

"THE VESTIBULATOR" A REVOLUTIONARY INNOVATION FOR HUMAN VESTIBULAR STIMULATION TO SOLVE GLOBAL PROBLEM OF CEREBRAL PALSY AND AUTISM"

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Abstract

The paper is a systemic review of various research articles on available physiotherapeutic and occupational practices to provide external Vestibular Stimulation for the treatment of development the cerebral palsy and autism.. The prevalence of cerebral palsy and autism is increasing on an alarming scale. These disorders are non-curable however medication or surgery along with physiotherapeutic and occupational exercises can improve the condition of the child. The etiology of these disorders is associated to varying degrees of Vestibular dysfunctions. The study also reflects the socio-economic impact and the challenges involved in the treatment of Cerebral Palsy & Autism. The paper describes the Vestibulator which is an unique, innovative and mechanized digital healthcare solution (Physiotherapeutic device) based on patented technology of IRCC-IIT Bombay and Transpact to achieve maximum Vestibular Stimulation for vestibular, neuro-developmental and sensory integration therapy. The paper outlines the key features & technological benefits of the Vestibulator.

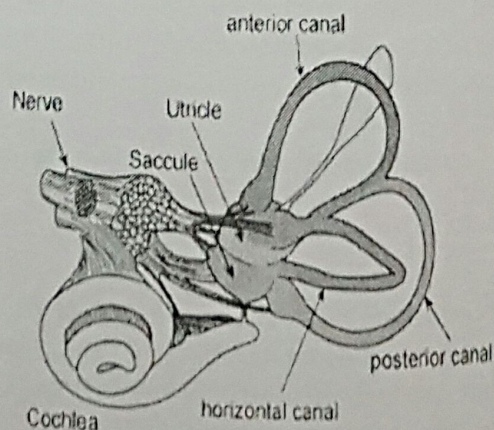
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Introduction

Cerebral palsy and Autism are the most common developmental disability & disorder in children which damages brain and affects their sense of balance, posture and co-ordination. It causes incapability to sit, stand, walk and even talk. Cerebral palsy is a Non curable disease caused by injuries or abnormalities of the brain at young age or low oxygen supply at any age. Some important effects of cerebral palsy are Muscle tightness and spasticity, difficulty in moving or involuntary movements such as disturbances in gait, balance, coordination, walking, and so on. Depending on an individual's condition and the affected areas of the brain Mental Retardation, Learning disabilities, Breathing Difficulties – because of postural problems ,Malnutrition & trouble with growth and development due to feeding trouble are seen in Cerebral Palsy . Whereas Autism Spectrum disorder is an another most common complex developmental disorder related to brain development It is characterized in varying degrees, by difficulties in social behavior & interaction, communication both verbal as well as nonverbal and repetitive behaviors. Cerebral palsy and Autism are the largest segments of vestibular disorders. Our body has a principal balancing organ in each of our ears known as vestibular apparatus. It comprises two important components: the semicircular canal system, which specifies rotational movements; and the otoliths, which control the linear accelerations. The vestibular system plays major contribution to the sense of balance and spatial orientation for the purpose of harmonizing the body movements with balance. The vestibular system sends signals (vestibulo-ocular reflex) to the neural structures that control eye movements and to the muscles that keep the body upright. The brain uses information from the vestibular system to recognize the body's dynamics and kinematics (position and acceleration both) from time to time .

The inferior cerebellar peduncle is the largest center through which balance info passes. It is the junction between the proprioceptive and vestibular inputs to



provide assistance in unconscious maintenance of balance and posture. The vestibular sense is first to develop in the growing fetus, it develops only in 5 months in utero and is stimulated by the movement of carrying mother's body. It is the only system that integrates sensory senses (acoustic, optic, tactile, smell) with brain activities, proprioception and muscle reflexes & tone rehabilitation of. Stimulation of this vestibular system can bring a considerable difference which helps in sustaining their lives independently. Vestibulator is an ultimate scientific and holistic physiotherapeutic device for Cerebral palsy and associated vestibular disorders, designed and developed by Seyed Ali Hosseini under the guidance of prof. G.G. Ray of Industrial Design Center, IIT-Bombay, Mumbai. Later on it was developed and automated by Transpact. It can impart various motions to stimulate Vestibular system of a CP child, like standing, seating, supine, quadruped, kneeling and so forth. The Vestibulator provides stimulation of all receptors of vestibular system including forward - backward tilting, side to side tilting, spinning, forward backward linear and gravitational ascending - descending motion. It provides different postures along with necessary supports while stimulating the system.

Objectives:

There are two basic objectives of this research article

1. To analyze the various (selected) published literatures on the physiotherapeutic and occupational treatments of vestibular stimulation for the treatment of CP and Autism disorders
2. Comparative narration of effectiveness of Vestibulator

Methodology

A systematic review of research papers was conducted in order to provide an overview on global prevalence of the Cerebral Palsy, Autism in the present time and evaluation of various treatments for Vestibular stimulation available for it. The full search strategy is available from the authors on request. We have additionally conducted personal interviews with therapists of different centers, hospitals, visits to rehabilitation centers and collecting product detail with performance tests of the products available in the health market. Our review was carried out using a protocol based upon recommendations from the Cochrane Collaboration and PRISMA statements.

Relevant articles were identified by searching the CINAHL (1983–2012); Cochrane Database of Systematic Reviews (1993–2013; www.cochrane.org); Database of Reviews of Effectiveness (DARE); EMBASE (1980–2012); ERIC; Google Scholar; MEDLINE (1956–2012); OTSeeker (www.otseeker.com); Physiotherapy Evidence Database (PEDro [www.pedro.fhs.usyd.edu.au]); PubMed. The search of published studies was performed in July and November 2016 and updated in December 2016.

Findings

Statistics & causes related to Cerebral Palsy and Autism:

Cerebral Palsy contributes the largest share to the globally existing human developmental disorders. Nearly 3-4/1000 live births are affected by cerebral palsy (CDC-Govt). 170 million people throughout the globe are affected by Cerebral Palsy with 25000 additional people every year according to world Cerebral Palsy Day organization Australia. About 70 million children in India suffer from this disorder. (www.worldcpday.org). There are various reasons for Cerebral palsy it may be a brain injury/malformation / disease during developmental stage or due to accident after birth.

Factors which effects on brain abnormalities can be

1. Infection during pregnancy: - where mother pass infection to the fetus in first few week. Rubella, cytomegalovirus can also causes cerebral palsy.
2. Infection after birth: Infection such as meningitis causes severe inflammation that can damage brain.
3. There are other reasons like jaundice, Asphyxiation, , Head trauma, Brain hemorrhage before or after birth.
4. There has been speculation of genetic and hereditary link with this disorder.

Autism Spectrum Disorder (ASD), associated with intellectual disability and poor motor coordination, poor health, sleep and other physiological disturbance. It affects 2.5 million individuals in U.S. and 1 in every 68 children is suffering from this disorder. There are tens of millions of autistic population across the world. It has tremendous growth; rate of prevalence is 10% to 17% annually in recent years. (www.autismspeaks.org).

Causes of Autism

1. Genetic influence
2. Environmental factors
3. Advanced Parental Age
4. Maternal Illness during pregnancy
5. Vitamin deficiencies during pregnancy

There are several other reasons for vestibular dysfunction and aging is one of them. One recent epidemiological study estimates that as many as 35% of adults aged 40 years or older in the United States, approximately 69 million Americans, have experienced some form of vestibular dysfunction. (Agrawal, Carey, Della Santina, Schubert, & Minor, 2009).

Economic Impact of CP and Autism

The economic costs of dealing with these pathological conditions (disease, disability & disorder) are huge. This includes the costs of "formal care" (health care, social and community care, relief care and long-term residential or nursing-home care) and "informal care" (unpaid care by family members, including their lost opportunity to earn). costs tend to rise as pathology progresses with time. Very little work has been done on evaluating the economic costs of these disorders in developing countries, reasons for this may be the absence of trained healthcare economists, the little priority given to mental health, the poorly developed mental healthcare services, the lack of justification for such services, and the absence of data sets. Further, any information that is available about the economic consequences of balancing disorders is mostly related to costs of hospitalization & rehabilitation, which constitutes a relatively small share to the total costs. According to Berg and colleagues (10), costs can be subdivided as follows:

1. direct costs: hospitalization, outpatient care, rehabilitation;
2. indirect costs: lost productivity, in particular after moderate or severe injuries;
3. intangible costs to patients, families and friends: related to death or reduced quality of life.

Medical costs for children with cerebral palsy alone were 10 times higher than for children without cerebral palsy or intellectual disability (\$16,721 vs. \$1,674 in 2005 dollars). CDC states that Medical costs for children with both cerebral palsy and intellectual disability were 26 times higher than for children without cerebral palsy or intellectual disability (\$43,338 vs. \$1,674 in 2005 dollars). Further it has been estimated that the lifetime cost to care for an individual with CP is nearly \$1 million (2003 dollars). It also has been estimated that the combined lifetime costs for all people with CP (born in 2000) is equal to \$11.5 billion (direct and indirect costs). (<http://www.cdc.gov/ncbddd/cp/data.html>)

According to CDC The total costs per year for children with ASD in the United States were estimated to be between \$11.5 billion - \$60.9 billion (2011 US dollars). This significant economic burden represents a variety of direct and in-direct costs, from medical care to special education to the loss of parental productivity. The average medical expenditures of Children and adolescents with ASD had that exceeded those without ASD by \$4,110-\$6,200 per year. On average, medical expenditures for children and adolescents with ASD were 4.1-6.2 times greater than for those without ASD. Variances in median expenditures ranged from \$2,240 to \$3,360 per year with median expenditures 8.4-9.5 times greater. In 2005, the average annual medical costs for Medicaid-enrolled children with ASD were \$10,709 per child, which is almost six times higher than costs for children without ASD (\$1,812). In addition to medical costs, intensive behavioral interventions for children with ASD cost \$40,000 to \$60,000 per child per year. (<http://www.cdc.gov/ncbddd/cp/data.html>)

Challenges in treating cerebral palsy and Autism:

These disorders are diverse in nature. The extent of suffering differs from person to person. Sedentary lifestyle, Pain, Presence of Other Medical Conditions, Certain Medications and/or Multiple Medications, Emotional Concerns Anxiety, panic, and depression occur frequently with these disorders and can cause difficulty with managing symptoms. There are a number of complexities in the process of balance rehabilitation, as patients present varied sequelae, including the varying degree of the following: Physical functioning limitations such as paralysis of the left or right side of the body, or both sides which limits the person's capacity of independent day to day living & mobility in the community. Patients can also present with rigidity, uncoordinated movements, and/or weakness.

Importance of Vestibular Stimulation

The vestibular organ in our inner ear is an ace of engineering. It rapidly detects the smallest of head movements and sends this information to the brain, leading to a cascade of actions (responses), including reflexive responses rapidly (less than 10 milliseconds). The vestibular-ocular reflex is an important reflex that works by altering eye position to compensate for head movements. Because of this, when we move around we do not see the world shaky. The vestibular system doesn't just stop with the reflex component. The signals reach to the cerebral cortex of the brain, the area responsible for thinking. The cerebral cortex obtains signals from the vestibular organ, which indicates and detects movement, and we can then feel that we are moving.

The vestibular system plays principal contribution to the sense of balance and spatial orientation for the purpose of harmonizing the body movements with balance. Hence vestibular stimulations play an important role in balance rehabilitation.

Clinical evidences for vestibular rehabilitation

A Medline search done in September 2012 found plenty clinical reports supporting the use of vestibular rehabilitation therapy. A very thorough review (Hillier & McDonnell 2011) outlined that vestibular rehabilitation brought in significant improvement in patients with unilateral peripheral vestibular dysfunction. Another, less in-depth study documented these findings (Morozetti et al 2011).

Several discrete clinical trials also have shown that patients benefit from vestibular rehabilitation, including both genetic and individualized interventions. Patients displayed development both on topic questionnaires as well as on clinical vestibular testing (Badaracco et al 2007, Badke et al 2005, Bittar et al 2007, Bittar et al 2005, Cohen 2011, Enticott et al 2008, Macias et al 2005, Meli et al 2006, Meli et al 2007, Nishino et al 2005, Venosa & Bittar 2007, Yardley et al 2004). Patients who experience anxiety or depression along with the vestibular symptoms might see development in their emotional state with vestibular rehabilitation (Meli et al 2007). Many patients, mostly elderly ones, have additional medical problems that contribute to the vestibular symptoms. Treatment of these other problems expressively affects their response to rehabilitation therapy (Moreira, 2007). Children with peripheral vestibular disorders benefit from rehabilitation (Medeiros, 2005), though clinical trials with children are rare.

Various treatments available for vestibular rehabilitation

Along with Medical Management there are Acupuncture, Aquatic physical therapy, Hippotherapy and traditional Physio & occupational therapy: Includes Exercises practiced were all aimed to improve your mobility and function of body parts. Also includes Manual therapy to relieve pain and stiffness & improve blood circulation. Assistive tools for exercises such as physioball, balance board, scooter, swings etc are used especially for children suffering from Cerebral Palsy and Autism.

The Vestibulator, A revolutionary therapeutic device, Invention of research center of IIT

It is a dosimetric, automated and programmed therapeutic device embedded with innovative technology to achieve desired levels of Vestibular Stimulation needed by Hospitals, Physiotherapy Institutions, Individuals, NGOs having schools for CPs and autistics. It is one of the most useful device for rehabilitation centers for, Autism, Cerebral Palsy, post trauma, Parkinson's, post stroke treatment, post brain surgery Coma, acoustic neuroma, sports injury, paralysis attack etc. The vestibulator was designed and developed in the School of Biosciences and Bio-engineering, IIT Bombay in the year 2007. It has ergonomically designed 40 matrixes of motion and postures. All essential postures namely standing, sleeping, crawling, quadruped, kneeling, sitting (chair position and Leg spread position), prone and supine are incorporated. Motion built-in 0 to 360 degree rotation, up-down sliding, tilting movement can be imparted at various speed and time range. It readily integrates with Cloud based health Management System, distant operating, monitoring and controlling intelligent system. A single Vestibulator can be customized and programmed for more than 10,000 patients at a time. It is accurate in terms of vestibular movements, saves 80% of time and space and reduces burden of Physiotherapists. Vestibular therapy stimulation is suggested to be given with smooth increase in rate, velocity and angle. Vestibulator provides safe position for child in each stage of motor development from lying position to standing position. It can perform Multiple & complex maneuvers easily and safely. Other features of the device include Secured railing with emergency stops, Infrared security, Separate console for operator, Optical & positional Sensors. It's child friendly design attracts children and reduces their resistance in the treatment process. It enhances patient comfort & tolerance. Also provides Safety & Comfort for both Patient and Operator. On a large it Meets needs of anxious, larger, frail or physically limited

patients. Since 2007 various clinical studies proving the importance of vestibular movements have been established using this device and effectiveness of the Vestibulator. Dr. Ali, an Iranian researcher also established using this device under guidance of Dr. G. G. Ray from IDC (Industrial Design Center) of IIT Bombay, conducted his trial with 65 cerebral palsy children and he concluded that Vestibulator is an operative solution for improving the existing conditions of these children. 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. Hosseini as the benchmark. He conducted the trial with 400 CP & Autism children. Various other trials were conducted in Iran by Dr. Hosseini using 3D gait analysis (IJRSR 2 (2015) 41-46) in the same direction. There is no such physiotherapeutic device in the world at present which provides automated, dosimetry and programmed for vestibular stimulation.

Conclusion:

A futuristic technology Adaptation Device i.e Vestibulator is able to cope with technological growth. Also it streamlines and manages the therapy, rehab clinical documentation, nutrition schedule, administrative processes, training and individual education plan. It can also be patient-specifically programmed. It has a Child friendly design also is provided fun activities (play tray) & audio-visual aids to engage the interest of children.

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