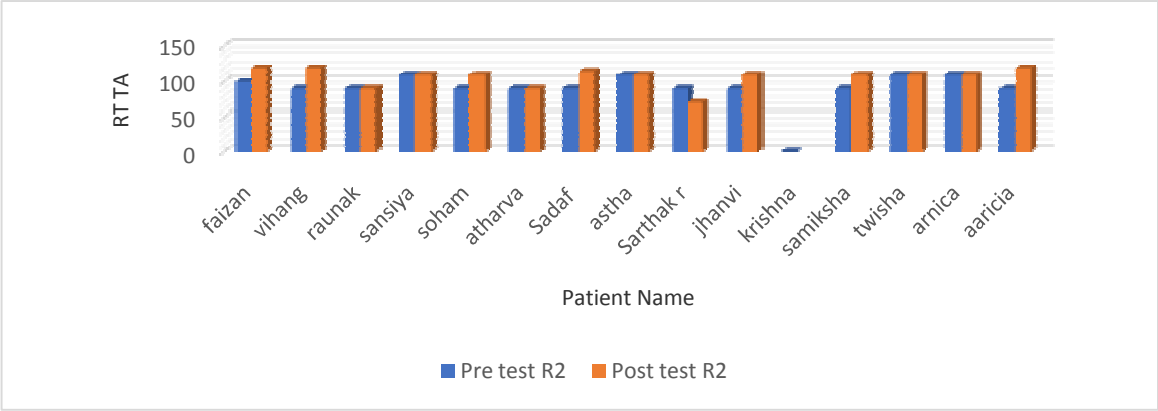

Figure 4.1: Multiple Bar Showing the Variation of Pre Test R2 and Post Test R2 The MTS -Plantar Flexors (TA) (Rt Hamstring).

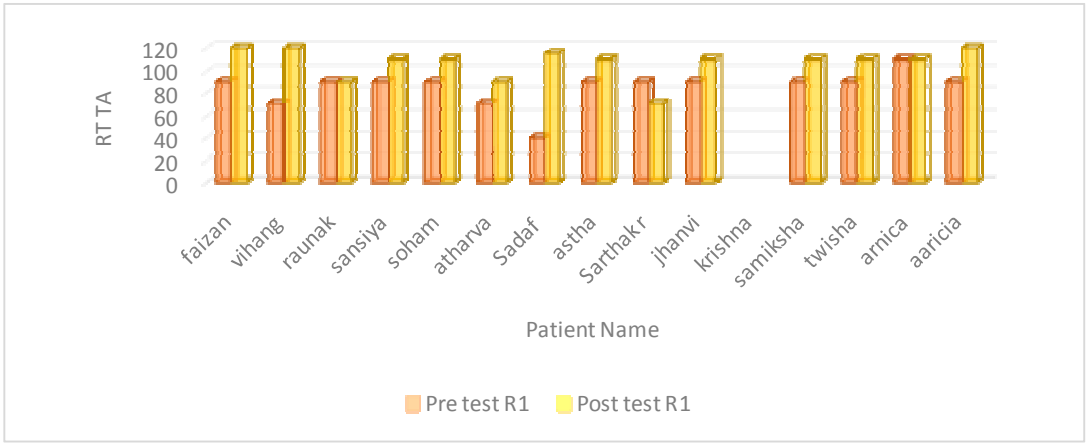

Figure 4.2: Multiple Bar Showing the Variation of Pre Test R1 and Post Test R1 The MTS -Plantar Flexors (TA) (Rt Hamstring).

Table 4.2: Coefficient Correlation of Pre Test and post Test of R1 and R2

	Pre Test R1	**Post Test R1**		**Pre Test R2**	**Post Test R2**		**Post Test R1**	**Post Test R2**
Pre Test R1	1		Pre test R2	1		Post test R1	1	
Post Test R1	-0. 093534	1	Post test R2	0.228846	1	Post test R2	1	1

DISCUSSIONS

Vestibular stimulation over a period of time would improve sensory integration and balance in individual with cerebral palsy (Shamsoddin I, 2009). Vestibular stimulation could enhance arousal level, visual exploratory behavior, motor development and balance and reflex integration in infants who are at risk and in development delay disorders (Behm DG, 2005).). Table 3.1 and 4.1 MTS-planar flexors right and left consistency in the improvement of the every subject owing to which consistency is obtained in mean after pre and post test of treatment. Mean of Table 3.1 of Post R2 is 107.2727273 and is greater than pre test R2 (95.45454545), simultaneously mean of pre test R1 is 83.63636364 which is lower than post treatment i.e. 103.6363636 whilst comparing the table 4.1 the mean of post test R2 is greater than Pre test R2. The standard deviation, it is spread out in graph in both the table 3.1 and 4.1. Both the multiple bar diagram depicts each subjects

development after undergoing vestibulator treatment. All the coefficient correlation data were showing a strong positive linear relationship. The coefficient correlation table 3.2 of post treatment of R1 and R2 (0.880854), and 4.2 is 1 A perfect linear relationship is obtained and evidently convinces that as one variable goes high, the other variable will also go high and giving a effective result when treatment is given via vestibulator.

REFLEX RESPONSES

The Early Clinical Assessment of Balance

The Early Clinical Assessment of Balance consists of 2 parts. The first part consists of automatic reactions including righting, equilibrium and protective reactions. The second part consists of static as well as dynamic balance activities in sitting and standing.

Most children showed a noticeable improvement in the post test scores.

DISCUSSIONS

The integration of visual, vestibular as well as somato sensory input is crucial to the development of postural control. Disruption of any one system results in disruption of postural strategies. In children with cerebral palsy, one or all three systems may be affected – either primarily or secondarily. When these inputs are provided consistently and in a graded manner , correct motor output can be activated, repeated and learnt so as to become more automatic in nature.

Some crucial observations have to be noted here.

- Children who depended heavily on their vision for balance found it very difficult to tolerate blindfolded sessions. In fact, they could not be given any. On being blindfolded, they responded with anxiety and a general stiffening of the body. It remains to be seen whether more sessions would have helped to activate their vestibular and somato sensory systems for participating in postural control.
- On the other hand, there were 2 children who showed excellent response when their eyes were closed, implying that the visual system was providing conflicting visual input and thus interfering with the normal development of postural control.
- Another important observation was pertaining to children who were unable to make postural adjustments (whether eyes open or closed) even when provided with tactile and verbal inputs from the therapist. If they did the response was momentary and not sustained. This showed that somato sensory inputs (kinesthesia and proprioception) are crucial in providing the feedback required for accurate postural reflexes. These children performed well when provided support but could not demonstrate the same response when support was removed.

Early Clinical Assessment of Balance

Table 5.1: Showing Pre-Test E cab and Post Test E cab Assessment of Balance

Sl. No.	Name	Pre Test ECAB	Post Test ECAB
1	Faizan	7	16
2	Vihang	22	36
3	Sansiya	22	31
4	Soham	11	18
5	Atharva	13	17
6	Sadaf	11	17
7	Astha	23	29

8	Sarthak r	62.5	64
9	Jhanvi	26	30
10	Aaricia	66.5	82.5
11	Raj	24	34
12	Sai (after 17 sessions)	14	20
13	Krishna	15	23
Mean		24.38461538	32.1153846
SD		18.7718249	19.8642831
SE		5.206367479	5.50936087

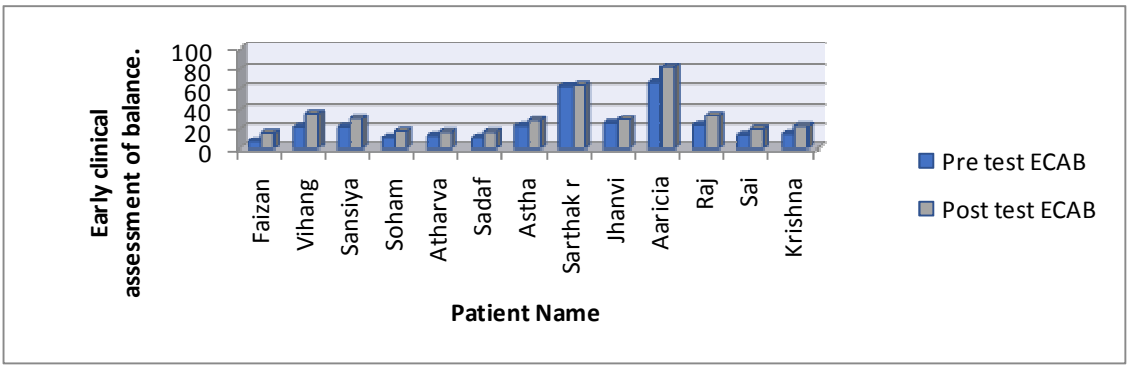

Figure 5.1: Multiple Bar Showing the Variation of Pre-Test Ecab and Post Test Ecab Assessment of Balance.

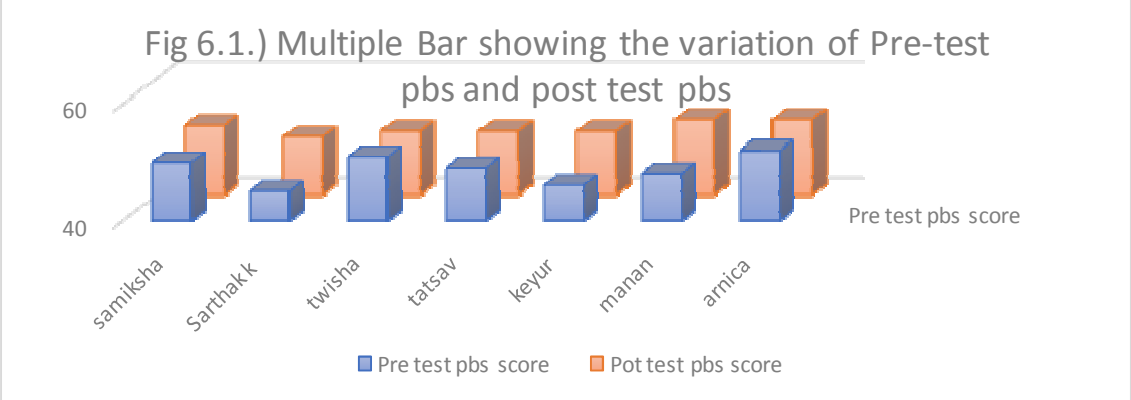

Table 5.2: Showing Coefficient Correlation of Pre-Test Ecab and Post Test Ecab Assessment of Balance.

	Pre test ECAB	Post test ECAB
Pre test ECAB	1	
Post test ECAB	0.9801118	1

The Pediatric Balance Scale

Table 6.1: Showing Pre-Test pbs and Post Test Pediatric Balance Scale.

Sr no	Name	Pre test pbs score	Pot test pbs score
1	samiksha	50	52
2	Sarthak k	45	50

3	twisha	51	51
4	tatsav	49	51
5	keyur	46	51
6	manan	48	53
7	arnica	52	53
Mean		48.71428571	51.57142857
SD		2.563479778	1.133893419
SE		0.968904283	0.428571429

Table 6.2: Coefficient Correlation of Pre-Test Ecab and Post Test Ecab Assessment of Balance

	Pre test pbs score	Pot test pbs score
Pre test pbs score	1	
Pot test pbs score	0.5815766	1

Pediatric Balance Scale

Discussions

The pediatric balance scale consists of static as well dynamic tests of balance with eyes open as well as closed. The post test scores reflected minimum improvement.

The prime factor for improvement of balance in both the groups could be an improved trunk stability and postural control as a result of increased trunk muscle strength by conventional exercises (Veerle,2007) (Stevens VK,2007)(Manuel M,2009) and (Bobath K) Balance is correlated to trunk muscle strength(Ayres,1972)

Most children were able to perform all the subtests with relative ease even at the beginning. The key subtests that proved difficult for them were tandem standing, one leg standing, and reaching forward. It is important to review these subtests more critically.

Tandem standing – Most children scored a 2, pre-test as well as post test. Some progressed from being required assistance to place foot in front to be able to take step independently but were unable to hold 30 seconds. This improvement could not be captured due to the nature of the scoring. It is possible that there would have been measurable difference, if treatment was continued.

One leg standing – This criterion showed little or no improvement in any of the children. It has been suggested that static balance is primarily affected by proprioceptive inputs and the vestibular system is primarily responsible for dynamic balance, therefore this test would not be an ideal indicator for improvement in vestibular function.

Reaching forward with outstretched arm- Most children were able to reach further than the previous assessment, however this progress could not be captured due to the nature of the scoring. It can be assumed that there has been some improvement in ability to move center of gravity over base of support more smoothly and confidently implying emerging postural control. Again, it is possible that a measurable difference could have been noted, if treatment was continued.

Feedback from the Therapists

- Most therapists reported a general relaxation of their patients, thus handling them became easier.
- The therapists felt the children were less fearful on movable surfaces making it easier to work on their balance.
- They also reported an increased ability to maintain static postures – sitting, kneeling, crawling and standing

demonstrating improved trunk control.

Feedback from Parents

- Parents too reported a general relaxation which made handling easy.
- Most parents reported improvement in the ability to maintain sitting, kneeling, and standing positions for a longer period of time.
- They felt the children were sitting and standing straighter and taller.
- Some children reported they were falling less.
- There was noticeable improvement in academics in some children- even handwriting.
- Some parents reported walking to have improved and transitioning was also easier.

CONCLUSIONS

The vestibular system acts as a GPS for the body. It detects linear, vertical and rotatory accelerations via sensory receptors located in the inner ear namely the otoliths and semicircular canals. Inputs from the visual and somato sensory systems are integrated with this information to provide motor output in the form of reflex responses to maintain static as well as dynamic equilibrium. These reflex responses are

Vestibulo – ocular reflex- the eyes are kept steady while head moves

Vestibulo – colic reflex – the head is kept steady while body moves

Vestibulo spinal reflex – adjusts posture for rapid changes in position

In children with cerebral palsy, these inputs may be affected primarily or secondarily causing abnormal tone and thus abnormal reflex responses. Stimulation of vestibular receptors in conventional therapy settings can be achieved using tilt boards and stability trainers, but this stimulation cannot be quantified, graded or consistent. Thus, the response too is inconsistent making it difficult for learning to take place. Hence, the automatic nature of the reflex response cannot be established. The Vestibulator could theoretically bridge this gap in clinical treatment settings and prove to be a useful adjunct to conventional rehabilitation protocols. Correct patient selection and sound clinical judgment is essential to achieving the desired outcomes and is thus the sole responsibility of the therapist. Once these criteria are fulfilled, the Vestibulator shows great promise in providing specific inputs and thus achieving targeted results saving time and money for the client as well as the therapist. Further research is definitely required but the Vestibulator could potentially become an effective tool for therapists.

Limitations of the Clinical Trial

- Attendance of the participants – The children and their families were very cooperative and tried very hard to attend the sessions regularly. Unfortunately illness, exams, family constraints and other issues caused absences and thus the continuity of treatment was compromised. A few children completed only 20 sessions while one was able to attend only 17 sessions.
- Technical issues –There were some instances when the Vestibulator faced technical issues and treatment had to be rescheduled thereby causing a break in continuity of treatment.

- Number of patients – Owing to the eligibility criteria, the number of participants that were finally enrolled was quite low. A larger sample would have been ideal.
- Novelty of the device – As this is new product knowledge about its inherent working was limited and this could have affected the actual treatment sessions. The therapist was also evolving the treatment sessions as and how her knowledge of the device evolved.

RECOMMENDATIONS

- It is recommended to study the effects of vestibular therapy using Vestibulator when more frequent, ideally daily sessions on the Vestibulator are provided.
- This study involved all kinds of cerebral palsy children. The sample can be restricted to a single kind in the future.
- Outcome measures have to be chosen with care based on the outcomes that are to be evaluated.

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