Original article:

Comparison of balance in children with and without hearing impairment

Hetal Patel1, Mandar Malawade2, Sneha Butte-Patil3, Prerna Khairnar4, Shweta Gawade5

Intern Student1,3,4,5, Dept of Pediatric Physiotherapy, Dr. APJ Abdul Kalam College of Physiotherapy, Loni, Maharashtra, India.
HOD, Dept of Pediatric Physiotherapy, Dr. APJ Abdul Kalam College of Physiotherapy, Loni, Maharashtra, India.
Correspondence: Dr Hetal Patel

ABSTRACT

Background: Hearing is one of the five major senses. There are many childrens who have sensorineural hearing impairment. They shows vestibular function impairment because cochlea and vestibule share continuous membranous labyrinth of the inner ear and balanceimpairment because otolith organs contribute to postural control, particularly through the vestibulospinal system. Balance assessment is not a routine procedure in children with hearing impairment. Hence, this study incorporates balance assessment to find out how much they lack when compared with normal children.

Objective: This study compared overall balance of children with and without hearing impairment.

Materials and Methods: This two-group study involved 60 children, i.e., 30 children with sensorineural hearing loss and 30 with normal hearing, aged between 7 to 15 years. Head Thrust Test, Dynamic Visual Acuity Test, One Leg Stance Test and Functional Reach Test were used to assess vestibular function, vestibulo-ocular reflex, static and dynamic balance, respectively. For data analysis paired and unpaired t test were used.

Result: Both vestibulo-ocular reflex and eyes closed, eyes opened static balances were significantly lower among hearing impaired than the normal hearing children and there was no significant changes in Vestibular function and Dynamic balance in hearing impaired children when compared with normal hearing children.

Conclusion: Children with hearing impairment perform poorly on vestibule-ocular reflex test and static balance tests compared with their normal-hearing subjects, while vestibular function and dynamic balance was comparable between both groups of subjects. Balance training program is recommended for children with hearing impairment who present movement and stability deficits.

KEY WORDS: Sensorineural hearing loss, vestibular function, static and dynamic balance

INTRODUCTION

Hearing is one of the major senses and like vision, it is important for distant warning and communication. It is a conscious appreciation of vibration perceived as sound. The range of sound frequencies that the human ear can perceive is 20 Hz–20,000 Hz. Deafness is defined as “a hearing impairment that is so severe that the child is impaired in processing linguistic information through hearing, with or without amplification.” Thus, deafness is viewed as a condition that prevents an individual from receiving sound in all or most of its forms.

In 2006, National Center for Hearing Assessment and Management reported that sensorineural hearing loss (SNHL) is the most common congenital sensory impairment.
occurring in three of every 1000 live births. Published reports show vestibular dysfunction is found in 20% to 70% of children with hearing loss of different causes. About 30% of persons with profound hearing impairment are estimated to have vestibular problems and have been reported to perform poorly on vestibular function tests and balance skills. This is because the vestibular end organs and cochlea are closely related anatomically and developmentally, therefore, strong potential exists for a related vestibular deficit when the hearing mechanism is impaired.

Balance is the ability to maintain a position, to move voluntarily and to react to perturbation. Balance is classified as either static or dynamic. Static balance is the ability to maintain a steady position in a weight bearing, antigravity posture. Dynamic balance is the ability altering a position or change position while maintaining stability.

Auditory system and vestibular system are interconnected. If any of this system gets affected, they may affect balance. Balance performance is an essential tool in the assessment and rehabilitation of patients with sensorineural hearing loss. Based on the above considerations, the aim of this study was to assess the balance of normal hearing students and their counterparts with sensorineural hearing loss and compare data among groups, considering age group.

**METHODOLOGY**

The participants were recruited from Shree S.K. Somaiya Vinaymandir, Vidyavihar; Sadhna Vidyalaya for Deaf, Dadar, Mumbai and Padmashree Dr. Vithalrao Eknathrao Vikhepatil Vidyalaya, Babhleshwar. A total of 60 children comprising of 30 with sensorineural hearing loss and 30 with normal hearing, aged between 7 to 15 years. Criteria for participation among the hearing impaired children was sensorineural hearing loss diagnosed by physician with no musculoskeletal and/or neurological disorders which affects balance. An informed consent was taken from parents.

**Clinical Test:**

**Head Thrust Test (HTT)**- The test was performed with examiner facing the patient. The subjects were instructed to look at his/her nose. The examiner grasped the subject’s head above the ears and positioned him into 30 degrees of cervical flexion. Subject’s head was rotated slowly left and right around a vertical axis ensuring cervical muscles relaxed and gaze remained fixed on the tester’s nose during rotations. Suddenly subject’s head was rotated 10 degrees from mid-line while maintaining good visibility on the subject’s eyes. The examiner then timed the duration of nystagmus. The same test was repeated with eyes closed. After rotating the subject’s head with eyes closed, the subject was asked to look at a white sheet and nystagmus was timed.

**Dynamic Visual Acuity Test (DVAT)**- For this test the subject sat 10′ away from the Lea Symbols chart. The chart had a total of 15 lines of 5 optotypes. The subject began at an acuity level where all symbols on a line could be correctly identified, and continued to identify progressively smaller symbols until no symbol could be identified. The number of optotypes unable to be identified was static visual acuity (SVA). For the DVA, the neck was flexed 30° by using the same anatomical landmarks as for the HTT, the head was moved at 2 Hz (120° per second) in the yaw plane, and the number of unidentified optotypes was
recorded. Then the difference in optotypes missed between the DVA and Static visual acuity test was scored.

**One Leg Stance Test** - This test was carried out on a level hard surface. The subject was instructed to stand on his dominant leg with contralateral leg flexed at a level of knee of stance leg. The subjects’ hand was placed by side. Timing with the stop watch began when the subject assumed a stable position. The timing was stopped when raised leg could no longer be maintained and leg touches the floor. Same test was performed with eye close.

**Functional Reach Test** - For this test transparent meter rule was mounted on the wall with the zero centimeter mark at the level of the subject’s acromion process. The subject stood with feet apart about shoulder width apart. The participant was asked to flex the shoulder such that it is parallel to the meter rule. The subject’s initial reach position was measured by noticing the point where the end of the third metacarpal was placed along the meter rule and was recorded in centimeters. For the end reach position, the subject was asked to reach forward as far as possible keeping the hand parallel to the meter rule without losing balance. The subject’s end reach position was then observed and recorded in centimeters. Each test was performed thrice and mean was taken.

**RESULT**

**TABLE NO 1. COMPARISON OF HTT IN DEAF AND NORMAL CHILDREN**

<table>
<thead>
<tr>
<th>GROUP</th>
<th>MEAN</th>
</tr>
</thead>
<tbody>
<tr>
<td>DEAF</td>
<td>0</td>
</tr>
<tr>
<td>NORMAL</td>
<td>0</td>
</tr>
</tbody>
</table>

**Comparison of Head Thrust Test in deaf and normal children**

Graph 1 shows that on comparison of HTT in deaf and normal children in which mean is 0; it indicated not significant
### TABLE NO 2. COMPARISON OF LINES MISSED BETWEEN SVAT AND DVAT IN DEAF CHILDREN

<table>
<thead>
<tr>
<th>Group</th>
<th>Mean±SD</th>
<th>T value</th>
<th>P value</th>
</tr>
</thead>
<tbody>
<tr>
<td>SVAT</td>
<td>7.66±1.516</td>
<td>1.439</td>
<td>0.1608</td>
</tr>
<tr>
<td>DVAT</td>
<td>7.73±1.680</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Considered Not Significant.

Graph 2 shows that on comparison of lines missed between SVAT and DVAT in deaf children using paired t test in which t value is 1.439 and p value is 0.1608; it indicated not significant.

### TABLE NO 3. COMPARISON OF LINES MISSED BETWEEN SVAT AND DVAT IN NORMAL CHILDREN

<table>
<thead>
<tr>
<th>Group</th>
<th>Mean±SD</th>
<th>T value</th>
<th>P value</th>
</tr>
</thead>
<tbody>
<tr>
<td>SVAT</td>
<td>5.36±0.4901</td>
<td>1.000</td>
<td>0.3256</td>
</tr>
<tr>
<td>DVAT</td>
<td>5.4±0.5632</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Considered Not Significant.
Graph 3 shows that on comparison of lines missed between SVAT and DVAT in normal children using paired t test in which t value is 1.000 and p value is 0.3256; it indicated not significant.

**TABLE NO 4. COMPARISON OF LINES MISSED BETWEEN DVAT IN DEAF AND NORMAL CHILDREN**

<table>
<thead>
<tr>
<th>Group</th>
<th>Mean±SD</th>
<th>T value</th>
<th>P value</th>
</tr>
</thead>
<tbody>
<tr>
<td>DVAT (Deaf)</td>
<td>7.73±1.680</td>
<td>7.212</td>
<td>&lt;0.0001 Considered Extremely Significant.</td>
</tr>
<tr>
<td>DVAT (Normal)</td>
<td>5.4±0.5632</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Graph 4 shows that on comparison of lines missed between DVAT in deaf and normal children using unpaired t test in which t value is 7.212 and p value is <0.0001; it indicated extremely significant.
TABLE NO 5. COMPARISON OF OLST WITH EYE OPEN IN DEAF AND NORMAL CHILDREN

<table>
<thead>
<tr>
<th>Group</th>
<th>Mean±SD</th>
<th>T value</th>
<th>P value</th>
</tr>
</thead>
<tbody>
<tr>
<td>OLST (Deaf)</td>
<td>5.33±2.249</td>
<td>48.892</td>
<td>&lt;0.0001</td>
</tr>
<tr>
<td>OLST (Normal)</td>
<td>42.93±3.562</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Considered Extremely Significant.

Graph 5 shows that on comparison of OLST with eye open in deaf and normal children using unpaired t test in which t value is 48.892 and p value is <0.0001; it indicated extremely significant.

TABLE NO 6. COMPARISON OF OLST WITH EYE CLOSE IN DEAF AND NORMAL CHILDREN

<table>
<thead>
<tr>
<th>Group</th>
<th>Mean±SD</th>
<th>T value</th>
<th>P value</th>
</tr>
</thead>
<tbody>
<tr>
<td>OLST (Deaf)</td>
<td>2.6±1.567</td>
<td>21.674</td>
<td>&lt;0.0001</td>
</tr>
<tr>
<td>OLST (Normal)</td>
<td>11.5±1.614</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Considered Extremely Significant.
Graph 6 shows that on comparison of OLST with eye close in deaf and normal children using unpaired t test in which t value is 21.674 and p value is <0.0001; it indicated extremely significant.

**TABLE NO 7. COMPARISON OF FRT IN DEAF AND NORMAL CHILDREN**

<table>
<thead>
<tr>
<th>Group</th>
<th>Mean+SD</th>
<th>T value</th>
<th>P value</th>
</tr>
</thead>
<tbody>
<tr>
<td>FRT (Deaf)</td>
<td>22.73+2.947</td>
<td>0.3914</td>
<td>0.6970</td>
</tr>
<tr>
<td>FRT (Normal)</td>
<td>22.43+2.991</td>
<td></td>
<td>Considered Not Significant.</td>
</tr>
</tbody>
</table>

Graph 7 shows that on comparison of FRT in deaf and normal children using unpaired t test in which t value is 0.3914 and p value is 0.6970; it indicated not significant.
DISCUSSION
This study compared balance performance in children with hearing impairment and their normal hearing counterparts. The result of this study was found to be not significant for Head Thrust Test and Functional Reach Test and was extremely significant for Dynamic Visual Acuity Test and One Leg Stance Test.

The Head Thrust Test and difference between Static Visual Acuity Test and Dynamic Visual Acuity Test used in this study was not significant. Rosenblütet al. concluded in their study that vestibular function was proved to be normal in 80% of individuals with hearing loss of less than 90 dB as opposed to only 20% of those whose hearing loss exceeded 98 dB. Vestibular function appears, therefore, to be normal up to a point at which acoustic function has been almost entirely lost.³

The difference of Dynamic Visual Acuity Test between deaf and normal children was extremely significant because retina and the cochlea structures are formed at the same developmental stage and embryonic layer, so any pathological defect within these areas could lead to oculo-auditory defects.⁷

The difference of One Leg Stance Test between deaf and normal children was extremely significant because of the immaturity of the visual postural control system.⁸ When it is not possible to use the visual system, the somatosensory and vestibular systems are most required for the maintenance of postural stability.⁹ The otolith organs also contribute to postural control, particularly through the vestibulospinal system. Damage to these structures may be responsible for the apparent immaturity of motor function and the noted aberration in balance responses.⁸

The difference of Functional Reach Test between deaf and normal children was not significant because the performance of dynamic balance does not depend on static balance.⁹ OlusolaAyaniyiet al studied on Static and dynamic balance in school children with and without hearing impairment, they found similar result that both eye closed and eye opened static balances were significantly lower among hearing impaired than the normal hearing subjects and dynamic balance was higher among hearing impaired, but was not statistically significant.⁵

CONCLUSION
From the above study it was concluded that there was no significant difference in vestibular function and dynamic balance but there was extremely significant difference in oculo-auditory reflex and static balance in children with hearing impairment when compared with children without hearing impairment.

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