Comparison of balance between auditory impaired, visually impaired and healthy elderly individuals using posturography

1.Dr. Snehal Joshi(PT)-Corresponding author
Professor& principal, D.E.Society's Brijlal Jindal College of Physiotherapy,Pune .
drsnehalmandke@gmail.com,9765122071
2.Dr. Pooja Sonawane (PT)-M.P.T., , D.E.Society's Brijlal Jindal College of Physiotherapy,Pune .

Abstract

Introduction: Fall is a major risk of accidental death for people over 65 years of age.
The postural control is aided by interaction of sensory systems which are visual, vestibular and somatosensory systems. The age-related impairments in sensory systems in elderly may have affection of visual and auditory function, which could influence balance. Thus, this study was conducted to compare the balance between visually and auditory impaired elderly individuals.
Methodology: Cross Sectional Analytical Study; Individuals were divided into 3 groups as per inclusion and exclusion criteria and were assessed on posturography and balance was compared
Results: There was highly significant ($p<0.001$) difference in the balance of all 3 groups.
Conclusion: Balance is more affected in visually impaired individuals than auditory impaired and healthy individuals.
Key words: falls, balance, auditory impairment, visual impairment, elderly

INTRODUCTION

Postural control is controlling the position of the body in space for the maintenance of stability and orientation. [1]

The balance gets influenced by intrinsic mechanism of postural control and extrinsic factors such as external environment, tasks which challenge them. [2, 3]

Postural stability is controlled by interaction of musculoskeletal and neural systems [1, 4-5].

Musculoskeletal components include joint range of motion, spinal flexibility, muscle properties, and biomechanical relationships among the body segments.

Neural components essential to postural control includes:

(a) Motor processes, (b) Sensory/perceptual processes, (c) Cognitive processes, are the higher-level processes essential for action. These processes are the basis for adaptive and anticipatory aspects of postural control.

Balance can be maintained by three main sensory systems, which are as follows:

1. **Visual system** (the relationship of the body to objects in the environment)
2. **Vestibular system (**gravity)
3. **Somatosensory system** (the relationship between different body segments, the body itself and the support surface) [2]

Effect of impaired visual function on balance in elderly:

There is a moderate association between impaired visual function and falls, reduced visual acuity approximately doubles the risk of a fall. [6, 7-8]

The removal of visual cues has been shown to increase body sway because vestibular or somatosensory system relies on visual system to maintain the balance. [9]

Effect of impaired auditory function on balance in elderly:

Age related impaired auditory function (age related hearing loss) seen in elderly is also known as Presbycusis and it comes on gradually as a person ages. [10, 11] Thus it becomes difficult for the elderly individuals to tolerate loud sounds or to hear others. It may occur because of changes in inner ear and auditory nerve. Hearing and balance are functions of the auditory and vestibular divisions of the eighth cranial nerve. The correlation of deficits and the anatomy imply that aging damages the receptors of the eighth nerve to impair hearing and to impair balance. [10, 12]

An epidemiological study in India shows 15.4% of auditory impairment in elderly individuals. [13]

Hearing loss can affect the most common and simple tasks due to imbalance. Sensory decline may give rise to various kinds of disabilities e.g. the person may not be able to detect sounds, to identify speech, especially in unfavorable conditions, and to identify sound sources. [14]

Impaired auditory function is associated with decreased functional and psychosocial participation, increased social isolation, depression, and rate of dementia. It is also associated with accelerated cognitive decline in in dementia. Disability may in turn affect the hearing-

impaired person's participation in interactions with other people. Thus it is associated with decreased quality of life, increased physical disability& mortality. [14-15]
Many studies have found out the correlation between sensory impairments with age and its effect on intellectual and cognitive functions. The studies interpreted that the age-related changes in vision and hearing has its indirect impact on cognitive functions. [10, 14]

Visual and auditory impairment also have an additional effect on their balance. Thus this study is conducted to find out which one of the above mentioned impairment will have more influence on the balance in elderly individuals. [14,16]
Fall is a major risk of accidental death for people over65 years of age, falling is prevented by the ability of each individual to properly balance and overcome the transient imbalances. [6, 17, 18, 19]

Balance is required for maintaining a position, remaining stable while moving from one position to another, performing activities of daily living, and moving freely. So decline in balance ability has been shown to occur with increasing age. [2, 20,21]
The ability of the body to balance is aided by interaction of three main sensory systems which are visual, vestibular and somatosensory systems. [18, 22] It has been shown that vision and auditory function plays an important role in maintaining a good balance and mobility. Several studies have identified visual and auditory impairment as a contributing factor to the occurrence of falls in the elderly. [14,16]
The physiological changes which occur due to age can lead impairment in visual and auditory function.
The age-related impairments in visual and vestibular sensory systems in elderly may have affection of visual and auditory function, so it could influence balance. Thus this study was conducted to compare the balance between visually and auditory impaired elderly individuals to identify that which one of the above mentioned impairment will have more influence on the balance in elderly individuals.

AIM AND OBJECTIVES

AIM:

To compare the balance between auditory impaired, visually impaired and healthy elderly individuals (above 65 years) using Posturography

OBJECTIVES:

a) To assess the balance in healthy elderly individuals using Posturography
b) To assess the balance in elderly individuals only with auditory impairment using Post urography
c) To assess the balance in elderly individuals only with visual impairment using Post urography
d) To compare the balance in healthy elderly individuals and elderly individuals only with auditory impairment

e) To compare the balance in healthy elderly individuals and elderly individuals only with visual impairment
f) To compare the balance in elderly individuals only with auditory impairment and elderly individuals only with visual impairment

MATERIALS AND METHODOLOGY

I) **Study design:** Cross Sectional Analytical Study

II) **Setting:** Community

III) **Study population:** Community dwelling elderly individuals

IV) **Duration of study** was 4 months

V) **Method:**

a. **Inclusion Criteria:**
1) Elderly individuals above age group of 65 years
2) Both males and females
3) Elderly individuals only with auditory impairment-based classification by Dept. of Personnel, Gov. of India.
- Elderly individuals with hearing level of dB 26 to 55 dB (mild to moderate hearing impairment)
4) Elderly individuals only with visual impairment based on classification by world health organization using Snellen chart of vision
- Elderly individuals with vision of 20/30 to 20/113 on Snellen chart (Mild to moderate visual impairment)

b. **Exclusion criteria:**
1) Elderly individuals with Cognitive, Perceptual and Neurological deficit
2) Elderly individuals with musculoskeletal impairments
3) Elderly individuals with psychological disorders

VI) **Method of selection of comparison or control group:**
1) **Group A** was healthy elderly individuals above age group of 65 years, without any visual and auditory system impairment
2) **Group B** was certified by medical practitioner as mild to moderate auditory impairment according to classification by Department of Personnel, Government of India (hearing level of dB 26to 55 dB) [23]
3) **Group C** was certified by medical practitioner as mild to moderate visual impairment according to classification by world health organization using Snellen chart of vision (vision of 20/30 to 20/113 on Snellen chart).[24, 25]

VII) **Matching criteria** was age and gender
X) **Research Methodology specified & explained for data collection:**

a) **Sample size:**
Pilot Study was conducted and sample size was estimated on it.

Formula: Based on comparison of two means:
{[2×SD2][Z(1-α/2)＋Z(1-β)]2}/E2

Here,
SD = Standard deviation
Z(1-α/2) =Confidence level
Keeping Confidence level as 95%= 1.96
Z(1-β) =Power
Keeping Power as 80%= 0.24
E = Difference between two means

Total Sample Size = 13
1) Healthy elderly individual group =20
2) Elderly individual only with auditory impairment group = 20
3) Elderly individual only with visual impairment group = 20
b) **Sampling Technique** was Purposive Sampling.

c) **Methods of data collection** relevant to objectives:
Ethics clearance was obtained from the institutional ethical committee. All participants were selected on the basis of inclusion and exclusion criteria The informed, written consent of participants was taken. The assessment was carried out under supervision.

All participants according to their impairment were divided into the following three groups:
1) Healthy elderly individual
2) Elderly individual only with auditory impairment
3) Elderly individual only with visual impairment

All 3 groups were assessed for balance by Posturoghraphy test on Neuro-Com Basic Balance Master (Version 9.2) from Natus balance and mobility.

To assess balance two components are chosen from Posturography test:
1) Modified Clinical Test of Sensory Interaction on Balance
2) Unilateral Stance
d) **Study instrument/Data collection tool:**
Neuro-Com Basic Balance Master (Version 9.2) from Natus balance and mobility. Basic balance master consists of static short foot plate which has dimension of 18”x18”x2”.

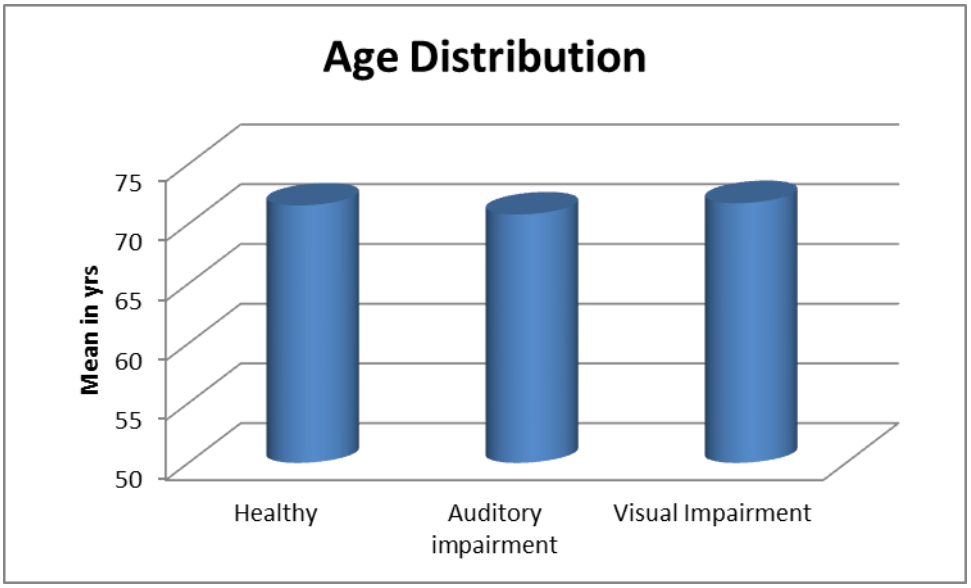
e) **SPSS Software was used for Data management & analysis** (procedure coding use of computers).

f) **Plan for statistical analysis:**
The collected data was parametric but the estimated sample size was less than 30 per group thus appropriate Non-parametric Mann Whitney u test [26] used for data analysis instead of using unpaired t test.

RESULTS AND TABLES

The data was collected by using two Posturography tests (Modified CTSIB and Unilateral Stance) on these three groups. The collected data was analyzed using appropriate Non-parametric test such as Mann Whitney u test. The obtained results after analysis are plotted in the form of tables and graphs which are as follows:

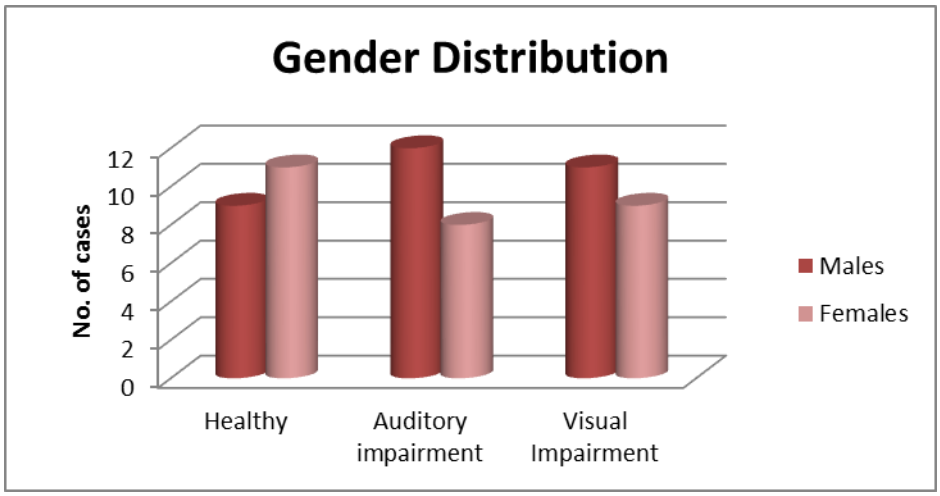
A) The comparison of age between Healthy elderly individual, elderly individual only with auditory impairment, elderly individual only with visual impairment
Graph No. 1



Inference: Graph no 1 show that there is no statistically significant difference of age between Group A (Healthy), Group B (Auditory Impairment) and Group C (Visual impairment)

B) The comparison of male to female ratio between Healthy elderly individual, elderly individual only with auditory impairment, elderly individual only with visual impairment

Graph No. 2:



Inference: Graph no 2 shows that there is no statistically significant difference of male to female ratio between Group A (Healthy), Group B (Auditory Impairment) and Group C (Visual impairment)

C) The comparison of balance between healthy elderly individuals, elderly Individuals only with auditory impairment, elderly Individuals only with visual impairment tested on Modified CTSIB test with firm surface eyes open condition

Table No. 1:

Groups	Firm Eyes Open-scores			Mann Whitney Z-value	P
	Mean (Deg/Sec)	Median	Sd		
Group A (Healthy)	0.47	0.45	0.17	1.21	0.271
Group B (Auditory impairment)	0.55	0.50	0.21		

Table No. 2:

Groups	Firm Eyes Open-scores			Mann Whitney Z-value	P
	Mean (Deg/Sec)	Median	Sd		
Group A (Healthy)	0.47	0.45	0.17	3.727	<0.001 **HS**
Group C (Visual Impairment)	0.13	0.13	0.07		

Table No. 3:

Groups	Firm Eyes Open-scores			Mann Whitney Z-value	P
	Mean (Deg/Sec)	Median	Sd		
Group B (Auditory impairment)	0.55	0.50	0.21	2.290	0.022 **Sig**
Group C (Visual Impairment)	0.13	0.13	0.07		

Table No. 1 shows that there is no significant difference of balance between Group A (Healthy) and Group B (Auditory impairment).
Table No. 2, 3 show statistically significant increase in sway in Group C (Visual Impairment) compared to Group A (Healthy) and Group B (Auditory impairment).

D) The comparison of balance between healthy elderly individuals, elderly Individuals only with auditory impairment, elderly Individuals only with visual impairment tested on Modified CTSIB test with firm surface eyes closed condition

Table No. 4:

Groups	Firm Eyes Closed-scores			Mann Whitney Z-value	P
	Mean (Deg/Sec)	Median	Sd		
Group A (Healthy)	0.41	0.40	0.5	3.431	0.001 **Sig**
Group B (Auditory impairment)	0.56	0.56	0.08		

Table No. 5:

Groups	Firm Eyes Closed-scores			Mann Whitney Z-value	P
	Mean (Deg/Sec)	Median	Sd		
Group A (Healthy)	0.41	0.40	0.5	1.021	0.307
Group C (Visual Impairment)	0.46	0.46	0.14		

Table No. 6:

Groups	Firm Eyes Closed-scores			Mann Whitney Z-value	P
	Mean (Deg/Sec)	Median	Sd		
Group B (Auditory impairment)	0.56	0.56	0.08	2.827	0.005 **Sig**
Group C (Visual Impairment)	0.46	0.46	0.14		

Inference–

Table No. 5 show that there is no significant difference of balance between Group A (Healthy) and Group C (Visual impairment).

Table No. 4, 6 show statistically significant increase in sway in Group B (Auditory Impairment) compared to Group A (Healthy) and Group C (Visual impairment).

E) The comparison of balance between healthy elderly individuals, elderly Individuals only with auditory impairment, elderly Individuals only with visual impairment tested on Modified CTSIB test with foam surface eyes open condition

Table No. 7:

Groups	Foam Eyes Open-scores			Mann Whitney Z-value	P
	Mean (Deg/Sec)	Median	Sd		
Group A (Healthy)	0.91	0.89	0.16	0.515	0.136
Group B (Auditory impairment)	0.93	0.94	0.04		

Table No. 8:

Groups	Foam Eyes Open-scores			Mann Whitney Z-value	P
	Mean (Deg/Sec)	Median	Sd		
Group A (Healthy)	0.91	0.89	0.16	5.113	<0.001 **HS**
Group C (Visual Impairment)	1.34	1.34	0.21		

Table No. 9:

Groups	Foam Eyes Open-scores			Mann Whitney Z-value	P
	Mean (Deg/Sec)	Median	Sd		
Group B (Auditory impairment)	0.93	0.94	0.04	5.430	<0.001 **HS**
Group C (Visual Impairment)	1.34	1.34	0.21		

Inference–

Table No. 7 show that there is no significant difference of balance between Group A (Healthy) and Group B (Auditory impairment).

Table No. 8, 9 show statistically significant increase in sway in Group C (Visual Impairment) compared to Group A (Healthy) and Group B (Auditory impairment).

F) The comparison of balance between healthy elderly individuals, elderly Individuals only with auditory impairment, elderly Individuals only with visual impairment tested on Modified CTSIB test with foam surface eyes closed condition

Table No. 2:

Groups	Foam Eyes Closed-scores			Mann Whitney Z-value	P
	Mean (Deg/Sec)	Median	Sd		
Group A (Healthy)	1.39	1.45	0.44	4.927	<0.001 **HS**
Group B (Auditory impairment)	2.35	2.40	0.29		

Table No. 3:

Groups	Foam Eyes Closed-scores			Mann Whitney Z-value	P
	Mean (Deg/Sec)	Median	Sd		
Group A (Healthy)	1.39	1.45	0.44	0.799	0.49
Group C (Visual Impairment)	1.51	1.51	0.18		

Table No. 4:

Groups	Foam Eyes Closed-scores			Mann Whitney Z-value	P
	Mean (Deg/Sec)	Median	Sd		
Group B (Auditory impairment)	2.35	2.40	0.29	5.420	<0.001 **HS**
Group C (Visual Impairment)	1.51	1.51	0.18		

Inference–

Table No. 3 show that there is no significant difference of balance between Group A (Healthy) and Group C (Visual impairment).

Table No. 2, 4 show statistically significant increase in sway in Group B (Auditory Impairment) than Group A (Healthy) and Group C (Visual impairment).

G) The comparison of balance between healthy elderly individuals, elderly Individuals only with auditory impairment, elderly Individuals only with visual impairment tested on unilateral stance test with right foot eyes open condition

Table No. 5:

Groups	Right Foot with Eyes Open-scores			Mann Whitney Z-value	P
	Mean (Deg/Sec)	Median	Sd		
Group A (Healthy)	2.33	2.30	0.99	0.152	0.534
Group B (Auditory impairment)	2.54	2.40	1.09		

Table No. 14:

Groups	Right Foot with Eyes Open-scores			Mann Whitney Z-value	P
	Mean (Deg/Sec)	Median	Sd		
Group A (Healthy)	2.33	2.30	0.99	4.356	<0.001 **HS**
Group C (Visual Impairment)	3.34	3.31	0.26		

Table No. 15:

Groups	Right Foot with Eyes Open-scores			Mann Whitney Z-value	P
	Mean (Deg/Sec)	Median	Sd		
Group B (Auditory impairment)	2.54	2.40	1.09	3.030	0.002 **Sig**
Group C (Visual Impairment)	3.34	3.31	0.26		

Inference–

Table No. 5 show that there is no significant difference of balance between Group A (Healthy) and Group B (Auditory impairment).

Table No. 14, 15 show statistically significant increase in sway in Group C (Visual Impairment) than Group A (Healthy) and Group B (Auditory impairment).

H) The comparison of balance between healthy elderly individuals, elderly Individuals only with auditory impairment, elderly Individuals only with visual impairment tested on unilateral stance test with right foot eyes closed condition

Table No. 16:

Groups	Right Foot with Eyes Closed-scores			Mann Whitney Z-value	P
	Mean (Deg/Sec)	Median	Sd		
Group A (Healthy)	2.88	2.64	1.13	3.030	0.002 **Sig**
Group B (Auditory impairment)	3.94	3.8	1.39		

Table No. 17:

Groups	Right Foot with Eyes Closed-scores			Mann Whitney Z-value	P
	Mean (Deg/Sec)	Median	Sd		
Group A (Healthy)	2.88	2.64	1.13	1.326	0.123
Group C (Visual Impairment)	2.91	2.92	0.22		

Table No. 18:

Groups	Right Foot with Eyes Closed-scores			Mann Whitney Z-value	P
	Mean (Deg/Sec)	Median	Sd		
Group B (Auditory impairment)	3.94	3.8	1.39	3.301	0.001 **Sig**
Group C (Visual Impairment)	2.91	2.92	0.22		

Inference–

Table No. 17 show that there is no significant difference of balance between Group A (Healthy) and Group C (Visual impairment).

Table No. 16, 18 show statistically significant increase in sway in Group B (Auditory Impairment) than Group A (Healthy) and Group C (Visual impairment).

I) The comparison of balance between healthy elderly individuals, elderly Individuals only with auditory impairment, elderly Individuals only with visual impairment tested on unilateral stance test with left foot eyes open condition

Table No.19:

Groups	Left Foot with Eyes Open-scores			Mann Whitney Z-value	P
	Mean (Deg/Sec)	Median	Sd		
Group A (Healthy)	2.28	2.44	0.73	1.299	0.194
Group B (Auditory impairment)	3.04	2.39	1.47		

Table No. 20:

Groups	Left Foot with Eyes Open-scores			Mann Whitney Z-value	P
	Mean (Deg/Sec)	Median	Sd		
Group A (Healthy)	2.28	2.44	0.73	4.952	<0.001 **HS**
Group C (Visual Impairment)	3.21	3.88	0.45		

Table No. 21:

Groups	Left Foot with Eyes Open-scores			Mann Whitney Z-value	P
	Mean (Deg/Sec)	Median	Sd		
Group B (Auditory impairment)	3.04	2.39	1.47	2.042	0.041 **Sig**
Group C (Visual Impairment)	3.21	3.88	0.45		

Inference–

Table No.19 show that there is no significant difference of balance between Group A (Healthy) and Group B (Auditory impairment).

Table No. 20, 21 show statistically significant increase in sway in Group C (Visual Impairment) than Group A (Healthy) and Group B (Auditory impairment).

J) The comparison of balance between healthy elderly individuals, elderly Individuals only with auditory impairment, elderly Individuals only with visual impairment tested on unilateral stance test with left foot eyes closed condition

Table No. 22:

Groups	Left Foot with Eyes Closed-scores			Mann Whitney Z-value	P
	Mean (Deg/Sec)	Median	Sd		
Group A (Healthy)	2.90	3.07	0.92	2.720	0.007 **Sig**
Group B (Auditory impairment)	3.90	3.69	1.15		

Table No. 6:

Groups	Left Foot with Eyes Closed-scores			Mann Whitney Z-value	P
	Mean (Deg/Sec)	Median	Sd		
Group A (Healthy)	2.90	3.07	0.92	0.194	0.507
Group C (Visual Impairment)	2.92	2.24	0.27		

Table No. 9:

Groups	Left Foot with Eyes Closed-scores			Mann Whitney Z-value	P
	Mean (Deg/Sec)	Median	Sd		
Group B (Auditory impairment)	3.90	3.69	1.15	2.199	0.008 **Sig**
Group C (Visual Impairment)	2.92	2.24	0.27		

Inference–

Table No. 6 show that there is no significant difference of balance between Group A (Healthy) and Group C (Visual impairment).

Table No. 22, 9 show statistically significant increase in sway in Group B (Auditory Impairment) than Group A (Healthy) and Group C (Visual impairment).

DISCUSSION

Balance is dependent on continuous afferent inputs from multisensory modalities (visual, vestibular and somatosensory) and a reduction in function of any of these system leads to affection of balance. [2]

In this study it was found that Table No. 1 3, 5,7 describe the comparison of balance between Group A (Healthy), Group B (Auditory Impairment) and Group C (Visual impairment) tested on modified CTSIB test with participant standing on firm or foam surfaces and unilateral stance test with eyes open condition. It shows no statistically significant difference of balance between Group A (Healthy) and Group B (Auditory Impairment).

That means auditory impaired individuals have same ability to maintain their balance as healthy elderly individuals.

The tables also show statistically significant increase in sway Group C (Visual impairment) when is compared with Group A (Healthy) and Group B (Auditory impairment).

Therefore, the mean degree of sway from the COG was greater in individuals with visual impairment than healthy elderly individuals and elderly individuals with auditory impairment.

That means the visually impaired group is having less ability to maintain their balance compared to auditory group. Good vision is important for identifying lower contrast hazards, estimating distances, discerning spatial relationships and maintenance of a balance. Visual motion perception may be affected in visually impaired individuals. [19, 27]

Thus Postural stability increases with the improvement of the visual environment.

The visually impaired individuals are more dependent on vestibular and somatosensory system to maintain their balance because these individuals have poor contrast sensitivity, poor visual acuity and poor maintenance of balance. [2, 6]

Balance can be maintained by other two systems if function of one system is compromised. [6-9] In eyes open condition normally the individual uses all three systems act to maintain their balance, but visual system is predominant. The elderly individuals rely more on visual system

to maintain their balance. [2, 16] Auditory impaired elderly individuals have maintained their balance well using visual and somatosensory systems. Visually impaired individuals have not maintained their balance using vestibular and somatosensory systems as good as auditory impaired elderly individuals.

Graph No. 4, 6, 8, 2 describes the comparison of balance between Group A (Healthy), Group B (Auditory Impairment) and Group C (Visual impairment) tested on modified CTSIB test with participant standing on firm or foam surfaces and unilateral stance test with eyes closed condition show that there is no statistically significant difference of balance between Group A (Healthy) and Group C (Visual impairment).

That means both the groups are having same ability to maintain their balance when they are standing in eyes closed condition. The visually impaired individuals are dependent on vestibular and somatosensory system to maintain their balance, because the function of visual system may be compromised. [6,9]

The graph also shows statistically significant increase in sway when Group B (Auditory Impairment) is compared with Group A (Healthy) and Group C (Visual impairment). Therefore the mean degree of sway from the COG was greater in elderly individuals with auditory impairment than other two groups.

This difference of balance was statistically significant, that means the auditory impaired group is having less ability to maintain their balance. In auditory impaired individuals the vestibular system may be impaired because auditory system has close relationship with vestibular system. [19, 20]

The inner ear contains the organs responsible for hearing and balance. There may be concomitant dysfunction of both the cochlear and vestibular sense organ because of their shared location within the bony labyrinthine of the inner ear. [19, 14]

Thus there is an observed association between auditory impairment and falls. These individuals are dependent on visual and somatosensory system to maintain their balance. [19, 14]

Normally the individual uses vestibular and somtosensory system to maintain their balance in eyes closed condition because the visual system is eliminated. [6,9]The auditory impaired individuals need to remain dependent only on somatosensory system to maintain their balance compared to visually impaired individuals. Thus, auditory impaired elderly individuals have shown more affection of balance than visual impairment.

CONCLUSION

Visually impaired elderly individuals have more affection of balance compared to auditory impaired elderly and healthy elderly individuals.

CLINICAL IMPLICATION

In this study, it was found that visually impairment has more impact on balance compared to auditory impairment.

In day to day life individuals are mainly dependent on visual system to do their most of activities thus visual system plays an important role to maintain the balance compared to vestibular system.

The different treatment strategies can be planned and implemented for elderly individuals with auditory and visual impairment to train their balance.

FUTURE SCOPE OF THE STUDY

A study can be done to find an effectiveness of the different treatment strategies for balance training on elderly individuals with auditory impairment, visual impairment and with both the impairments.

LIMITATIONS OF THE STUDY

The dynamic balance was not assessed in this study.

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