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A SYSTEMATIC REVIEW STUDY ON THE EFFECTS OF VESTIBULAR STIMULATION IN CHILDREN WITH AUTISM

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Abstract:
People with autism spectrum disorder (ASD) and especially the minimally verbal, often fail to learn basic perceptual and motor skills. This deficit has been demonstrated in several studies, but the findings could have been due to the non-optimal adaptation of the paradigms. Responses to vestibular stimulation can, under well-controlled experimental conditions, provide a measure of brainstem function. Autistic children had significantly longer time constants during the primary nystagmus response and significantly fewer beats during the secondary response than normal children when stimulated with constant angular acceleration in complete darkness. These findings could not be attributed to gross differences in arousal, to developmental retardation, to associated clinical conditions, or to either the influence of vision or habituation. Rather, they are suggestive of a neurophysiologic dysfunction, perhaps involving the brain stem, and may be an expression of the process that underlies those autistic behaviors that suggest faulty modulation of sensory input and motor output. Brain-stem centers modulate both general sensory input and motor excitation and may play a role in the elaboration of the more complex adaptive and motivated behaviors that are also disturbed in autism. In this review, we have generally focused on the Autism Spectrum Disorder and their treatment by using a different techniques and therapies.

Keywords: vestibular stimulation, autism, neuro-sensory disorders, neurophysiology

1. Introduction

Vestibular stimulation is very powerful as a tool to help regulate arousal levels to enable self-calming and focused attention. One of the strategies to decrease a hyper aroused state in a child is to use sensory inhibition to diminish arousal prior to bedtime or at other times when the child is overly active and needs to sit quietly for learning or table top activities. Linear movement activities (e.g., forward-back and head-to-toe rocking,

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swinging coupled with low frequency sounds) are calming and serve to inhibit the reticular activating system via the vestibular system.

Anatomical structures related to postural control show three (Pompeiano, 1994) main tracts which originate from vestibular nuclei; lateral vestibulospinal, medial vestibulospinal and reticolospinal tracts. Medial vestibulospinal tracts originate from the vestibular nuclei and most of its fibers terminate at the cervical spinal tract. Therefore, it is reasonable to assume that stimulating the vestibular system would have an effect on the cervical postural control.

These neural pathways has an important role in balance, both stability and movements (Hosseini, 2007; Pompeiano, 1994; Mori, 1998) thus, vestibular stimulation has a strong effect on postural control and balance in children with cerebral palsy, especially through the medial and lateral vestibulospinal tracts. It is clear that the vestibular labyrinth has a critical role to play in the balance system. The balance system is not limited to just the vestibular system. A more accurate picture of the balance system consists of various sensory inputs (visual, proprioceptive, and vestibular) integrated by automatic and coordinated postural control of muscles. Visual and proprioceptive information are changing all the time but the vestibular reference (that is gravitation) remains the same. Alum and Faltz (Allum, 1983) suggested that vestibular stimulation is effective on the dynamic balance of human beings at 65%, consequently visual and proprioceptive would have fewer portions. If proximal muscle structures are not well developed, it results in inability of maintaining balance (Hosseini, 2007; Herdman, 1994). Numerous studies in this field have shown that ankle proprioceptive is necessary for repositioning action (Hosseini, 2007; Allum, 1983; Horak, 1990; Horak, 1986). Nashner and Greem showed that when proprioceptive information from the lower extremity is not available, the vestibular system will be responsible for balance control and answers result in responds to perturbations with some delays (Nashner and Greem, 1995).

DeQuiros and Schrager (1978) believe that vestibular stimulation is necessary for development of the ability to exclude excess information about posture, movement and equilibrium from consciousness in order that learning may occur. DeQuiros (1976) postulates that language development progresses as the child gains the ability to close out much of the sensory input which is received.

Vestibular system dysfunction is a characteristic of autism (Ayres & Hesket, 1972; Wing, 1976). Autistic children frequently engage in self-stimulatory behavior such as rooking, whirling, head banging and spinning of objects, all of whioh stimulate the vestibular system either through direct input, optokinetic effects, or both (Ayres, 1979; Kinnealy, 1973; Knickerbocker, 1980; Ornitz, 1970, 1974; Ornitz & Ritvo, 1968). Knickerbocker (1980) believes that this behavior represents an excessive need for vestibular stimulation as well as a means of facilitating sensory integration. Ornitz, Atwell, Kaplan and Westlake (1985) suggest that the abnormalities in nystagmus which they observed indicated brain stem dysfunction, which could be sufficient to explain many of the symptoms and behaviors of autism.

2. What is Autism?

Autism is a condition characterized by disturbances of language, perceptual integration, motility, relationships with others, and development. It is felt that the pathology may be present at birth in most cases, rendering the individual virtually incapable of effectively utilizing incoming stimuli (Ornitz & Ritvo, 1968).

Autism is a severe type of developmental disorder. It is found that out of 1000 children only 2 to 6 children are diagnosed as autistic. Usually autism falls under the category of pervasive developmental disorders. Pervasive developmental disorders are characterized by severe and pervasive impairment in several areas of development: reciprocal social interaction skills, communication skills, or presence of stereotyped behavior, interests, and activities.

Autism does not follow typical patterns of child development. In some children the problem can be prevalent from birth but in others it can be only detected when the child attains age of 2 and above.

Autism is a spectrum condition. This means that some people are affected more than others. For example, some autistic people do not use spoken language, while others have excellent spoken language skills but may find it difficult to understand what other people mean.

While all autistic people share some common differences in the way they see hear and feel the world, they all have different strengths and abilities and challenges which affect their lives in different ways at different ages and in different environments.

No two people on the spectrum are the same. Some autistic people also have intellectual disabilities or learning difficulties. Others have mental health issues, most commonly anxiety, depression and Attention Deficit Hyperactivity Disorder (ADHD).

The differences between people in terms of their autistic traits and the impact of these other conditions mean people need different levels of support. With the right support all autistic people can lead fulfilling lives as part of their community.

Autism Spectrum Disorder (ASD) is a neurological developmental disorder clinically characterized by impairments in social interaction and communication and restricted or repetitive patterns of behavior, interests or activities (American Psychiatric Association, 2013). In 2018, the Centers for Disease Control and Prevention reported that 1 in every 59 children in the United States has ASD (Baio, et al, 2018). Among those diagnosed with ASD, it is estimated that over 90% show symptoms of sensory abnormalities (Geschwind, 2009; Marco, et al, 2011). Research in ASD sensory processing has become increasingly prevalent since Kanner's initial description of the condition in 1943.

Recently, in the Diagnostic Manual for Mental Disorders-Fifth Edition (DSM-5), hypo- and hyper-sensory reactivity has been included as diagnostic criteria of ASD (American Psychiatric Association, 2013). These criteria, however, manifest differently across individuals with ASD; for example, some individuals seem unaware of certain auditory, visual or tactile stimuli (hyposensitive), while others may avoid the same

stimuli altogether (hypersensitive). These behaviors can contribute to and/or overlap with the aforementioned core characteristics and hinder participation in everyday activities (Jasmin, et al, 2009; MacDonald, et al, 2013; Matsushima and Kato, 2013).

Ornitz (1970) suggests that autism is primarily a disorder of faulty sensorimotor integration. He states that, under normal conditions, the vestibular system suppresses sensory input during motor discharge, while vestibular influence on motor output may in turn be suppressed during excessive sensory input. A number of language anomalies are typically observed in autistic children and delayed development of speech is common in this population. According to Wing (1976) half of all children with autism never develop speech at all. Also, common is echolalia, which for 75% of all autistic children are the first language to develop (Wing, 1976).

According to Rutter (1968), Kanner, who first described the syndrome of autism in 1943, considered failure to relate to others, or social withdrawal, to be its most important characteristic. Rutter presents a number of pieces of evidence to refute this view, including the following: (a) that social withdrawal tends to decrease with age, although the individual remains autistic; (b) that it is impossible to explain the characteristic intelligence test scores or the specific language defects encountered in terms of social withdrawal; (c) that other conditions which involve social withdrawal do not show a similar pattern of intelligence test scores; (d) that some autistic children may never develop language and yet, as they mature, they become less socially withdrawn; and (e) that the most important predictors of eventual prognosis include IQ and degree of language improvement, while social withdrawal has only a weak correlation with prognosis.

3. Autism Spectrum Disorder and Sensory Processing Disorder

Ayres (1979) hypothesised that children with ASD have deficits in the brain areas responsible for processing sensory input (e.g., visual, tactile, auditory, gustatory, vestibular, and proprioceptive) and motor output. Many authors have theorised that apparently bizarre or aberrant behaviours evinced by individuals with Autism may be explained as an attempt to seek preferred stimuli and avoid other types of sensations to achieve an internal state of equilibrium (Ayres, 1979; Fisher & Murray, 1991). The term "Sensory Processing Disorder" (SPD) has only been identified since the year 2000. A definition of SPD has been proposed (Miller & Cermak, 2000; Miller, Cermak, Lane, Anzalone, & Koomer, 2004) but has not been universally accepted. The distinguishing characteristics of SPD include unusual responses to tactile stimuli and abnormal body movement with deficits either in sensory-motor timing, differentiation, or motion and problems strongly associated with one of the processing senses (Kranowitz, 2005).

Autism Spectrum Disorder (ASD) develops in early childhood. Recent population analysis indicates that the number of cases of ASD is increasing in many countries, particularly in technologically developed countries (Grzadzinski, et al, 2013; Amaral, et al, 2011; Simonoff, et al, 2008; Van Steensel, et al, 2011; Masgutova and Masgutov, 2015) .

The U.S. Center for Disease Control research claims that, in some states, one of every 68 children (one of 42 boys) has a diagnosis of the ASD, a 30% increase from 2012 (IACC Strategic Plan for Autism Spectrum Disorder Research, 2013) (Lemur, 2014; Lemur, 2008; Rutter and Silberg, 2002; O'Reilly, et al, 2013; Gutstein, 2009; Randal and Parker, 1999).

4. Different Therapies Used for Treating Autism

There are various therapies used for treating these types of neuro-sensory disorders like autism, autism spectrum disorder, sensory processing disorders, cerebral palsy etc. Few of therapies used for treatment of Autism are mentioned below:

4.1 Occupational Therapy

These activities help children with autism get enhanced at everyday tasks, like learning to button a shirt or hold a fork properly. But it can involve anything connected to school, work or play. The focus depends on the child's needs and goals. These goals often involve social interaction, behavior, and classroom performance.

4.2 Speech Therapy

This helps children with speaking, as well as communicating and interacting with others. It can engage non-verbal skills, like making eye contact, taking turns in a conversation, and using and understanding gestures. It might also teach kids to articulate themselves using picture symbols, sign language, or computers.

4.3 Applied Behavior Analysis (ABA)

This type of therapy uses rewards to reinforce positive behaviors and teach new skills. Parents and other caregivers are trained so they can give the autistic child moment-by-moment feedback.

Treatment goals are based on the individual. They include communication, social skills, personal care, and schoolwork. Studies show children who receive early, intensive ABA can make big, lasting gains.

There are different types of ABA. They include:

- Discrete Trial Training (DTT). This breaks a desired behavior into the simplest steps.
- Early Intensive Behavioral Intervention (EIBI). This form of ABA is designed for young children, usually under age five.
- Pivotal Response Treatment (PRT). The focus here is on important areas of a child's development, like self-management and taking charge in social situations.
- Verbal Behavior Intervention (VBI). Improving a child's verbal skills is the goal.

4.4 Therapeutic Horseback Riding

Doctors also call this "hippotherapy." Here, a child rides a horse under the guidance of a therapist. Riding is a form of physical therapy because the rider needs to react and adjust

to the movements of the animal. Research shows it helps children from ages 5 to 16 improve their social and speaking skills. It can also help them to be less irritable and hyperactive

4.5 Picture Exchange Communication System (PECS)

This form of therapy teaches children to trade pictures for items or activities. The system is designed for those who don't speak, can't understand, or are difficult to understand. PECS may not work for kids who don't try to communicate or aren't interested in particular objects, activities or food. A review of research on PECS found that those who used it had some improvements in communication but little or no gains in speech.

4.6 Social Skills Class

This is group or one-on-one instruction at home, in school, or in the community. The aim is to improve how a child interacts socially and forms bonds with others. This usually means learning through role playing or practice. Classes are often led by a therapist. Like ABA, parent training is key to helping a child improve his social skills.

5. Sensory Integration

It seems clear that some degree of vestibular malfunction is involved in autism and is responsible, at least in part, for the language deficits experienced by individuals with the disorder. Kawar (1973), studying children with learning disabilities, found that sensory integrative therapy which included vestibular stimulation, produced improvement in right ear scores on tests of dichotia listening in a group of 18 subjects. Researchers specifically studying children with autism have also reported significant results. Ayres and Hesket (1972) provided a source of sensory integrative therapy to a seven-year-old girl with autism and reported an increase in auditory-language ability.

> "*Sensory integration theory is used to explain why individuals behave in particular ways, plan intervention to ameliorate particular difficulties, and predict how behavior will change as a result of intervention" (Murray, et.al., 2001). Dr Ayres defined sensory integration as "the organization of sensations for use. Our senses give us information about the physical conditions of our body and the environment around us... The brain must organize all of our sensations if a person is to move and learn and behave in a productive manner*".

Ayres published her definition of "sensory integration" in 1972 as "*the neurological process that organizes sensation from one's own body and from the environment and makes it possible to use the body effectively within the environment*" (Ayres, 1972). In 1979, Dr. Ayres published *Sensory Integration and the Child*, a book to "*help parents to recognize sensory integrative problems in their child, understand what is going on, and do something to help their child*" (Ayres, 2005).

6. Sensory Integration Therapy

As an intervention approach, Sensory integration therapy is used as "*a clinical frame of reference for the assessment and treatment of people who have functional disorders in sensory processing*". Ayres considered sensory integration intervention "*a specialty of occupational therapy*" (Ayres 1979). Thus, the assessment and intervention from a sensory integration perspective are most commonly used by occupational therapy practitioners in their treatment of children with difficulties in occupational performance and participation related to sensory integrative or sensory processing dysfunction.

She developed the intervention approach through empirical research (Ayres, 1955; Ayres, 1977; Ayres, 1972; Ayres, 1972; Ayres, 1981; Ayres, 1978; Ayres, 1980). Many professionals hold that Dr. Ayres created one of the first structures for evidence-based practice in occupational therapy through her theory development (Ayres, 1972), model development (Ayres, 1979-2005), assessment development (Ayres, 1989) and intervention strategies (Ayres, 1972), (Parham, et al., 2011).

A recent review concluded that SIT is "*ineffective and that its theoretical underpinnings and assessment practices are un-validated*." Moreover, the authors warned that SIT techniques exist "*outside the bounds of established evidence-based practice*" and that SIT is "*quite possible a misuse of limited resources."*

Sensory integration theory and practice has been met with resistance within the occupational therapy profession as well as other disciplines (Parham and Mailloux, 2011). Postural control is dependent on the integration of proprioception, vision and vestibular systems of which vestibular input are particularly important (Tsang, et. al., 2014). Adequate motor performance and postural control is needed for an infant or a young child to independently perform and participate in play, activities of daily living and social interactions. Infants diagnosed with cerebral palsy demonstrate difficulties with postural control and locomotion and can miss opportunities to explore their environment (Case-Smith, et. al., 2013).

Sensory integration of the vestibular system provides a "*gravitational security*" which helps with the emotional well-being (Schaaf and Smith, 2006). The vestibular system is thought to be a primary organizer of sensory information and contributes to physical and emotional security (Bundy, et al., 2002).

To address the existing treatment challenges in sensory integration therapy for cerebral palsy, Vertigo, Autism etc., Transpact Enterprises in association with Industrial Design Centre (IDC) , The Industrial Research and Consultancy Centre (IRCC) of Indian Institute of Technology Bombay (IIT-b), has developed "Vestibulator" it an award-winning front runner product amongst the top 100 upcoming technologies in India, to stimulate the human vestibular system.

Vestibulator is a compact and innovative therapeutic healthcare device, which is useful for vestibular, neuro-developmental and sensory integration therapy. Vestibulator provides efficient treatment and multiple time more effective than current discreet methods. Vestibular therapy stimulation can be given with smooth increase in

rate, velocity and angle. It provides 42 postures and motions matrices. It is designed to manage accurately the number of cycles, amplitude as prescribed by the therapist.

The cloud-based data storage of personalized records will make it easy to access and monitor the treatment records across distances. It saves upon the cost of treatment, out-of-pocket expenditures and time. It will also make physiotherapeutic healthcare delivery fairer by lowering the cost and increasing access, thereby making therapeutic treatment available and affordable to rural parts of our country.

During his Clinical study for "Vestibular Stimulation on cerebral palsy for designing a vestibulator" by Hosseini S. A. [PhD dissertation] India: School of biosciences and bioengineering IITB; 2007, over 65 children with cerebral palsy at SRCC –Mumbai, found that Vestibulator is very impactful for sensory integration.

Clinical study titled "To study the effects of vestibular stimulation using the Vestibulatar on the muscle tone and reflex responses in children with cerebral palsy" conducted at Physio Occupational Speech academy of therapist, Borivili, Mumbai, India by Dr. Maya Nanvati and Dr. Neha Rane (2018) strongly recommended use of Vestibulator for treatment of cerebral palsy, autism, Vertigo etc. Dr. Maya Nanavati remarks that vestibular 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. According to him, 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 judgement 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.

It can be treated by Vestibulator, Diagnostic and Statistical Manual of Mental Disorders (DSM-IV-TR), MNRI, Sensory Integration Therapy and also different therapies are used to treat this disorder in children with autism.

7. Conclusion

The present research identified a number of avenues for future research in the area of treating autism and other neuro-sensory disorders. Children with ASD frequently present with challenging behaviour (notably aberrant behaviour and stereotype) which can lead many families to seek treatment to alleviate such behaviors. The current review, along with previous research on parental perception, reviews of ASD and comparative studies of neuro-sensory disorders and SIT, provide some information on how to meet the needs of children and make interventions for challenging behavior more effective. Despite the failure to demonstrate effectiveness for individuals with ASD, across areas of academic achievement, task engagement, language, social interaction or challenging behaviour, SIT continues to be a popular treatment choice of families. It is believed that the popularity of SIT may be as a result of the opportunity for positive interactions it

provides families with their child as opposed to therapeutic benefits or changes in the core symptoms of ASD.

With the progression of neuroimaging and other inventive technologies, scientists have begun to map the structure and function of the brain areas that may underlie sensory processing deficits in ASD. Further research is necessary to better understand the relationship between neural abnormalities in ASD and therapeutic approaches intended to ameliorate sensory impairment symptoms and to promote easier participation in everyday life activities.

As a method of using the information given by the external environment, sensory integration refers to how human beings process and organize this information about sights, sounds, textures, smells, tastes and movements, so that they can respond in a healthy and functional way. As a function of the overall sensory system, the vestibular system helps us detect movement, gravitational pull, and positional changes of the head, while it also helps us control balance. The effects of vestibular dysfunction in children are similar to overall sensory integration dysfunction.

Sensory integration and vestibular therapies generally involve a variety of specific movement protocols, dependent upon what each client requires. The Vestibulator Therapy Systems are much easier to set up, and they are also simpler to take down and move to another location. Yet, they are extremely tough and durable, and will stand up to repeated and constant usage, such as that required by a busy clinic or facility. Many parents with special needs children have also purchased them to use at home, in order to keep therapy going between visits to the therapist, and to reach physical and occupational goals more quickly.

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