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Effect of Gaze Stability Exercises on Balance in Elderly

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Abstract: *Balance and gait disturbances place older adults at significant risk of falling and hence fall prevention has become an important consideration in elderly. Studies have shown vestibular rehabilitation to be effective in reducing fall risk in individuals with symptoms of dizziness but so far their effect on balance in vestibular asymptomatic elderly has not been studied. Hence present study intends to investigate the effect of incorporation of Gaze Stability Exercises (GSE) in Balance Training (BT) of elderly who though are vestibular asymptomatic but have decreased balance and increased risk of fall. Thirty elderly volunteers were divided into 3 groups; Group A received GSE with BT, Group B received only BT and Group C was control group. Outcome measures were Berg Balance Scale, Dynamic Gait Index and the Activities - Specific Balance Confidence Scale. Both the experimental groups showed improvement on outcome measures after 6 weeks of intervention while control group did not show any significant improvement. However, on comparing Group A and Group B, the non-significant difference was found. Conclusion: The inclusion of gaze stability exercises in elderly with asymptomatic vestibular function did not show significant improvement on balance and fall risk when compared with those who received balance exercises only.*

Keywords: *Balance, elderly, gaze stability exercises, vestibular rehabilitation*

I. Introduction

Balance is defined as the ability to maintain an upright posture during static and dynamic tasks [1] which requires complex interactions between peripheral and central factors such as vision, somatosensation, vestibular sensation, motor output, and musculature [2]. With advancing age, decline in aforementioned factors, significantly affect the mobility and functional ability of aged persons and increase likelihood of falls in them [3]. Though whole host of factors have been identified to be important for balance in aged people but it is postural stability that is considered as of utmost importance to perform common Activities of Daily Living (ADL) such as walking, turning, rising to standing etc. Association of decreased postural stability and balance with changes in individual sensory systems such as vibration, proprioception and vision have been well documented with propensity of falls in elderly [4]

Along with interaction of nervous and musculoskeletal system, balance and postural control also requires interaction between vestibular system, visual system and somatosensory system. Vestibular system sends information to the occulomotor nucleus which then triggers the reflexes such as the Vestibulo-Ocular Reflex (VOR) and the Vestibulo-Spinal Reflex (VSR) that act on visual field stabilization thus helps to stabilize the eyes and helps to maintain postural stability during stance and walking [5]. Studies have highlighted existence of interaction between VOR function and locomotor control systems.

In older population, decline in VOR instability makes them vulnerable to lose balance while walking in community or even during stance phase or when there would be sudden distraction causing increased postural sway with higher risk of fall [6].VOR function can be retrained through gaze stability exercises [7]. These exercises include vestibular adaptation and substitution exercises. The aim of gaze stability exercises is to improve the vestibule-visual interaction during cephalic movement and to increase static and dynamic postural stability in conditions that produce conflicting sensory information [8]. It is assumed that subtle age related changes in VOR although not amounting to dizziness and other vestibular symptoms can effect gaze stability & gaze fixation ability in older adults, predisposing them to balance, gait and postural instability. It is therefore hypothesized that inclusion of these exercises in balance training will prove beneficial in elderly having balance impairment, hence present study intends to investigate effect of incorporation of gaze stability exercises in balance training of elderly who though are vestibular asymptomatic but have decreased balance and increased risk of fall.

II. Methods

2.1 Participants: Thirty elderly volunteers, both males and females, with non-documented vestibular dysfunction, independent in ambulation and activities of daily living but with impaired balance having Berg Balance Scale (BBS) score between 35-45 and Dynamic Gait Index(DGI) score between 11-19 were included in study while subjects having difficulty in following instructions, undertaking medication affecting equilibrium

and balance and presenting with complaint of dizziness as determined by Dynamic Visual Acuity Test (DVA) were excluded from the study. None of subjects had any history of marked musculoskeletal impairment, lower limb injury, surgery or balance impairment other than age related changes. Informed written consent prior to participation in study was obtained from each participant and they were explained in detail about the nature of the study. Study was approved by Departmental Ethics Committee of Department Physiotherapy, Punjabi University, Patiala. Participants were randomly allocated to three groups. Group A (n=10) age (66.40±4.48) years; Group B (n=10) age (70.60±6.00) years; Group C (n=10) age (64.60±6.48) years, respectively (TABLE 1).

Table 1: Demographic details and baseline measurements of participants in 3 groups

DEMOGRAPHIC	AGE	WEIGHT	HEIGHT	BMI
	Mean ± S.D.	Mean ± S.D.	Mean ± S.D.	Mean ± S.D.
GROUP A(n=10)	66.40±4.48	57.70±4.32	1.58±0.06	22.94±0.88
GROUP B(n=10)	70.60±6.00	60.30±6.04	1.62±0.08	22.89±1.39
GROUP C(n=10)	64.60±6.48	62.00±7.27	1.63±0.09	23.08±0.58

2.2 Design: This study was experimental in nature with pre-post test design. Participants were randomly allocated to three groups, i.e. Group A, B and C, respectively. Group A underwent Balance Training along with Gaze Stability exercises while Group B was given only Balance Training. Group C acted as control group, the subjects in this group were not given any training. Baseline measurement of Berg Balance Scale (BBS), Dynamic Gait Index (DGI), the Activities–Specific Balance Confidence (ABC) Scale was taken for each participant prior to commencement of training and then again at the end of six weeks of intervention.

2.3 Intervention: Participants recruited in study underwent randomized allocation into 3 groups, Group A, Group B and Group C, respectively. Group A performed Gaze Stability Exercises plus Balance Training. Gaze Stability exercises included Vestibular adaptation exercises and Substitution exercises. Adaptation exercises require the individual to fixate on a visual target during either horizontal or vertical head movement (TABLE 2, fig1) with the aim to increase gaze stability invoking long-term changes in the gain of the remaining vestibular system in response to input [9]. Substitution exercises are designed to foster the use of other eye movement strategies in order to substitute for lost vestibular function and maintain visual fixation. Substitution exercises require the individual to perform eye-head movements between targets with the goal of seeing clearly during those tasks (TABLE 3) [9]. Balance training comprised of both static and dynamic balance training exercises, designed to improve postural stability and mobility with progressively increasing challenging tasks. It included- Standing on firm surface with feet apart, heel stand, toe stand, marching on firm surface, semi tandem stand, walking forward and backward with normal base of support with weekly progression (TABLE 4, Fig. 2). Each of these tasks was performed for 5 repetitions. The difficulty level of exercise was increased gradually, with the goal being set just above the patient's ability level to perform it. Rest intervals were given whenever required for the total of 5 minutes in one treatment session. The intervention was given for 6 weeks, everyday regularly for two days a week under supervision of researcher, rest 5 days of week at home. Subjects were instructed to perform these exercises three times a day with gap of at least 4 hours between two sessions. In this way each session lasted for 45 minutes to 60 minutes. 5-10 minutes of warm up and cool down was performed by the subjects before and after the exercises respectively. Group B underwent only aforementioned Balance Training but no Gaze stability exercises and same schedule was followed by Group B with session lasted from 45 minutes to 60 minutes.

Figure 1: Gaze stability exercises (Adaptation exercises: Horizontal x1 viewing exercise with near target) in sitting position

Figure 2: Unilateral leg stance (Firm surface, Eyes open)

Group C acted as control group, as the subjects in this group were devoid of any intervention any training. They were however advised to carry out their normal routine activities but not to do activities that can have affect on their balance and vestibular system for e.g., travelling in hilly areas, by aeroplane.
At the end of the six week period, participants were re – tested on the same three balance tests used in the pre test session. Collected data was analysed.

Table 2 Gaze Stability Exercises Protocol (Adaptation Exercises)

Exercise	Frequency (per day)	Position	Week
Adaptation: Horizontal and vertical x1 viewing exercise with near target (arm's length)	3 times	Sitting	1st
Adaptation: Horizontal and vertical x1 viewing exercise with near target (arm's length)	3 times	Sitting	2nd
Adaptation: Horizontal and vertical x1 viewing exercise with near (arm's length)and far targets (6-10 feet away)	3 times	Standing	3rd
Adaptation: x1 viewing, far/near targets, horizontal/vertical	3 times	Sitting	4th
Adaptation: x1 viewing, far/near targets, horizontal/vertical	3 times	Sitting	5th
Adaptation: x1 viewing, far/near targets, horizontal/vertical	3 times	Standing	6th

Table 3 Gaze Stability Exercises Protocol (Substitution Exercises)

Exercise	Frequency (per day)	Position	Week
Substitution: eye-head movements between near targets (4 feet way), horizontal/vertical	3 times	Sitting	4th
Substitution: eye-head movementbetween near targets (4 feet way), horizontal/vertical	3 times	Sitting	5th
Substitution: eye-head movements between near targets (4 feet way), horizontal/vertical	3 times	Standing	6th

Table 4 Balance Training Exercises

Week 1	Week 2	Week 3	Week 4	Week 5	Week 6
Static stance, feet spread apart, arms close to body (EOFS)	Heel stand and Toe stand, (with support) (EOFS)	Heel stand, Toe stand (without support) Unilateral leg stance (with support) (EOFS)	Standing with alternate heel touch forward and toe touch backward, Forward reach and Unilateral leg stance (Without support) (EOFS)	Ankle sway (anterior-posterior) Hip sway (anterior-posterior) Multidirectional reach (EOFS)	Ankle sway (laterally) Hip sway (laterally) (EOFS)
Heel stand and Toe stand (with support) (EOFS)	Tandem stance (with/without support) (EOFS)	Tandem stance (with support) (ECFS)	Heel stand and Toe stand, (with support) (ECFS)	Unilateral leg stance (with/without support) (ECFS)	Unilateral leg stance (with / without support) (EOFoS)
March in place, Semi Tandem stance. (EOFS)	Static stance, feet spread apart, arms close to body and March in place (ECFS)	Static stance, feet spread apart, arms close to body and March in place (EOFoS)	Tandem stance (with/without support) (EOFoS), Static stance, feet spread apart, arms close to body and March in place (ECFoS)	Tandem stance (ECFos)	Forward reach (EOFoS)
Walking forward and backward, normal BOS (EOFS)	Walking forward and backward, narrow BOS	Gait with narrowed base of support; eyes open; wide or sharp turns to right and left	Gait with sudden starts and stops Squat down by bending at knees and keeping back straight	Stepping activities, Tandem walk	Gait with eyes closed with BOS progressively narrowed, firm surface Gait including negotiating uneven terrains and obstacles

EOFS- Eyes Open Firm Standing, ECFS- Eyes Closed Firm Standing, EOFoS- Eyes Open Foam Standing, ECFoS- Eyes Closed Foam Standing

III. Data Analysis and Results

Data Analysis: Data were analyzed using SPSS version 13. Student't' Test was applied for intra-group comparison of differences in pre-intervention and post-intervention scores of BBS, DGI and ABC, respectively for each group and readings within a single group. One-way analysis of variance (ANOVA) was applied to examine whether pre and post-intervention scores of outcome measures (BBS, DGI and ABC) significantly differ among the three groups. When a significant difference existed between the three groups, a post hoc Scheffe multiple range Test was applied to reveal which groups differ significantly from each other. The results were concluded to be statistically significant with $p < 0.05$.

Results

Table 5: The comparison of scores of BBS for Group A, Group B and Group C respectively, before and after 6 weeks of intervention

GROUP	Pre-intervention scoresMean ± S.D.	Post-intervention scores Mean ± S.D.	't' value
GROUP A	43.20 ± 1.14	50.70 ± 0.95	13.82*
GROUP B	42.40 ± 0.95	48.60 ± 2.07	8.18*
GROUP C	42.00 ± 2.98	41.80 ± 3.36	1.50

*P<0.05

TABLE 5: Shows pre and post intervention scores of BBS significantly differ for Group A and Group B while non-significant differences existed in pre -post intervention BBS scores of Group C.

Table 6: The comparison of scores of DGI for Group A, Group B and Group C respectively, before and after 6 weeks of intervention

GROUP	Pre-intervention scoresMean ± S.D.	Post-intervention scores Mean ± S.D.	't' value
GROUP A	16.90±1.85	22.00±1.15	6.30*
GROUP B	16.40±2.59	20.10±2.18	5.84*
GROUP C	17.90±1.45	17.80±1.62	1.00

*P<0.05

TABLE 6: Shows pre and post intervention scores of DGI significantly differ for Group A and Group B while non-significant differences existed in pre -post intervention DGI scores of Group C.

Table 7: The comparison of scores of ABC for Group A, Group B and Group C respectively, before and after 6 weeks of intervention

GROUP	Pre-intervention scores Mean ± S.D.	Post-intervention scores Mean ± S.D.	't' value
GROUP A	88.94±13.12	92.00±10.96	3.75*
GROUP B	69.56±20.95	75.19±17.33	2.16*
GROUP C	72.94±16.25	72.00±17.85	1.24

*P<0.05

TABLE 7: Shows pre and post intervention scores of ABC significantly differ for Group A and Group B while non-significant differences existed in pre -post intervention ABC scores of Group C.

Table 8:One-way ANOVA analysis of BBS scores for Group A, Group B and Group C

Mean difference- BBS	Mean Square	Sum Square	Df	F	Sig
Between Groups	169.90	339.80	2	57.57*	.001
Within Groups	2.95	79.70	27		
Total		**419.50**	**29**		

*P< 0.05

TABLE 8: Indicates that there is a statistically significant difference among the three groups on the BBS scores (F(2, 27)=57.57, p=.001).

Table 9:One-way ANOVA analysis of DGI scores for Group A, Group B and Group C

Mean difference- DGI	Mean Square	Sum Square	Df	F	Sig
Between Groups	72.40	114.80	2	20.38*	0.021
Within Groups	3.55	95.90	27		
Total		**240.70**	**29**		

*P< 0.05

TABLE 9: Indicates that there is a statistically significant difference among the three groups on the DGI scores (F(2, 27)=20.38, p=0.021).

Table 10: Table 5:One-way ANOVA analysis of ABC scores for Group A, Group B and Group C

Mean difference- ABC	Mean Square	Sum Square	Df	F	Sig
Between Groups	109.38	218.77	2	4.11*	0.0267
Within Groups	26.58	717.73	27		
Total		**936.51**	**29**		

*P< 0.05

TABLE 10: Indicates that there is a statistically significant difference among the three groups on the ABC scores (F(2, 27)=4.11, p=0.026).

Table 11: The post hoc Scheffé test for the three groups on mean difference BBS scores

Contrast	Mean Difference	Sign.
Group A vs Group B	1.30	0.257
Group B vs Group C	6.40	0.001*
Group C vs Group A	7.70	0.001*

*P<0.05

TABLE 11: Indicates that there is non significant difference between Group A and Group B but significant difference between Group B and Group C and Group C and Group A.

Table 12: The post hoc Scheffé test for the three groups on mean difference DGI scores

Contrast	Mean Difference	Sign.
Group A vs Group B	1.40	0.269
Group B vs Group C	3.80	0.001*
Group C vs Group A	5.20	0.001*

*P<0.05

TABLE 12: Indicates that there is non-significant difference between Group A and Group B but significant difference between Group B and Group C and Group C and Group A.

Table 13: The post hoc Scheffé test for the three groups on mean difference ABC scores

Contrast	Mean Difference	Sign.
Group A vs Group B	-2.56	0.547
Group B vs Group C	6.56	0.029*
Group C vs Group A	4.00	0.024*

*P<0.05

TABLE 13: Indicates that there is non-significant difference between Group A and Group B but significant difference between Group B and Group C and Group C and Group A.

IV. Discussion

Balance and gait disturbances place older adults at significant risk of falling, with potentially life threatening sequelae [10] and hence fall prevention has become an important consideration in elderly as falls represent a major source of morbidity in this population [11]. Physiological changes that occur with advancing age causing decline in somatosensory system (vision, vestibular, proprioception) and motor (strength, coordination, endurance) function have been identified as major intrinsic factors contributing to falls [12].

Vestibular hypofunction, too has been identified as an important factor for balance deficits especially during dynamic activities like walking. Age related decrements of vestibular function results in symptoms of dizziness and increased fall risk. As Vestibulo-Ocular Reflex (VOR) gain reduces with age, it places the elderly at the risk of falling. Elderly subjects respond with longer time lags during saccadic target shifts and execute more catch-up saccades during smooth pursuits and it affects their postural coordination which leads to balance problems [13].

Studies have shown Vestibular Rehabilitation (gaze stability exercises) to be effective in reducing fall risk in individuals with symptoms of dizziness, by improving their postural stability and visual acuity during head movements [9] but so far the effect of gaze stability exercises on balance in vestibular asymptomatic (without the complaints of dizziness) elderly has not been studied. It was hypothesized that subtle age related changes in vestibular function although not amounting to symptoms of dizziness and disequilibrium, can affect balance in elderly while performing dynamic activities especially walking and during cephalic movements, which can be minimized using vestibular exercises. So present study was designed to investigate whether the gaze stability exercises in asymptomatic elderly people can improve balance and decreases the risk of fall in them.

Results of present study depict that both experimental groups (Group A and Group B) improved significantly in balance performance after six weeks of intervention as indicated by increased mean values of post BBS scores while Group C did not show any improvement. The findings of the present study are in accordance with the study of Macias et al. (2005) in which a statistically significant improvement in BBS score was seen after vestibular rehabilitation therapy in elderly patients above the age of 50, suggesting that treatment resulted in significant reduction in fall risk [14]. In another study done by Giray et al. (2009) significant post exercise improvement in BBS score was observed after receiving vestibular rehabilitation that consisted of adaptation, substitution exercises, visual desensitization and balance exercises, in patients with chronic unilateral vestibular dysfunction [15]. They concluded that the customized vestibular rehabilitation programs decreased symptoms, increased postural stability, and improved dizziness-related disability in patients with chronic decompensated vestibular deficit.

Result of One way ANOVA, ($F(2, 27)=57.57$, $p=.001$) calculated on mean difference scores of BBS from three groups indicated at least one significant difference existed among the means. Further comparison of mean difference of improvement scores of BBS using Post- hoc Scheffe multiple range test indicated that significant difference existed between Group A and Group C; Group B and Group C while between both the experimental groups, Group A and Group B, no significant difference was found. However on comparison of mean values of mean difference of improvement scores of BBS, Group A showed slight improvement than Group B. The improvement in performance of functional tasks of BBS can be accounted to the retraining of Vestibulo-Ocular Reflex (VOR) by the gaze stability exercises which were given in addition to the balance exercises in Group A.

Similar findings were observed for performance of gait, i.e. both experimental groups, Group A as well as Group B, significantly improved on DGI scores after six weeks of intervention. Result of One way ANOVA, ($F(2, 27)=20.38$, $p=0.021$) calculated on mean difference scores of DGI from three groups and subsequent Post-hoc Scheffe test revealed that Group A and Group B did not significantly differed from each other, hence equally improved in gait performance while control group (Group C) showed decline albeit non-significant in DGI scores and significantly differed with both experimental groups. The results of the present study are in agreement with the study carried by Hall et al. (2010) on elderly patients with dizziness where gaze stability exercising group showed reduction in fall risk (indicated by significant improvement on DGI score) as compared with control group [9]. This improvement was attributed to the adaptation of the vestibulo-ocular reflex through performance of specific vestibular exercises and the second possibility was that participants in the Gaze Stability (GS) group became more accustomed to head movements, one of the elements in the DGI test. In another study conducted by Badke et al. (2004), the effect of vestibular rehabilitation and balance exercises on adults of age (65.5+17.3 years) having central or peripheral vestibular dysfunction was seen and found that both types of patients improved on DGI score indicating effectiveness of vestibular rehabilitation in these patients [16]. They ascribed this to the effect of vestibular exercises that influence recovery mediated by adaptation in

the vestibular ocular and vestibular spinal system. In the present study, gaze stability exercise group showed improvement on DGI scores, these changes can also be assumed due to accommodation and adaptation in vestibular ocular and spinal systems achieved through gaze stability exercises. However, there was non-significant difference in improvement on DGI between Group A and Group B; this could be due to inclusion of vestibular asymptomatic elderly subjects.

Similar trend in findings was observed for confidence in balance as measured on the Activities Specific Balance Confidence Scale (ABC) scale, that is both experimental groups, Group A and Group B, significantly improved on ABC scores after six weeks of intervention, however on intergroup comparison non-significant differences existed between both groups, meaning Group A and Group B had equally improved on confidence in balance. Control group, Group C non – significant decline in ABC values. Similar findings were reported by Hall et al. (2010) and Jung et al. (2009) that gaze stability exercises along with balance exercises led to improved self perceived confidence in balance- ABC scores of elderly patients [9,15]. This increase in self perceived confidence in balance in present study and previous studies can be associated with changes that occurred with participation in training and exercises.

V. Conclusion

Results of present study revealed that inclusion of gaze stability exercises in balance training of elderly did not produce significant improvement in their balance and gait performance. Although significant results cannot be found but comparison of mean values of improvement scores of BBS, DGI and ABC suggested that group who underwent combination of exercises fared better than the group that received only balance exercises.

Limitations of the present study: It could not measure all the components of vestibular system. The balance training was given for a short duration of time and some portion of the gaze stability exercises was included in the home exercise program. Also, sample size was small.

Suggestions for further research: Future study should include long term intervention period. Follow up assessment should be done to know the retention effect of these interventions. Large sample can be studied. Balance performance can be studied using other balance measures such as Clinical Test for Sensory Interaction on Balance (CTSIB) and Performance Oriented Mobility Assessment (POMA). All the components of the vestibular system can be tested and study can be done to see the effect of gaze stability exercises on gait of elderly. The effect of other components of vestibular rehabilitation such as habituation exercises and visual desensitization exercises should also be studied on balance of elderly

References

[1]. N. Benjuva, L. Melzer, and J. Kaplanski, Aging-induced shifts from a reliance on sensory input to muscle cocontraction during balanced standing, The Journals of Gerontology. SeriesA, Biological Sciences and Medical Sciences, 59(2), 2004, 166

[2]. K. Dodd, N. Taylor, and S. Bradley, Strength training for older people (Sydney, Australia: Edinburgh, Butterworth-Heinemann, 2004) 125-58. As quoted in: C.J. Knerl, P.B. Schuler, L.W. Taylor, L.M. Cosio-Lima, and K.A. Caillouet, The effects of six weeks of balance and strength training on measures of dynamic balance of older adults, Californian Journal of Health Promotion, 7(2), 2009, 111-22.

[3]. A.A. Guccione, Geriatric physical therapy (St. Louis: Mosby publication, 1993) 237-52.

[4]. A. Shumway-Cook, and M. Woolacott, Motor Control: Translating research into clinical practice, 3rd edition (Baltimore, Maryland: Lippincott Williams and Wilkins, 2007) 160-232.

[5]. N.A. Ricci, M.C. Aratani, F. Dona, C. Macedo, H.H. Caovilla, and F.F. Gananca, A systematic review about the effects of the vestibular rehabilitation in middle-age andolder adults, Rev Bras Fisioter, Sao Carlos, 14(5), 2010, 361-71.

[6]. G.J. Chapman, and M.A. Hollands, Evidence for a link between changes to gaze behaviour and risk of falling in older adults during adaptive locomotion, Gait & Posture, 24, 2008, 288–94

[7]. C.A. McGibbon, D.E. Krebs, S.L. Wolf, P.M. Wayne, D.M. Scarborough, and S.W. Parker, Tai Chi and vestibular rehabilitation effects on gaze and whole-body stability, Journal of Vestibular Research, 14, 2004, 467–78.

[8]. J. Massion, Postural control systems in developmental perspective, NeurosciBiobehavRev, 22(4), 1998, 465-72. As quoted in: N.A. Ricci, M.C. Aratani, F. Dona, C. Macedo, H.H. Caovilla, and F.F. Gananca, A systematic review about the effects of the vestibular rehabilitation in middle-age andolder adults, Rev Bras Fisioter, Sao Carlos, 14(5), 2010, 361-71.

[9]. C.D. Hall, L.H. Gillig, R.J. Tusa, and, S.J Herdman, Efficacy of gaze stability exercises in older adults with dizziness, JNPT, 34(2), 2010, 64-69.

[10]. M.C. Nevitt, S.R. Cummings, and S. Kidd, Risk factors for recurrent nonsyncopal falls: a prospective study, JAMA, 261, 1989, and 2663–8. As quoted in: J.D. Macias, S. Massingale, and R.D. Gerkin, Efficacy of vestibular rehabilitation therapy in reducing falls, Otolaryngology–Head and Neck Surgery, 133, 2005, 323-25.

[11]. J.W. Runge, The cost of injury. Emerg Med Clin North Am, 11, 1993, 241–53. As quoted in: J.D. Macias, S. Massingale, and R.D. Gerkin, Efficacy of vestibular rehabilitation therapy in reducing falls, Otolaryngology–Head and Neck Surgery, 133, 2005, 323-25.

[12]. M.E. Tinetti, M. Speechley, and S.F. Ginter, Risk factors for falls among elderly persons living in the community, N Engl J Med, 319, 1988, 1701–7. As quoted in: J.D. Macias, S. Massingale, and R.D. Gerkin, Efficacy of vestibular rehabilitation therapy in reducing falls, Otolaryngology–Head and Neck Surgery, 133, 2005, 323-25 .

[13]. C. Paquette, and J. Fung, Old age affects gaze and postural coordination, Gait & Posture, 33(2), 2011, 227-32.

[14]. J.D. Macias, S. Massingale, and R.D. Gerkin, Efficacy of vestibular rehabilitation therapy in reducing falls, Otolaryngology–Head and Neck Surgery, 133, 2005, 323-25.

[15]. M. Giray, Y. Kirazli, H. Karapolat, N.Celebisoy, C. Bilgen, and T. Kirazli, Short-term effects of vestibular rehabilitation in patients with chronic unilateral vestibular dysfunction: A randomized controlled study, Arch Phys Med Rehabil, 90, 2009, 1325-31.

[16]. M.B. Badke, T.A. Shea, J.A. Miedaner, and C.R. Grove, Outcomes after rehabilitation for adults with balance dysfunction, Arch Phys Med Rehabil, 85, 2004, 227-33.
[17]. J.Y. Jung, J. Kim, P.S. Chung, S.H. Woo, and C.K. Rhee, Effect of vestibular rehabilitation on dizziness in the elderly, American Journal of Otolaryngology–Head and NeckMedicine and Surgery, 30, 2009, 295–299.