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Research Article

Efficacy of Vestibular Stimulation on Auditory and Visual Reaction Time in Adolescents with Down Syndrome.

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ABSTRACT
BACKGROUND - Down syndrome is associated with challenges in processing speed and reaction time throughout the lifespan. Research suggests that individuals with Down syndrome have slower reaction times than typically developing individuals. The effect of vestibular stimulation on reaction time has been studied extensively. Research indicates that vestibular exercises can have a positive impact on auditory and visual reaction time in young adults. These exercises have been shown to improve cognitive functions related to reaction time, highlighting the potential benefits of vestibular stimulation in enhancing sensory and motor systems, especially in the motor system. Studies have suggested that vestibular stimulation may lead to improvements in reaction time for both auditory and visual stimuli. Additionally, the vestibular system, responsible for balance and equilibrium, plays a role in cognitive functions, further supporting the link between vestibular stimulation and reaction time.
OBJECTIVE - To examine the effect of vestibular stimulation on auditory and visual reaction time in adolescents with Down syndrome.
METHOD– After the ethical approval from the institutional ethical committee, 42 participants were screened and 40 participants were selected based on eligibility criteria and were randomly allocated into two groups Group A (Experimental group) and Group B (Control group). Group A received vestibular stimulation with auditory and visual cues and Group B received only auditory and visual cues. Both groups received treatment for 4 times a week for 6 weeks.
RESULTS – Both groups showed significant differences when analyzed at week 6. Moreover, the mean difference showed a highly significant difference in the Experimental group.
CONCLUSION – Through this study, it was concluded that the vestibular stimulation program has a significant effect on auditory and visual reaction time in Down syndrome adolescents. Thus, the study provided evidence to support that vestibular stimulation holds a promising benefit in improving auditory and visual reaction time in Down syndrome adolescents.

KEYWORDS – Down syndrome, vestibular stimulation, reaction time.

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INTRODUCTION

DOWN SYNDROME

Down syndrome, the most common genetically defined cause of intellectual disability, results from an extra chromosome 21. Individuals with Down syndrome generally exhibit deficits in visuomotor integration, motor coordination, and balance.[1] Neuromuscular abnormalities in children with Down syndrome, which coincide with developmental delays, include generalized muscular hypotonia, persistence of primitive reflexes beyond the normal age of disappearance, and slowed reaction times during voluntary movement.[2] These abnormalities significantly impact the neural, physiological, and biomechanical systems, leading to a movement profile characterized by clumsiness, slow movements, and impaired coordination. This includes delayed motor development, deficits in balance, speed, visuomotor control, bilateral coordination, and hypotonia.[3] Anatomical studies reveal a smaller cerebellum in individuals with Down syndrome, impairing motor performance and learning compared to typical individuals. A smaller cerebellum and brain stem, loss of neurons, generalized brain hypocellularity, and decreased myelination in various brain regions during the first year of life may contribute to motor and postural delays.[4]

Motor development in Down syndrome follows the same pattern but is delayed and highly variable, with slower reaction and movement times compared to age-matched controls. Individuals with Down syndrome often display perceptual-motor deficits. Parents, teachers, and physical therapists note that individuals with Down syndrome perform better when movements are demonstrated rather than verbally instructed. Experimental studies show that adults with Down syndrome are more successful in learning new movements with visual cues than with verbal instructions. Previous research indicates difficulties in processing auditory movement information compared to peers with undifferentiated developmental disabilities. This suggests that modeling or copying movements is more effective for learning new skills than verbal instructions. Participants with Down syndrome are less affected by the elimination of visual feedback in target-aiming tasks and show lower proficiency and more errors in verbal-motor performance compared to visual-motor performance groups. Cognitive impairments, including a short attention span, slow learning, and delayed language and speech development, also impact reaction time in individuals with Down syndrome.[5]

VESTIBULAR STIMULATION

The vestibular system, crucial for balance, equilibrium, and reflexes, also influences cognition, general health, and stress reduction. Vestibular stimulation, which involves movement or direction changes, can be mild (e.g., nodding head) or intense (e.g., skydiving). It provides the CNS with information about head movement and position, aiding in postural and balance control, head position, and eye-head coordination. Controlled vestibular stimulation offers benefits such as decreased self-stimulation, increased postural security, concentration, balance, body awareness, calming effects, and reduced abnormal muscle tone.[6] The vestibular system's main functions include motor skill development, postural reflex integration, eye movement coordination, and visual attention skills. Vestibular dysfunctions can lead to motor incoordination and learning disabilities. Stimulation of vestibular end organs transmits signals to the brain, coordinating motor responses, head position, posture, and eye movements. Rotational vestibular stimulation has improved motor performance in children with Down syndrome.[7]
Mechanical vestibular stimulation, such as spinning movements, stimulates labyrinth receptors and produces the vestibulo-ocular reflex, aiding postural control by integrating external feedback. This stimulation, involving irregular, fast, and arrhythmic oscillations, facilitates muscle tone and improves postural control by reducing deviations in the center of gravity. The vestibular system's connection to auditory, visual, proprioceptive, and motor systems affects muscle tone, visual gaze, and spatial orientation.[8]

REACTION TIME

Reaction time, the elapsed time between a sensory stimulus and the subsequent behavioural response, is a physical skill closely related to human performance, reflecting neuromuscular coordination. Simple reaction time can be determined by pressing a button in response to a light or sound.[9] Research indicates that auditory stimuli typically result in faster reaction times than visual stimuli, though there is some variation in findings. Factors affecting reaction time include stimulus intensity and duration, participant age and gender, and practice effects. Children with Down syndrome exhibit longer reaction and movement times compared to their peers.[10]

Studies show that vestibular stimulation significantly decreases visual reaction time for green and red lights and auditory reaction time for high-pitched sounds in both males and females. Vestibular stimulation impacts reaction times across sensory modalities, enhancing auditory and visual reaction times and mitigating stress-induced changes. Vestibular exercises also significantly decrease reaction times in elderly individuals, suggesting therapeutic applications for improving cognitive function. Adolescents with Down syndrome exhibit longer reaction times compared to their peers, and vestibular stimulation effectively reduces these times.[11] This study aims to assess auditory and visual reaction times in adolescents with Down syndrome and the effect of vestibular stimulation on these reaction times.

METHODOLOGY:

- **Type of study**: Experimental study
- **Study design:** Pre and Post test
- **Sampling method:** Simple random sampling method

- **Sample size:** A total 40 male and female with down syndrome will be recruited in this study.
- **Place of study:** Karad
- **Inclusion Criteria:**

1. Age group 10 – 15 years
2. Children diagnosed with Down Syndrome
3. Down syndrome children with IQ 70 and above

- **Exclusion Criteria:**

1. Participants having any disease/disorder affecting hearing.
2. Participants having any disease/disorder affecting the visual system.

Outcome Measures:

Reaction Time: RT apparatus for research, manufactured by Anand Agencies, Pune, was used to record auditory and visual RT. Anand Agencies (http://www.anandagenciespune.in).

Sensory Profile 2: Manufactured by Pearson India Education Services Private limited, Uttar Pradesh

PROCEDURE

After the ethical approval from the institutional ethical committee, the participants are selected based on the inclusion and exclusion criteria for eligibility. The subjects' parents were informed about the proposed benefits of the procedure of the study in a language best understood by them. Informed consent is obtained from the parents and demographic data is recorded. In this experimental study, 40 subjects with Down syndrome and from the adolescent age group were selected. Sensory profile score and auditory and visual reaction time score were taken before starting the intervention. Participants were randomly allocated into 2 groups that is Group A (Experimental group) and Group B (Control group). Group A received Vestibular stimulation with auditory and visual cues and Group B received only auditory and visual cues. After completion of 6 weeks sensory profile score and auditory and visual reaction time was taken again for comparision. An intervention study was designed to investigate the effect of vestibular stimulation on auditory and visual reaction time in Down syndrome adolescents. For both the groups treatment was given for 4 days/week for 6 weeks.

Data Analysis

Statistical data was summarized using descriptive statistics including percentages.

Frequencies, mean, and standard deviation. Analysis of data was done using INSTAT

To compare the outcomes post-rehabilitation, we concluded the difference between baseline (Pre-rehabilitation) values and after 6 weeks after completion of rehabilitation by using paired t test within the group. An unpaired t test was used to compare pre-pre and post-post values between the groups.

The level of significance (p value) was set up at < 0.005.

Result

Gender Distribution

Gender	Male	Female
Total	26	14

TABLE NO 8.1: Gender Distribution

Interpretation: A total of 40 subjects with Down syndrome were included in this study. Out of 40 subjects, 26 were male and 14 were female.

Age Distribution

Age	Mean ± SD
Total	12.5 ± 1.797

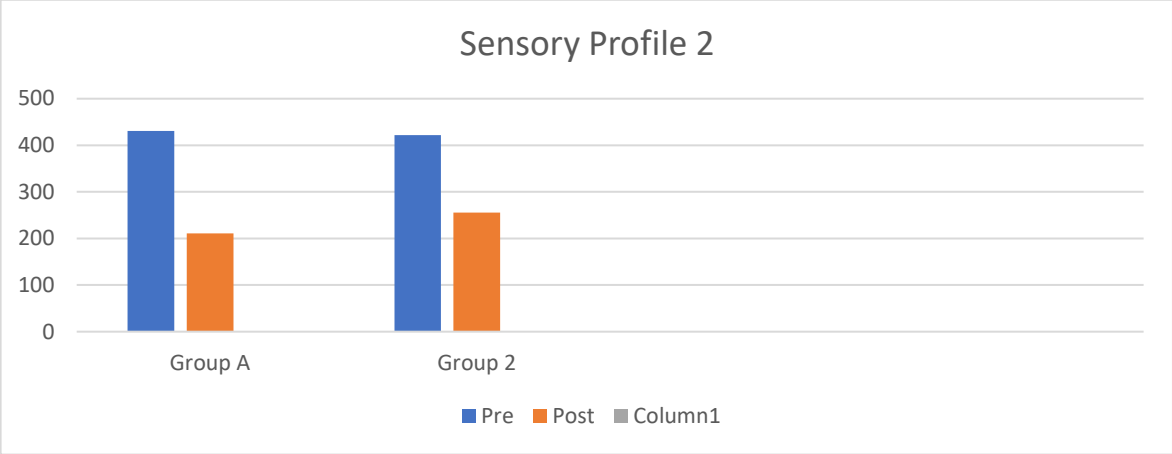
TABLE NO 8.2: Age Distribution

Interpretation: Mean ± SD value of age group 10 -15 is 12.5 ± 1.797

1.Sensory profile score

	Pre	**Post**	**P value**	**T value**	**Inference**
Group A	430.45 ± 36.803	211.20 ± 41.481	<0.0001	22.770	Extremely significant
Group B	421.80 ± 44.181	255.65 ± 78.878	<0.0001	14.495	Extremely significant

TABLE NO 8.3: Mean and SD OF Pre and Post Sensory profile score of Group A and Group B



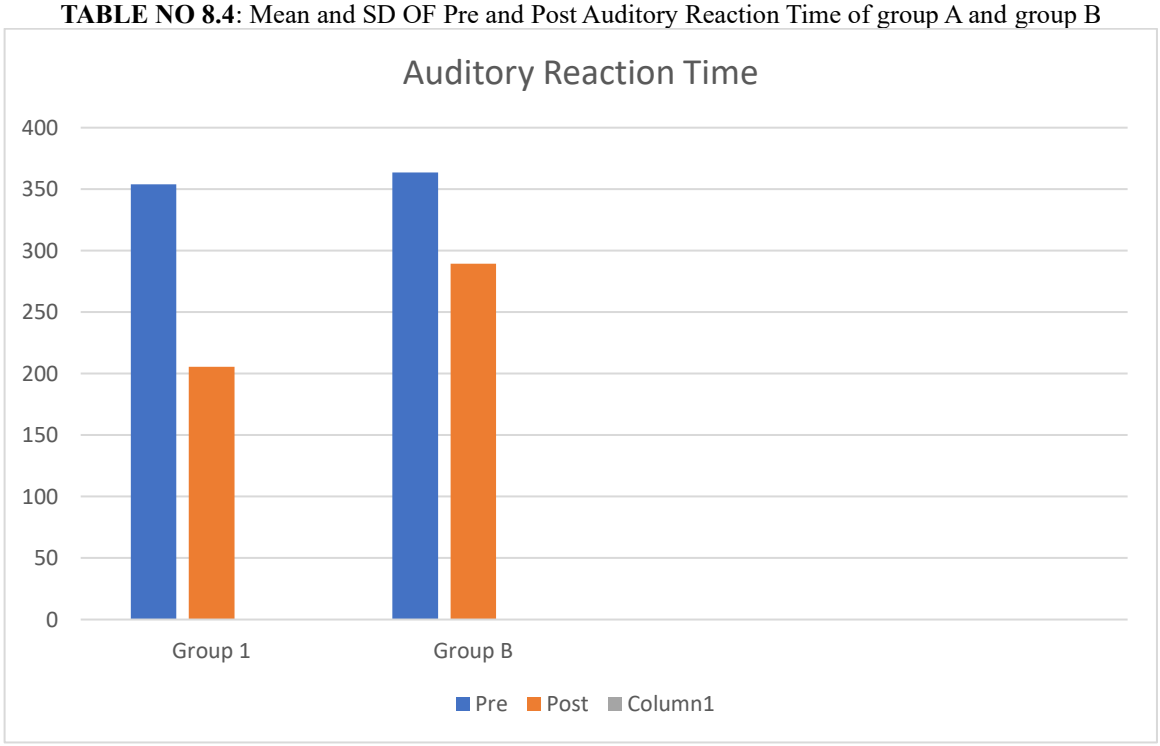
GRAPH 8.3: Mean and SD OF Pre and Post Sensory profile score of Group A and Group B

Interpretation: The above table and graph show significant improvement after vestibular stimulation in the experimental group with a mean difference of 211.20±41.481 whereas conventional training in the control group shows the mean difference of 255.65±78.878.

2.Auditory Reaction Time

	Pre	**Post**	**P value**	**T value**	**Inference**
Group A	354 ± 79.047	205.65 ± 26.226	<0.0001	17.467	Extremely significant
Group B	363.65 ± 59.664	289.65 ± 59.012	<0.0001	19	Extremely significant

TABLE NO 8.4: Mean and SD OF Pre and Post Auditory Reaction Time of group A and group B



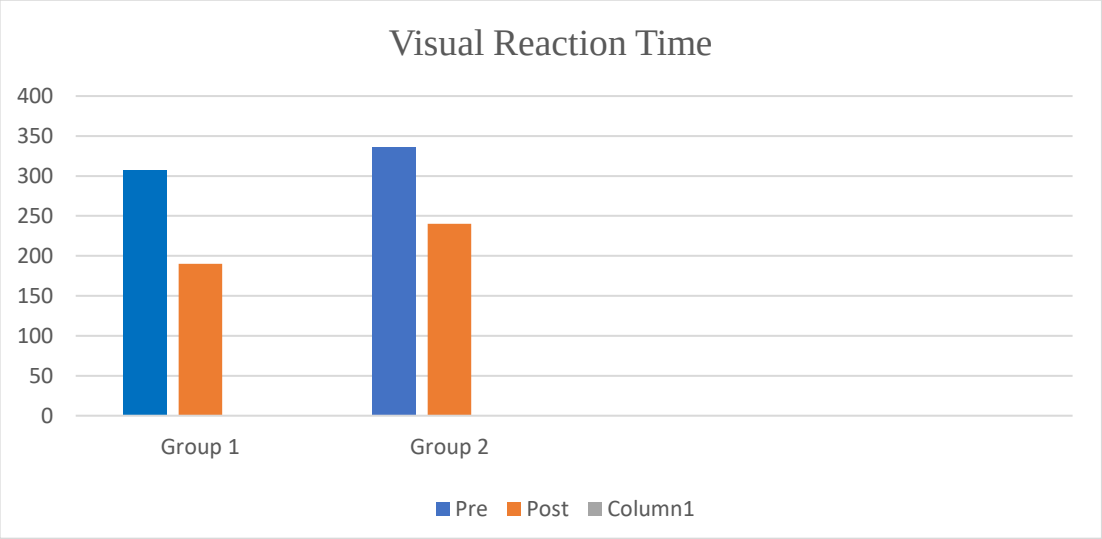
GRAPH 8.4: Mean and SD OF Pre and Post Auditory Reaction Time of group A and group B

Interpretation: The above graph and table show a significant improvement in the experimental group with a mean difference of 205.65± 26.226 and the control group shows a mean difference of 289.35± 59.012.

3.Visual Reaction Time

	Pre	**Post**	**P value**	**T value**	**Inference**
Group A	306.90 ± 44.380	190.05 ± 45.998	<0.0001	18.477	Extremely significant
Group B	335.80 ± 41.805	240.05 ± 40.719	<0.0001	26.364	Extremely significant

TABLE NO 8.5: Mean and SD OF Pre and Post Visual Reaction Time of group A and group B



GRAPH 8.5: Mean and SD OF Pre and Post Visual Reaction Time of group A and group B

Interpretation: The above graph and table show a significant improvement in the experimental group with a mean difference of 190.05± 45.998 whereas the control group shows a mean difference of 240.05± 40.719.

DISCUSSION

Down syndrome is a genetic disorder caused by the presence of all or part of a third copy of chromosome 21, also known as trisomy 21. It is the most common chromosomal condition.[1,15] It affects individuals by causing developmental delays, mild to moderate intellectual disability, and characteristic physical features like flattened faces, slanting eyes, and small ears. Down syndrome is associated with challenges in processing speed and reaction time throughout the lifespan.[16] Individuals with Down syndrome take significantly longer than typically developing individuals to reach motor development milestones. One of the deficits often noted in children with Down syndrome is decreased, or slower, reaction time to a stimulus.[17] Individuals with Down syndrome often experience sensory processing challenges. These challenges are common and can significantly impact the daily functioning and participation of these individuals.[18] Common cognitive features of individuals with Down syndrome include challenges with executive function, learning, and memory. Two related cognitive components that impact executive function abilities are processing speed, or the efficacy of cognitive task completion, and reaction time.[19] The development of motor skills in individuals with Down's syndrome differs from that in non-disabled individuals. The motor skills and development of these individuals are markedly slower.[20]

The present study was undertaken to observe the effectiveness of vestibular stimulation on improving the auditory and visual reaction time in Down syndrome adolescents after a 6-week training protocol. 42 subjects were screened out of which 40 were selected according to the inclusion and exclusion criteria. Subjects were randomly divided into two groups: Group A: The experimental group, and Group B: the Control group. In group A the individuals were given vestibular stimulation with auditory and visual stimulation and group B individuals received only auditory and visual cues.

The sessions were conducted 4 days/week. After 6 weeks data was statistically analyzed and the results indicated that vestibular stimulation is effective in improving the auditory and visual reaction time in adolescents with Down syndrome. The comparison of the pre and post-test values of sensory profile 2 and auditory and visual reaction time shows higher significance in Group A than in Group B. Assessment of performance showed extremely significant results with a P value < 0.0001. There was a significant decrease in auditory and visual reaction time by vestibular stimulation with auditory and visual reaction time. A paired t-test was used for analysis. Studies in the published literature have shown that different therapy programs have been used to facilitate mental and motor development in Down syndrome. Sensory integrative therapy, perceptual–motor training, neurodevelopmental therapy, vestibular stimulation, and play therapy have been used either as sole treatment programs or as combined programs according to the necessity of the children with motor problems.[21]

A study found that 8 weeks of vestibular exercises led to a significant improvement in auditory and visual reaction time in young adults compared to the control group. The researchers concluded that "vestibular exercises have a positive impact on auditory and visual reaction time." [22]Down syndrome is associated with slower reaction times compared to typically developing individuals.[23]therefore this study was done to check the effect of vestibular stimulation on subjects with Down syndrome.

The above table 8.3 and Graph 8.3 show that improvement in sensory profile score after vestibular stimulation in Group A shows a significant difference of 211.20± 41.481 whereas in Group B after conventional exercises mean difference is 255.65 ± 78.878.

Individuals with Down syndrome may struggle to process sensory information, leading to frustration, inappropriate behaviour, and impact on motor development. Through this study sensory profile scores is also improved.

In study by Basavaraj Muralidhar Tenginkai, Sai Sailesh Kumar Goothy they found that vestibular exercises had a positive impact on auditory and visual reaction time in young adults, indicating that vestibular stimulation can improve cognitive functions.1 As the subjects with Down syndrome show slower reaction time than the typically developing individuals this study was done to check the effect of vestibular stimulation exercises on auditory and visual reaction time.[2] The study by Joseph M. Furman, Mark S. Redfern investigated the impact of visual-vestibular stimulation on the performance of an auditory information processing task and found that visual-vestibular stimulation influences spatial and non-spatial cognitive processing, with otolithic stimulation and visual stimulation being associated with greater task cost compared to semicircular canal stimulation.[25]The study by Nina Božanić Urbančič, Saba Battelino discussed the importance of appropriate vestibular stimulation in children and adolescents, emphasizing its effect on bodily homeostasis, cognition, and emotion. Overall, these studies suggest that vestibular stimulation can have a positive impact on cognitive functions, including auditory and visual reaction time.[26]

The above table 8.4 and Graph 8.4 show that improvement in auditory reaction time after vestibular stimulation in Group A shows a significant difference of 205.65 ± 26.226 whereas in Group B after conventional exercises mean difference is 289.65 ± 59.012.

The above table 8.5 and Graph 8.5 show that improvement in visual reaction time after vestibular stimulation in Group A shows a significant difference of 190.05 ± 45.998 whereas in Group B after conventional exercises mean difference is 240.05 ± 40.719.

The study Mechanical vestibular stimulation versus traditional balance exercises in children with Down syndrome proved that mechanical vestibular stimulation is better added to the rehabilitation program to improve balance in children with Down syndrome. Studies of vestibular stimulation on individuals with Down syndrome are few. Early studies determined vestibular stimulation training had a positive effect on the motor skills of children with DS.[27]

Cognitive impairments associated with Down syndrome (DS) can make it challenging for patients to complete exercises independently, necessitating tailored treatment strategies and increased education to enhance outcomes. Individuals with Down syndrome often experience cognitive impairments that can hinder their ability to follow instructions, understand complex information, and perform exercises independently. This study uses strategies that are easy to understand and follow, such as visual aids, simple instructions, and repetitive exercises. This helps patients with DS to better comprehend and engage with the exercises, leading to improved outcomes. Educating patients with DS and their caregivers about the exercises and treatment plans is crucial. We should conduct thorough assessments to identify the patient's cognitive strengths and weaknesses. This information can be used to adapt exercises and treatment plans to better suit the patient's abilities, promoting more effective physiotherapy outcomes. The attention span in Down syndrome individuals is also less than the of peers. As per studies, attention improves with the growing age and that was observed in this study. Individuals with Down syndrome have communication challenges, which make it difficult for them to express their needs and understand instructions. Family members and teachers play a crucial role in helping children's and to convey their needs to the therapist. Repetitive demonstration of exercises helps individuals with Down syndrome to understand and to incorporate the exercise protocol effectively.

The interpretation of this study was done on the basis of comparing the Pre and Post-intervention values using outcome measures. Within the group comparison of Pre and Post-intervention, there were significant improvements in both outcome measures. The difference between the pre-test and post-test averages of the experimental group we studied is significantly higher than the difference between the control group averages this shows the effect of vestibular stimulation.

According to the present data collected, there was an improvement in auditory and visual reaction time. The study concluded that vestibular stimulation effectively improves auditory and visual reaction time in adolescents with Down syndrome.

CONCLUSION

In this study, based on statistical analysis, presentation, and interpretations it was concluded that the vestibular stimulation program has a significant effect on auditory and visual reaction time in Down syndrome adolescents. Thus, the study provided evidence to support that vestibular stimulation holds a promising benefit in improving auditory and visual reaction time in Down syndrome adolescents.

LIMITATIONS

- A larger sample size is required to make the study more reliable.
- The study was limited to one geographical location.

FUTURE SCOPE

- A similar study can be done with other outcome measures like a ruler drop test or software-based test to measure the reaction time.

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