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THE VESTIBULATOR A MECHANO-THERAPY DEVICE WITH MORE THAN ONE MILLION MODULES OF VESTIBULAR STIMULATION

[1]Prof. Dr. Irani Ali, [2]Dr. Thaver Sabah and [3]*Baig Aaliya

[1](PhD. PhD. DPT) Head of Department Physiotherapy and Sports Medicine Dr.Balabhai Nanavati Hospital, S.V. Road, Vile Parle (West), Mumbai 400 056, India.
[2](MPT Neurosciences), PhD Assistant Professor Sunandan Divatia School of Science SVKM's NMIMS University, India.
[3]M.Sc. M.B.A. Research Head Transpact SINE-IIT Bombay, Powai, Mumbai 400076, Maharashtra India.

***Corresponding Author: Ms. Aaliya Baig**
(M.Sc. M.B.A.), Research Head Transpact SINE-IIT Bombay, Powai, Mumbai 400076, Maharashtra India.

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ABSTRACT
Background: The vestibular system is the foundation for the development of all other sensory systems such as touch, vision, sound, and proprioception. It controls equilibrium and balance, body movement, and facilitates the development of muscle tone. Vestibular Rehabilitation is the need for Pediatric cases of ADHD, learning disabilities, Autism, Cerebral Palsy, and the geriatric population suffering from dizziness, vertigo, and various other Vestibular Dysfunctions. Particularly in the pediatric population, therapists strive to improve the child's ability to integrate sensory integration from the tactile, vestibular, and proprioceptive senses. There are multiple therapeutic devices used in providing sensory integration in these cases. A modern aged new automated therapeutic device provides controlled vestibular stimulation useful for the treatment of many such disorders. Purpose: The objective of this study is to investigate the design, functions and reliability of vestibular stimulations provided by 'Vestibulator' of a new innovative device invented by IDC department of IIT Bombay. Material and methods: PhD thesis of Dr.Hosseini S. A. (IIT-B) based on the design of the device was referred along with a report of the clinical study conducted for the testing of Vestibulator. Observation of therapists was recorded, those who are handling the device for more than two years. Observation: The device was found to felicitate therapists with most of the postures needed with controlled motions. This is a cloud-based programmable device which is capable to record, store, and generate real-time therapy data. Conclusion: The Vestibulator, a mechano-therapy device is a potential game-changer in the field of Vestibular Rehabilitation. This device is designed to give more than 1million therapy modules for Vestibular Stimulation.

KEYWORDS: Vestibulator, Vestibular rehabilitation, Sensory Integration, Cerebral Palsy.

INTRODUCTION
The first detailed descriptions of the vestibular labyrinth were published in "De Auris AuditusOrganiStructura" (1610).[1] The vestibular apparatus is situated inside the inner ear adjacent to the cochlea. It consists of three semi-circular canals, utricle and saccule The Vestibular Processing System plays an essential role in the relationship between the body, gravity, and the physical world. The Vestibular Sense keeps one oriented to gravity, the vestibular system works in tandem with eyes, muscles and joints to facilitate balance and movement. It informs the brain in which direction is the movement and how fast it is. A vestibular contribution to the most crucial aspects of the human sense of self and self-consciousness has recently been highlighted by neurological and neuroscientific investigations: vestibular signals contribute to the experience that the self is located within the boundaries of the body.[2] It also tells whether one-self is stationary or in motion, and whether objects are moving or motionless in relation to the bodies. The smallest movement of any part of the body or the movement of the environment stimulates the Vestibular network which informs the balancing brain (cerebellum) to balance the person's body in space against gravitational forces.The semicircular canals, which detect rotational movement, are located at right angles to each other and are filled with a fluid called endolymph.[3]

MATERIAL AND METHODS
PhD thesis of Mr Ali Hussaini (IIT-B) based on the design of the device was referred along with a report of the clinical study conducted for the testing of Vestibulator. Observation of therapists recorded, those

who are handling the device for more than two years. The contributors have gone through the different research publications on Vestibular therapy, different therapeutic devices available in public domain. Interviewed the therapists operating Vestibulator, physically worked on the vestibulator with VR, blind and open eye exercises with children having cerebral palsy, ADHD, and autism etc.

Observation: The research by Marianne Dieterich and Thomas Brandt has examined the bilateral organization of multiple multisensory cortical areas and revealed the vestibular dominance of the non-dominant hemisphere. [4]For example, whether a person is walking or he is in the vehicle (bus, train, car) whether he is climbing steps or is in the lift, rotating in space or enjoying a ride on a rollercoaster, the vestibulo – cerebellar network keeps him upright, not allowing him to be a victim of gravitational forces which are continuously influencing the body. It is responsible for grounding a person in space. The automatic body orientation in space is the foundation of one's body posture and therefore self-confidence and personality. It keeps one's audio-visual network free for learning new things. The vestibular apparatus starts emerging from the 8th-week intrauterine life.[5] The network starts forming with the fetal movements in the womb. The formation of the apparatus is completed by nine months, just before the birth to experience the first gravitational pull at the time of birth.

Psychological investigations have recently demonstrated how vestibular information may play a role in spatial cognition like mental imagery, bodily self-consciousness and self-motion perception, including its influences on emotional aspects and mood as reported earlier workers.[6,7,8] with an overview of the higher cognitive processes of self-consciousness.

The Vestibular system provides a foundation for the development of all other sensory systems such as such, vision, sound, and proprioception. The vestibular system is crucial/paramount for the development of balance, coordination, motor control of the eye, bilateral coordination, etc.

The Vestibular System an internal GPS of the body

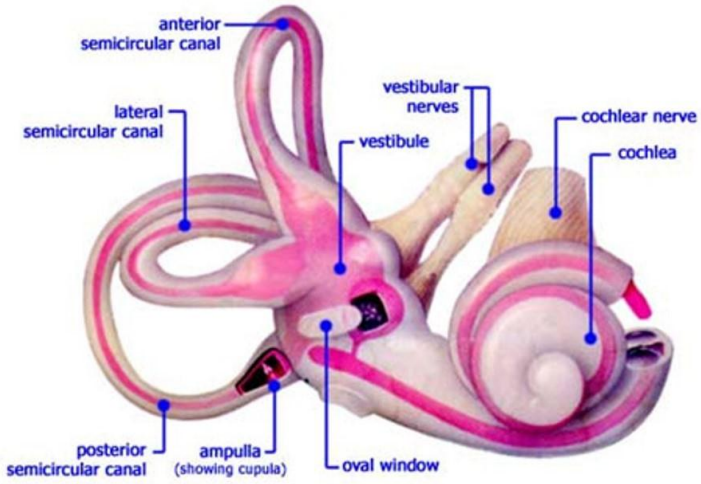

Fig. 1: The Vestibular apparatus: Credit wordpress.com.

Vestibular dysfunctions/disorders, Prevalence and Impact

Because of difficulties posed by accurately diagnosing and reporting vestibular disorders, statistics estimating how common they are, how often they occur, and what social impacts they have ranged widely. Even the lowest estimates reflect the fact that vestibular disorders or dysfunctions occur frequently and can affect people of any age.

One recent large epidemiological study estimates that as many as 35% adults aged 40 years or older in the United States—approximately 69 million Americans—have experienced some form of vestibular dysfunction.[9] According to the National Institute on Deafness and Other Communication Disorders (NIDCD), 4% (8 million) of American adults report a chronic problem with balance, while an additional 1.1% (2.4 million) reported a chronic problem with dizziness alone.[10] Eighty per cent of people aged 65 years and older have experienced dizziness,[11] and BPPV, the most common vestibular disorder, is the cause of approximately 50% of dizziness in older people.[12] Overall, vertigo from a vestibular problem accounts for a third of all dizziness and vertigo symptoms reported to health care professionals.[13] Vestibular vertigo is 3 times more common in the elderly and exhibits nearly a 3-fold female preponderance.[14,15] Symptoms of chronic dizziness or imbalance can have a significant impact on the ability of a disabled person to perform one or more activities of daily living such as bathing, dressing, or simply getting around inside the home, affecting 11.5% of adults with chronic dizziness and 33.4% of adults with

chronic imbalance.[16] The painful economic and social impacts of dizziness are significantly underestimated.

A study evaluated the social impact of dizziness through the Social Life and Work Impact of Dizziness questionnaire administered in populations in Italy and England. Twenty-seven percent of subjects with dizziness reported changing jobs, 21% gave up work, and 50% reported reduced efficiency at work. Fifty-seven percent reported a disruption in their social life, 35% reported family difficulties, and 50% reported difficulties with travel. [17]

Vestibular disorders have also been shown to impact mood and cognitive status. Patients who presented to a neurotology clinic with a documented vestibular disorder experienced greater than expected anxiety and depression distress. [18]

Individuals with vestibular disorders also frequently report cognitive impairment or "brain fog" as well as difficulties in spatial memory/attention. Decreased hippocampus size has been observed in patients with bilateral vestibular loss.[19,20] The impact of vestibular disorders may also be determined based on the increased risk of clinically significant outcomes such as falls. Falls exert a tremendous individual and societal toll: 10% of falls result in major injuries such as hip fractures, falls with injury increase the risk of nursing home placement 10-fold, and the costs of falls in the United States are estimated to exceed $20 billion annually.[21,22,23,24] Problems associated with vestibular processing can make many aspects of everyday life challenging.

Children with the dysfunctional vestibular processing system may be hyper or hypo-responsive to movement. That is either they may appear to be fearful of movement because they feel insecure and unbalanced this often leads to children preferring sedentary activities or they may appear to be constantly in motion and unable to sit still this can impact activities like reading writing at school and sustaining concentration.

Both cases lead to interruptions in normal functioning and play-related activities. Unable to match their behaviour to the intensity of the vestibular input, these children resist movement and are gravitationally insecure, often taking a long time to adjust to and partake in activities like swinging, running, or climbing. As they cannot move about in an organized way, their behaviour, attention, and emotions get adversely affected.

Vestibular dysfunction can also result in poor muscle coordination (or dyspraxia) and the children may not develop the postural responses necessary to keep them upright. They may exhibit sprawling on the floor, slumping while sitting, and they might lean their heads on both hands when seated at a table. They often show awkward, uncoordinated, and clumsy moves, and are more susceptible to falling, bumping into furniture, and losing their balance.

Vestibular system dysfunction not only affects them physically but also psychologically it can be responsible for high emotional reactions from stressful experiences and can develop into anxiety or insecurity in the environment.

The Vestibulo-cerebellar network is the first network to function in life. It starts degenerating after the age of 35 years. As age advances the person becomes the victim of gravity and is prone to lose balance in a new environment. There is a need for Vestibular-Rehab for the geriatric population to keep them upright, to prevent falls, and thereby avoid fractures which are very common in the old age population.

The importance and the need of Vestibular stimulations and Rehabilitation as one of the aspect sensorimotor techniques of therapeutic intervention of the paediatric population with developmental disorders and geriatric population are supported by many pieces of research**.**

What is Vestibular Stimulation and how it is achieved

Treatment methods used for Vestibular Rehabilitation and stimulations along with medical management are acupuncture, aquatic physical therapy, hippotherapy and conventional physio and occupational therapy. Assistive tools used for exercises are physio-ball, balance board, scooter, swings etc.

Particularly in the paediatric population, therapists strive to improve the child's ability to integrate sensory integration from the tactile, vestibular and proprioceptive senses. The idea is to develop vestibular therapy exercises, which are tailored for the individual child. Such therapies are effective for reducing or eliminating dizziness, improving sensory-motor control, improving balance and coordination, and promoting normal development in children with vestibular disorders or dysfunctions. Children with vestibular disorders need such interventions that will continuously challenge their neurological systems to compensate and adapt to the Vestibular deficits i.e. neural plasticity.

In order to include all permutations and combinations to involve head and body, movement, posture adjustment and visual stabilisation some activities may be fast versus others which are slow-paced. Activities may be linear or rotatory. Some may involve vestibular processing with functional activities like reading or writing. The others may involve using visual targets like throwing a ball onto a target.

Conventional examples of vestibular integration activities may include

- Hopping on a therapy / swiss ball
- Rolling
- Sliding

- Jumping on a trampoline.

The Vestibulator-A Device offering more than a million modules of Vestibular Stimulations:

Since 2007, various clinical studies proving the importance of vestibular movements have been established using Vestibulator and its effectiveness. Dr. Ali, an Iranian researcher also the inventor of this device under guidance of Dr. G.G. Ray from IDC (Industrial Design Center) of IIT Bombay, conducted his study with 65 cerebral palsy children and he concluded that Vestibulator is an operative solution for improving the existing conditions of Cerebral Palsy children.[25] Another research fellow Arun Raj R S in the year 2014 redesigned this therapeutic equipment and tried to come up with a better model considering the findings of Dr. Hossieni as the benchmark. He conducted a study with 400 CP & Autism children.[26]This design of Vestibulator was further developed into a device which now offers more than a million modules of Vestibular Stimulations.

Picture 2: Vestibulator Credit: Transpact Enterprises

The Vestibulator is an innovative mechano-therapy device which is useful for vestibular, neurodevelopmental and sensory integration therapy. It is ergonomically designed, an automated therapeutic device which performs the complete vestibular stimulation required for treatment of cerebral palsy, autism spectrum disorder, attention deficit hyperactivity disorder, learning disabilities, sensory-neural hearing impairment, global developmental delay, vertigo and various other vestibular dysfunctions.

It is a Comprehensive device which provides stimulations to the vestibular system against gravity in 13 postures with 54 sensory variants and in 13 Motions with 184 variants of speed and duration. In total allowing more than a million modules of vestibular stimulation along with a dynamic alliance with VR technology, which is a very good tool in treating autism and ADHD[26] thus allowing a therapist to design completely tailor-made program for each patient keeping into account their strengths of cognition and perception.

Vestibulator is designed in such a way that all the motions in all positions can be imparted with a smooth increase in rate, velocity and angle. Thus, defines a therapeutic dose. This mechano-therapy device enables the therapist to increase the vestibular challenges in the basic treatment by allowing variations such as open eye treatment, with and without VR, closed eye treatment, with and without back support, diversified options for muscle weight-bearing viz single-legged standing, chair sitting, long sitting, crossed legged, forearm weight-bearing, straighten elbows and more. It also provides a safe position for the child in each stage of motor development from lying position to standing position.

Based on the variation of vestibular challenges and the consistency the device offers, it has great potential of application at the rehabilitation centres, health centres, physiotherapy and occupational therapy centres, and gymnasiums and for individual use as well.

During its Clinical Study on Cerebral Palsy Children at Physio Occupational Speech Academy of Therapist (POSAT) Foundation, Vestibulator demonstrated significant results. Dr Maya Nanavati, an Occupational Therapist by profession with more than 40 years of experience, impressed with the clinical result of Vestibulator reported that treating the child on Vestibulator for 10 minutes during the regular sensory integration therapy session reduced the symptoms of hyperactivity and poor attention span drastically.

Perquisite of Vestibulator

Vestibulator provides both sensory and behavioural Vestibular substitution opportunities. The vestibular functions are dependent on the entire sensory integration process which combines vestibular, visual, somatosensory, and haptic cues. Dynamic vestibular functions can be replaced by new behavioural strategies involving several neuronal networks distributed in the brain, which reorganize to mimic the lost function.

Sensory substitution is a powerful tool for compensating with the vestibular loss, and it is easy to increase the remaining inputs by manipulating the visual cues (eyes open, eyes closed.) balance control (from most state positions to difficult ones) and by combining both protocols. As it is a powered platform, the Vestibulator allows the patient to rely not only on feedback mechanisms for control of posture but also on feed-forward mechanisms: the patient learns to develop the righting reflexes and responses.

The variations in terms of the different postures offered by the Vestibulator is helpful, children having no trunk control can also be treated. Likewise, children who show

good stability can be treated with a narrower base of support i.e. in standing and kneeling.

The vestibular issues resulting from vestibular injury affect homeostasis and the adaptive stress response is initiated, which in turn leads to the release of glucocorticoids via the activation of the hypothalamo-pituitary-adrenal (HPA) axis. The stimulation given on the Vestibulator can be maintained at a constant speed thereby having a calming effect on these children. Also, the speed can be altered to suit the needs of the children. This helps the children who have hyperactivity issues and those who have severe gravitational insecurities.

Having the potential of allowing more than a million matrices of treatment motion and postures it offers a therapist a new arena for therapy delivery. Besides making the therapy quantified, Vestibulator also enables tracking and managing health records, improvement, medical history and more. Generation of therapeutic E-data will be a milestone to future research.

Further, the therapy sessions on Vestibulator along with simultaneous therapy sessions of regular sensory integration therapy for the children with ADHD, Autism and Neurodevelopmental therapy for cases with Cerebral Palsy or global developmental delay reduces the number of sessions required for improvement in the child, With the combined treatment, it is easier to achieve the desired qualitative results. The faster results, in turn, lessen the financial burden of the family also the time and energy of the therapist is saved which helps them to cater more number of patients.

CONCLUSION

Studies have shown that vestibular stimulation in children with cerebral palsy resulted in the significantly improved development of gross motor skills and motor coordination and furthermore, the effects of vestibular stimulation and sensory-motor activities resulted in calming and hyperactivity control in children with Attention Deficit Hyperactivity Disorder.

The Vestibulator helps to achieve positive effects on consciousness system, and increasing attention, decreasing impulsivity and modulating feedback loops, or in an interaction with cerebellum and proprioceptive inputs thus having a positive effect in the treatment of children suffering from Autism Spectrum Disorder and Learning Disabilities.

It is a very well-studied fact that Vestibular Rehabilitation is a must in the treatment of Vestibular disorders such as vertigo, dizziness, Parkinson's and more thus, Vestibulator shall definitely prove helpful in the treatment of vertigo, dizziness and imbalance.

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