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Original Article

A study on static balance of school children in India with different degrees of hearing impairement

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Abstract:
Purpose - The present study was taken into account to study the variations of static balance with degree of hearing loss. **Problem Statement -** Therefore, the problem was stated as a study on static balance of different degree of hearing impaired school children. **Methodological approach-** A total of two hundred and ten (N=210) hearing impaired school children were selected as subjects for this study. The age of the subjects for the present study were ranged from 13-20 years. Firstly all the subjects for both sexes i.e. Boys (N_B=102) and Girls (N_G=102) were sub divided into five equal groups viz. *Profound Group, Severe Group, Moderately Severe Group, Moderate Group* and *Mild Group,* having representatives twenty one (n=21) each depending on their hearing ability as measured by audiometric techniques. In the present study the only dependent variable i.e. Static balance was measured by *Stork Stand Test*. Mean, standard deviation (SD) and Two way ANOVA were used for the inter group comparison of Static balance. Level of significance was tested at 0.05 levels. To find out the exact location of differences pair wise comparison analysis were done for Row, Column and Interaction separately by using Tukey's LSD test as post hoc test. **Results -** On the basis of the result, in static balance, it was observed that 1) the girls were significantly superior than boys when all degree of hearing loss groups were combined 2) there were significant differences in few pair of hearing impaired groups when both sexes were combined. It was also observed that 3) the mean static balance of the girls were greater than the boys belonging to Moderate and Mild group where as no differences were observed in Profound, Severe and Md. Severe groups between boys and girls 4) there were significant differences between few pair of hearing impaired groups both for boys section as well as girls section separately. **Conclusions -** it can be concluded that the static balance of the girls is significantly superior to their boy's counterpart when all degree of hearing loss groups are combined. Again, the static balance increases with decreasing hearing loss when both sexes are combined or both sexes considered separately. Thus there is a linear relationship between hearing ability and static balance for combined sexes as well as separately for boys and girls.
Keywords: Deaf & dumb, Degree of hearing loss, Profound, Severe, Md. Severe, Moderate, Mild, and Stork Stand.

Introduction

Among various sensations, hearing ability is one of the most important ability that makes sense not only to the stressors related to sound waves from external environment to brain but also related to another most important things i.e. maintenance of balance of the human body. Therefore, those having hearing problem or cannot hear at all simultaneously suffers with balancing ability proportionately with varying degree of hearing loss while tried to initiate movement. Thus, undoubtedly there was an interrelation or connection between hearing loss and decreased balance ability (Effgen, S. K. 1981). Balance is that the skill of maintaining the body's center of gravity vertically over the base of the support, and it relies on rapid and continuous feedback from visual, vestibular and somatosensory structures for the next execution of smooth and coordinated neuromuscular actions (Winter, 1995; Zatsiorsky and Duarte, 1999).

Balance is a fundamental skill of a person. Postural control is one of the basics for most everyday's life activities in human beings. It is a complex ability to maintain, achieve or restore a state of balance while a person was stationary, preparing to move, in motion or preparing to stop moving (De Kegel et al., 2011). Postural stability was an important factor to maintain the center of gravity and also required appropriate motor responses in any position in respect to the base of support (Cherng, Lin, Ju, & Ho, 2009). In respect of sports balance denotes that the ability to stay upright or stay in control of movement. Balance is one of the main components of performance related fitness is basically of two types: i) Static Balance *which means maintaining the body weight in a stationary position* and ii) Dynamic Balance, *maintaining the body mass in different motion*. In the present investigation static balance was the focus of attention of the researchers. In other words Static balance is the ability to maintain a base of support with minimal movement while the dynamic balance may be considered the

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ability to perform a task while maintaining or regaining a stable position (Winter, D. A. et al., 1990) or the ability to maintain or regain balance on an unstable surface (Kioumourtzoglou, E. et al., 1997; Paillard, T. H., & Noé, F., 2006) with minimal extraneous motion. Static balance was involved with muscular strength (Sanjari, A., & Qasemi, G.). A simple field test for static balance is the timed unipedal stance (Kioumourtzoglou, E. et al., 1997; Wells, G. D., et al., 2009).

The most prevalent laboratory test for static balance is monitoring the centre of pressure unaltered for a specified duration as an athlete attempts to stand motionless on a force platform, unipedal, eyes open or eyes shut (Paillard, T., et al., 2002; Asseman, F. B., et al., 2008; Hrysomallis, C., 2011).

The vestibular mechanism controls our sense of balance and movement. Balance is obtained when our center of gravity relies on the base of support of our body. As a child grows and develops, their body and center of gravity also changes. The center of gravity varies greatly in each child because the head, trunk and legs do not grow proportionately, and there is a difference between males and females also (https://ilslearningcorner.com/2016-05-why-balance).

The vestibular system is located in the semicircular canals of ear which was related to the balance and has a function with cochlea responsible for hearing (de Souza Melo 2012). In the present research work the variations of static balance ability with respect to the degree of hearing loss was the focus of attention of the researchers. Therefore, the purpose of the study was to investigate the static balance among different degree hearing impaired school boys and girls.

Material & Methods

To achieve the purpose, present study was planned to initiate research work in the following way- A total two hundred ten (N = 210) hearing impaired school children, hundred and five girls and hundred and five boys aged between 13-20 years, were selected as subjects for this study. The subjects were purposively selected according to their degree of hearing loss by using audiometric technique from three separate districts of West Bengal i.e. Burdwan, Hooghly and Kolkata. For both sexes, depending on the frequency level of hearing ability, as recorded by audiometric technique, all the subjects were purposively divided into five groups; viz. (1) Profound Group– hearing disability 91 up to 100 dB, (2) Severe Group - hearing disability 71 up to 90 dB, (3) Moderately Severe Group - hearing disability 56 up to 70 dB, (4) Moderate Group - hearing disability 41 up to 55 dB and (5) Mild Group - hearing disability 25 up to 40 dB. In each hearing impaired group no. of subjects were considered as twenty one (n=21). For the present investigation static balance was considered as only dependent variable. To measure this variable stork stand test was used.

The subject was asked to stand on the foot of the dominant leg where the other foot were placed on the inside edge of the supporting knee and place the hand on the hips. Upon a given signal, raise the heel from the floor and maintain the balance as long as possible without moving the ball of the foot from its initial position or letting the heel touch the floor. The score was the greater number of seconds counted between the time the heel is raised and the balance is lost. Three trials were given and the best one is recorded. For data interpretation two way Analysis of Variance (ANOVA) were performed, followed by Tukey's LSD test as post hoc test for finding the exact location of the differences separately in row, column and interaction for different age groups and degree of hearing loss groups. The level of significance was set at $p< 0.05$.

Results

In the following table the descriptive statistics of the subjects in the present study has been presented

Table - 1

Descriptive Statistics of Different Hearing Impaired Groups both for Girls and Boys

Sl. No.	Name of the Group	No. of Subjects in different Group		Girls			Boys		
				Age (years)	Height (cm.)	Weight (kg.)	Age (years)	Height (cm.)	Weight (kg.)
		Boys	Girls	Mean ± SD	Mean ± SD	Mean ± SD	Mean ± SD	Mean ± SD	Mean ± SD
1.	**Profound**	21	21	16.71±4.67	150.19±7.59	44.62±6.38	18.19±4.11	160.81±8.91	51.71±5.98
2.	**Severe**	21	21	17.02±2.86	154.14±3.85	49.05±3.02	17.91±3.77	160.14±6.77	48.57±7.24
3.	**Md. Severe**	21	21	15.51±3.61	151.04±4.45	46.19±6.82	17.29±3.02	160.81±7.59	50.86±4.73
4.	**Moderate**	21	21	18.86±5.25	155.43±6.81	47.57±6.00	18.24±2.99	164.90±6.79	50.71±4.60
5.	**Mild**	21	21	16.77±2.50	147.62±5.89	39.52±6.15	15.81±0.93	156.81±4.84	45.11±6.93
Total no. of Subjects		105	105						
Grand Total (N) =		**210**							

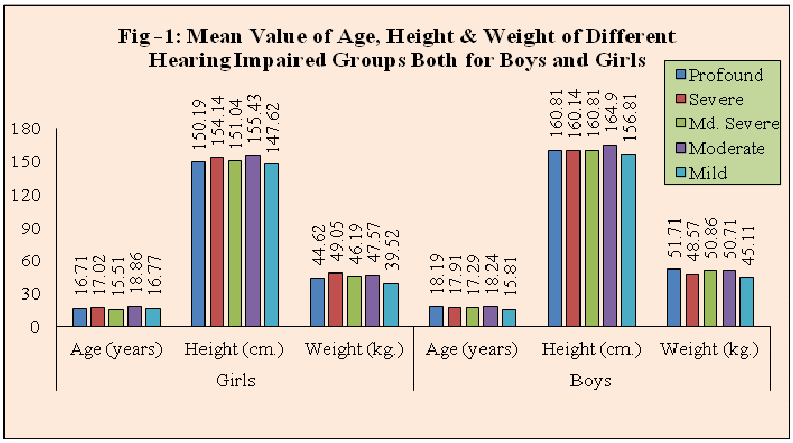


Table-1 showed that for each category of hearing impaired group no. of subjects was twenty one (n=21) , the total number of subjects for all Hearing Impaired groups for Girls were one hundred and five and for the Boys Groups were also one hundred and five. Thus the total number of subjects for both sex were two hundred and ten (N=210). In this table age in year, heights in cm, weight in kg for all the five groups have been presented again in Fig-1 it was depicted graphically as well.

Table- 2 Two Way Analysis of Variance (ANOVA) for the data on Static Balance (S)

Source of Variance	df	Sum of squares (SS)	Mean squares (MS)	F -value	Table Value of F	at
Sex ***(Row)***	1	534.21	534.21	23.19 *	3.89	$F_{0.05}(1, 200)$
Degree of Hearing Loss ***(Column)***	4	2523.39	630.85	27.38 *	2.41	$F_{0.05}(4, 200)$
Interaction ***(Sex × Degree of Hearing Loss)***	4	366.00	91.50	3.97 *	2.41	$F_{0.05}(4, 200)$
Error ***(Residual)***	200	4608.06	23.04			
Total	209	8031.67				

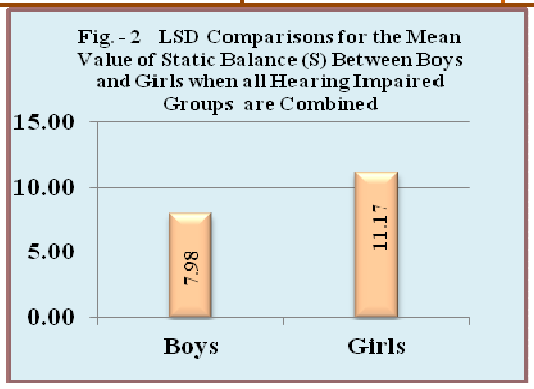
** Sign indicates Significant at 0.05 level of significance*

In Table-2 the two way analysis of variance (ANOVA) for the data on Static Balance (S) were presented. It was observed from the table that the computed F-value for Row, Column and Interaction were 23.19, 27.38 and 3.97 respectively which were greater than their corresponding Tabulated value of F at 0.05 level i.e. $F_{0.05}(1, 200) = 3.89$, F0.05 (4, 200) = 2.41 and F0.05 (4, 200) = 2.41 respectively, therefore, significant difference existed in Sex *(Row)*, Degree of Hearing Loss *(Column)*, and Interaction *(Sex × Degree of Hearing Loss)*. To get the exact location of differences pair wise comparison analysis were done for Row, Column and Interaction separately by using Tukey's LSD test.

Tukey's LSD test for Row Analysis

Table-3 Mean Value of Static Balance (S) Mean diff and Critical Diff for Boys & Girls (All Hearing Impaired Groups Combined)

Mean Scores of Rows		Mean Difference	CD at 0.05 level
Boys	Girls		
7.98	11.17	3.19 *	1.30



** Sign indicates Significant at 0.05 level of significance*

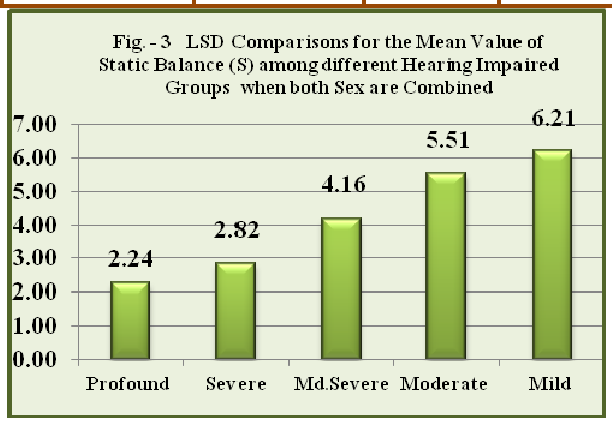
In Table - 3 the mean value of Static Balance for combined hearing impaired Groups both for Boys and Girls were presented which were 7.98 Seconds and 11.17 Seconds respectively. The value of mean difference

between Boys and Girls group were 3.19 which was greater than the value of critical difference 1.30 at 0.05 level of significance. Thus it may be concluded that the static balance of hearing impaired girls is higher than the hearing impaired boys when all degree of hearing loss groups are combined. These mean values were depicted graphically in Fig-2.

Tukey's LSD test for Column Analysis

Table-4 Mean Values of Static Balance (S) Mean diff and Critical Diff for Different Hearing Impaired Groups (Both Sexes Combined)

Mean Scores of Column					Mean Difference	CD at 0.05 level
Profound	Severe	Md. Severe	Moderate	Mild		
2.24	2.82				0.58	2.06
2.24		4.16			1.92	2.06
2.24			5.51		**3.27** *	2.06
2.24				6.21	**3.97** *	2.06
	2.82	4.16			1.34	2.06
	2.82		5.51		**2.68** *	2.06
	2.82			6.21	**3.39** *	2.06
		4.16	5.51		1.35	2.06
		4.16		6.21	2.05	2.06
			5.51	6.21	0.70	2.06



** Sign indicates Significant at 0.05 level of significance.*

In Table - 4 the mean values of Static Balance in Seconds, when two sex (boys & girls) were combined, for different degree of hearing impaired Groups i.e. Profound, Severe, Md. Severe, Moderate and Mild groups were presented which were 2.24, 2.82, 4.16, 5.51 and 6.21 respectively. These mean values were depicted graphically in **Fig-3**. It was evident from the above table that the value of mean difference between ***Profound vs. Moderate***, ***Profound vs. Mild***, ***Severe vs. Moderate*** and ***Severe vs. Mild*** group were 3.27, 3.97, 2.68 and 3.39 respectively which were greater than the value of critical difference 2.06 at 0.05 level of significance. Thus it may be concluded that the static balance of profound group significantly weaker than the moderate group and mild group when both sexes were combined. Again, static balance of the severe group significantly weaker than the moderate group and mild group when both sexes were combined. In rest of the pair of groups the value of mean difference were not found significant, at 0.05 level of significance, when both sexes were combined. In general, it may be concluded that there are significant difference between few pair of hearing impaired groups when both sexes are combined. From Fig-3 it was seen that the mean value of static balance increases with increasing hearing ability when both sex are combined, therefore, an increasing tendency with a positive gradient of static balance was observed from profound group towards the mild group. It indicated that there was a linear relationship between hearing ability and static balance with a positive gradient.

Tukey's LSD test for interaction analysis

Table-5 Mean value of Static Balance (S) for different Sexes in Each Hearing Impaired Groups

Interaction Row Vs. Column		Mean Scores of Row		Mean Difference	CD at 0.05 level
		Boys	Girls		
Mean Scores of Column	Profound	4.82	5.41	0.59	2.91
	Severe	6.30	6.60	0.31	2.91
	Md. Severe	8.26	10.76	2.51	2.91
	Moderate	9.26	15.91	**6.65** *	2.91
	Mild	11.25	17.14	**5.89** *	2.91

** Sign indicates Significant at 0.05 level of significance*

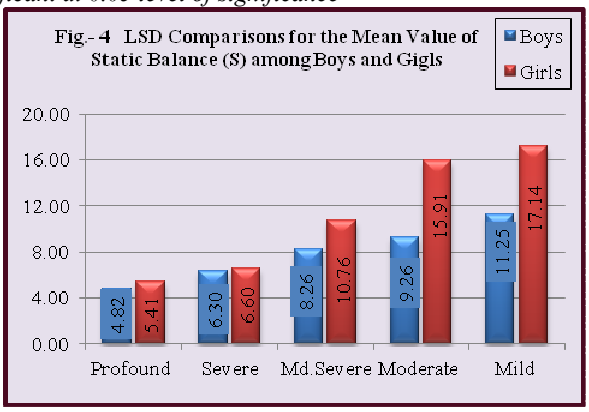
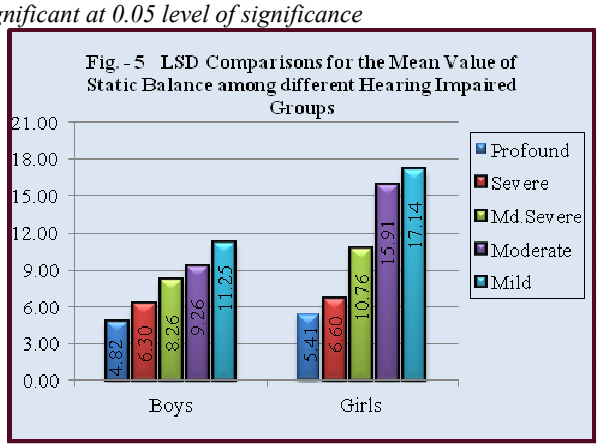


Table – 5 showed that there was no significant difference in static balances between Boys and Girls for profound, severe and Md. Severe groups. Whereas the difference was significant for Moderate and Mild group at 0.05 level when compared between the boys and girls as the corresponding mean difference was 6.65 and 5.89 respectively and which was greater than the table value 2.91. Thus it may be concluded that the mean static balance of the girls were greater than the boys belonging to Moderate and Mild group. The mean values of static balance of boys and girls belonging to different degree of hearing loss groups were depicted graphically in **Fig-4**.

Table-6 Mean Value of Static Balance (S) for different degree of hearing loss group in each Sex

Interaction Column Vs. Row		Mean Scores of Column					Mean Difference	CD at 0.05 level
		Profound	Severe	Md. Severe	Moderate	Mild		
Mean Scores of Rows	Boys	4.82	6.30				1.47	2.91
		4.82		8.26			**3.43** *	2.91
		4.82			9.26		**4.44** *	2.91
		4.82				11.25	**6.43** *	2.91
			6.30	8.26			1.96	2.91
			6.30		9.26		**2.96** *	2.91
			6.30			11.25	**4.95** *	2.91
				8.26	9.26		1.01	2.91
				8.26		11.25	**2.99** *	2.91
					9.26	11.25	1.99	2.91
	Girls	5.41	6.60				1.19	2.91
		5.41		10.76			**5.35** *	2.91
		5.41			15.91		**10.50** *	2.91
		5.41				17.14	**11.73** *	2.91
			6.60	10.76			**4.16** *	2.91
			6.60		15.91		**9.31** *	2.91
			6.60			17.14	**10.54** *	2.91
				10.76	15.91		**5.15** *	2.91
				10.76		17.14	**6.38** *	2.91
					15.91	17.14	1.23	2.91

** Sign indicates Significant at 0.05 level of significance*



In Table - 6 it was observed that for the boys section the mean difference of static balance between ***Profound vs. Md. Severe, Profound vs. Moderate***, ***Profound vs. Mild***, ***Severe vs. Moderate***, ***Severe vs. Mild*** and

Md. Severe vs. Mild group were 3.43, 4.44, 6.43, 2.96, 4.95 and 2.99 respectively which were greater than the table value of critical difference 2.91 at 0.05 level of significance. In rest of the pair of groups for the boys section the value of mean difference were not found significant at 0.05 level of significance. Thus it may be concluded for the hearing impaired boys that the static balance of Mild Group are significantly better than the Profound Group, Severe Group and Md. Severe Group. The static balances of the hearing impaired boys of the Moderate Group are significantly better than the Profound Group and Severe Group. Again, the static balance of the hearing impaired boys of the Md. Severe Group is significantly better than the Profound Group.

In Table - 6 it was observed that for the girls section that the mean difference of static balance between ***Profound vs. Md. Severe, Profound vs. Moderate***, ***Profound vs. Mild***, ***Severe vs. Md. Severe, Severe vs. Moderate***, ***Severe vs. Mild, Md. Severe vs. Moderate*** and ***Md. Severe vs. Mild*** group were 5.35, 10.50, 11.73, 4.16, 9.31, 10.54, 5.15 and 6.38 respectively which were greater than the value of critical difference 2.91 at 0.05 level of significance. In rest of the pair of groups for the girls section the value of mean difference were not found significant at 0.05 level of significance. Thus it may be concluded for the hearing impaired girls that the static balance of Mild Group are significantly better than the Profound Group, Severe Group and Md. Severe Group. The static balances of the hearing impaired girls of the Moderate Group are significantly better than the Profound Group, Severe Group and Md. Severe Group. Again, the static balance of the hearing impaired girls of the Md. Severe Group is significantly better than the Profound Group and Severe Group. The mean values of static balance as illustrated in Table-6 were depicted graphically in Fig-5, from which it was seen that the mean value of static balance increases with increasing hearing ability when both sex, i.e. boys & girls were considered separately, therefore, an increasing tendency with a positive gradient of static balance was observed from profound group towards the mild group. It indicated that there was a linear relationship between hearing ability and static balance with a positive gradient both for hearing impaired boys as well as girls.

Discussion

The findings of the study indicated that the hearing impaired girls were superior in static balance than that of boys when all hearing impaired groups were combined. Again, the findings of the study also indicated that the static balance of the girls were better than the boys belonging to Moderate and Mild group. These results may be explained by the fact that due to the wider and heavier pelvic region of the girls, it is conventional that the centre of gravity (CG) of the girls is comparatively lower than the boys (Luttgens, K., et al. 1997; Hall, S. J. 1999; Knudson, D., 2007). Lower the CG higher is the balance and stability (Knudson, D., 2007; Hamilton, N. P., 2011; Ghosh, S. S., & Banerjee, S., 2015). Again higher the stature higher is the chance of the position of CG, consequently, lower is the chance of balance and stability (Hall, S. J. 1999). In the present investigation the height of the hearing impaired girls were comparatively lower than the boys. Therefore, for the above two reason, the static balance of the girls may have been superior to their boy's counterpart when all hearing impaired groups were combined as well as for the Moderate and Mild group also when compared separately. The above findings were supported by few studies (Era, P. et al. 2006; Sullivan, E. V. et al. 2009; Smith, A. W. et al., 2012; Melam, G. et al. 2014). On the other hand few studies not supported the findings (Figura, F. et al. 1991; Golshaei, B. A. H. M. A. N. 2013).

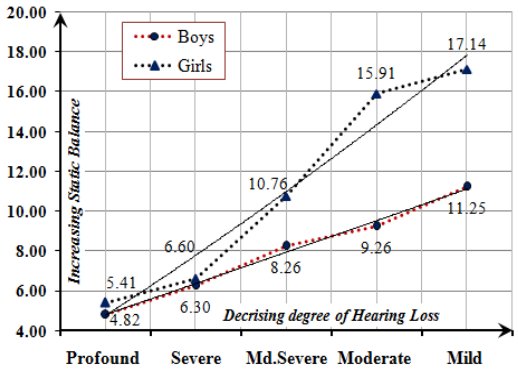


Fig-6 Mean Value of Static balance and it's Trendline for Boys and Gigls

Again, the findings of the study indicated that static balance increases with decreasing hearing loss when both sexes were combined, therefore, an increasing tendency with a positive gradient of static balance was observed from profound group towards the mild group. It indicated that there was a linear relationship between decreasing hearing loss and static balance with a positive gradient. The findings of the study also indicated that static balance increases with decreasing hearing loss when both sexes, i.e. boys & girls were considered separately, therefore, an increasing tendency with a positive gradient of static balance was observed from profound group towards the mild group. It indicated that there was a linear relationship between decreasing degree of hearing loss and static balance with a positive gradient both for hearing impaired boys as well as girls (shown by the trend line in Fig-6). This tendency of positive gradient in static balance i.e. increasing balance with decreasing degree of hearing loss may be explained by the fact that hearing disability has an effect on the vestibular mechanism in the human body. The proper functioning of the vestibular system is highly responsible for the balance ability. Balance is maintained by three biomechanical signal systems, namely, visual, proprioceptive and vestibular. Damage to any of these systems or an abnormality in the central nervous system (CNS) can cause balance problems (Casselbrant M. L. et.al. 2005) The balance is made up of three parts the eye, inner ear, muscle & central nervous system, the eyes receive visual clues from light receptors that give the brain information as to the position of the body relative to its surroundings. The receptors

in the muscle and joints are called proprioceptors. The most important ones are in the head and neck (head position relative to the rest of the body) and the ankles and joints. The inner ear balance mechanism has two main parts: three semicircular canals and the vestibule. Together they are called the vestibular labyrinth and are filled with fluid. When the head moves, fluid within the labyrinth moves and stimulates nerve endings hat send impulses along the balance nerves to the brain. Those impulses are sent to the brain in equal amounts from both the right & left inner ear. When the inner ear is not functioning correctly the brain receives the nerve impulses that are no longer equal, causing it to perceive this information as distorted or off balance. The brain gives the messages to the eyes, informing them to move back and forth, making the surroundings appear to spin. It is this eye movement that creates a sensation of things spinning that affect the balance and co-ordination while executing any motor task. Thus from the result it may be generalized that balance inversely depends on degree of hearing loss i.e. if the degree of hearing loss increases then the balance decreases. This findings was inconsonance with (Effgen, 1981; Rine et al., 1996; Wong et al., 2013)

Conclusion

On the basis of the result following conclusions can be drawn:

1) The static balance of the girls is significantly superior to their boys counterpart when all degree of hearing loss groups are combined.
2) There are significant differences in few pair of hearing impaired groups when both sexes are combined.
3) The static balance increases with decreasing hearing loss when both sexes are combined. Thus there is a linear relationship between hearing ability and static balance for combined sexes.
4) Static balance of the girls is greater than the boys belonging to Moderate and Mild group. But there are no differences in Profound, Severe and Md. Severe groups between the boys and girls.
5) In static there are significant differences between few pair of hearing impaired groups both for boys section as well as girls section separately.
6) The static balance increases with decreasing hearing loss separately for boys and girls. Thus there is a linear relationship between hearing ability and static balance separately for boys and girls.

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