ORIGINAL ARTICLE

PRESBYSTASIS INCIDENCE AND ASSOCIATION WITH PRESBYCUSIS

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Serap BULUT ÇÖBDEN[1]
Mehmet YAŞAR[1]
Aykut KURU[2]
Esra DİŞBUDAK[3]
Altan KAYA[1]
Yunus KANTEKİN[1]
Ali BAYRAM[1]

[1] Kayseri city hospital, Otorhinolaryngology Head and Neck Surgery Department, Kayseri, Türkiye

[2] Samsun Medikalpark Hospital, Otorhinolaryngology Head and Neck Surgery Department, Samsun, Türkiye

[3] Kahramanmaraş Necip Fazıl City Hospital, Otorhinolaryngology Head and Neck Surgery Department, Kahramanmaraş, Türkiye

Correspondence

Serap BULUT ÇÖBDEN
Phone : +905068766887
e-mail : dr.srpblt@gmail.com

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Abstract

Introduction: Presbystasis is defined as anage-related imbalance not due to any known pathology and is acritical problem in elderly patients. The study aimed to prospectively evaluate the association between presbystasis and presbycusis using audiology and vHIT (video Head Impulse Test) tests.

Materials and Method: Patients over 60 years of age who presented to the otolaryngology outpatient clinic and had no prior acute vertigo attacks were included in the study. Pure-tone audiometry (500–8,000 Hz) and vHIT testing were performed on these patients. Patients with bilateral VOR (vestibulo-ocular reflex) reduction on vHIT were considered to have presbystasis. Correlations between vHIT gain values and audiometric thresholds were analyzed using Spearman's correlation coefficient, and theMann–Whitney U test was used to compare mean audiometric thresholds between the reduced vHIT gain group and the normal gain group.

Results: The mean age was 68 years, and 20.6% (13/63) of patients showed reduced vHIT gains. Hearing loss was present in 55.6% (35/63) of participants. Weak-to-moderate negative correlations were observed between vHIT canal gains and audiometric thresholds. Significant negative correlations were identified only for the right lateral canal gain with right ear PTA and the left posterior canal gain with left ear PTA ($p< 0.05$). No significant association was found between age and vHIT values. Additionally, audiometric thresholds did not differ significantly between patients with and without reduced vHIT gains.

Conclusion: Since presbycusis and presbystasis are likely to occur together, morbidities can be prevented by performing vHIT in potential centers for patients with presbycusis and by initiating early rehabilitation for patients with low canal gains.

Keywords: Gait Disorders, Neurologic; Postural Balance; Accidental Falls; Presbycusis; Head Impulse Test; Aging; Vertigo.

INTRODUCTION

Presbystasis is defined as an age-related imbalance not due to any known pathology and is a critical problem in elderly patients. Falls and subsequent fractures carry significant risks, such as becoming bedridden or dying (1). In recent studies, the incidence has been reported to be 30% in patients over 60 years of age and over 50% in those over 85 years of age (2,3). Chronic imbalance can lead to decreased quality of life and related psychiatric conditions such as anxiety and depression (4). Vision, deep sense, and the vestibular system are the three basic elements that provide balance. In the elderly patient population, besides vestibular system aging, degenerative changes in vision and the musculoskeletal system, additional diseases such as diabetes mellitus (DM) and hypertansion (HT), and multiple drug use are among the causes of imbalance. Dizziness, a broad term often used interchangeably with imbalance, encompasses a spectrum of sensations, including vertigo, disequilibrium, lightheadedness, and spatial disorientation. In older adults, dizziness is typically multifactorial and may arise from the combined effects of sensory, neurological, and systemic impairments. Although the multifactorial nature of falls in elderly patients is well recognized, recent studies have focused on the effects of aging on the vestibular system (5).

In recent years, the concept of presbyvestibulopathy has been introduced to describe an age-related decline in vestibular function, characterized by bilaterally reduced vestibulo-ocular reflex (VOR) gain and/or impaired otolith function, in the absence of other identifiable causes. This entity provides a more specific diagnostic framework within the broader definition of presbystasis and emphasizes objective vestibular dysfunction.

Similarly, presbycusis is defined as age-related hearing loss, predominantly affecting high-frequency hearing and resulting from a combination of cochlear, neural, and metabolic changes. Its etiology is multifactorial, involving degeneration of hair cells, stria vascularis dysfunction, spiral ganglion neuron loss, microvascular insufficiency, and cumulative environmental factors such as noise exposure. Importantly, both presbycusis and presbyvestibulopathy may share common pathophysiological mechanisms related to aging, including oxidative stress, mitochondrial dysfunction, and progressive neurodegeneration.

In both balance disorders and age-related hearing loss, it is essential to distinguish between sensory deficits (such as hair cell loss in the cochlea and vestibular end organs) and neural deficits (including degeneration of afferent pathways and central processing structures). This distinction is critical for understanding disease mechanisms and guiding appropriate diagnostic and therapeutic strategies.

The diagnosis of presbystasis is based on patient history, bedside examination, and laboratory evaluation. Significantly, there is a slow, progressive balance disorder in the anamnesis, with no significant bilateral difference. For the diagnosis of presbystasis, bilateral VOR dysfunction must be detected. This condition can be determined with vHIT (video Head Impulse Test), caloric testing, or rotary chair testing (6). While the caloric test assesses low-frequency horizontal semicircular canal function, its diagnostic value in presbystasis is limited, as age-related vestibular degeneration may predominantly affect higher-frequency ranges. Therefore, newer methods such as the video head impulse test (vHIT), which evaluates high-frequency VOR function, provide important complementary information. In the VEMP (Vestibular Evoked Myogenic Potential) test, increased threshold values and decreased amplitudes can be observed with aging. However, these are not typical of vestibular system aging and do not help in clinical diagnosis (7).

The present study aimed to prospectively evaluate the association between presbystasis and presbycusis using audiology and vHIT tests. Its importance and benefits are that it can reduce the morbidity associated with this disease through

vestibular exercise programs for patients who can be diagnosed and hearing aids forthose who need them.

MATERIALS AND METHOD

The study was conducted prospectively on patients admitted to the Kayseri City Hospital otolaryngology outpatient clinic. Patients over 60 years of age who had no previous acute vertigo attacks were included in the study.To ensure a homogeneous study population, individuals with known vestibular disorders, chronic dizziness, previous acute vertigo attacks, or diagnosed hearing disorders were excluded. In addition, patients using hearing aids or cochlear implants were not included in the study. Patients with chronic neurological disorders such as Parkinson's or Alzheimer's, patients with a history of CVD (cerebrovascular disease), patients with blindness or advanced visual impairment, and patients with cervical spondylosis were excluded. Hearing and vHIT tests were performed on these patients.

Cerebellar tests (straight-line gait, Romberg, finger–nose test) were performed in patients with postural imbalance or instability, gait disturbance, chronicdizziness (more than 3 months), and recurrent falls in the anamnesis. In addition to these, a neurology consultation was requested, and as a result, vHIT was performed for patients who were not considered to have central pathology.

A total of 63 participants (30 males, 33 females) were included in the study. The mean age was 68 years. Patients with VOR reduction on vHIT were considered to have presbystasis, and the results were evaluated for the incidence of presbystasis and its association with presbycusis. A separate control group was not established; instead, participants were categorized according to vHIT gain status (reduced vs. normal) for comparative analyses.

Audiological and Vestibular Assessment

All participants underwent a comprehensive audiological and vestibular evaluation.

Audiometry:

Pure-tone audiometry was performed at frequencies ranging from 125 Hz to 8,000 Hz using both air- and bone-conduction thresholds. Speech audiometry, including speech reception thresholds and speech discrimination scores, was also conducted. All audiometric measurements were performed using a calibrated clinical audiometer (AC 40; Interacoustics, Denmark) in a sound-treated booth.

Tympanometric evaluation was performed in all patients to exclude middle ear ventilation disorders.

vHIT Assessment:

Vestibular function was assessed using the vHIT. Horizontal and vertical semicircular canal functions were evaluated by measuring VOR gain. The test was performed using rapid, passive, and unpredictable head impulses delivered in the plane of each semicircular canal. Consistent angular head accelerations (typically >150–200°/s) were applied to ensure reliability. All gain values were automatically recorded by the system and manually verified for artifacts.

Patients demonstrating bilateral reduction in VOR gain on vHIT were classified as having presbystasis.

Statistical analyses were performed using the Statistical Package for the Social Sciences (SPSS, v.15, SPSS Inc., Chicago, IL, USA).The patients' ages, audiometric results measured between 500 and 8,000 Hz for both ears, and vHIT values measured for both ears were recorded. Normality of continuous variables was assessed using the Shapiro–Wilk test. As the majority of vHIT gain parameters did not conform to a normal distribution, non-parametric statistical methods were applied. Accordingly, between-group comparisons were performed using the Mann–Whitney U test, while correlations between continuous variables were evaluated using Spearman's rank correlation coefficient. Although one parameter demonstrated borderline normality, a uniform non-parametric approach was adopted to ensure methodological consistency across

all analyses. A *p*-value of <0.05 was considered statistically significant.

Ethical Considerations

This study was conducted in accordance with the Declaration of Helsinki. Ethical approval was obtained from the institutional review board.

Written informed consent was obtained from all participants prior to inclusion. All procedures were performed with minimal risk, and patient confidentiality was strictly maintained. Participants were enrolled on a voluntary basis, and fair selection criteria were applied.

RESULTS

Our study included 63 patients (30 male and 33 female). All patients were over 60 years old, with a mean age of 68. Of the13 patients with low vHITgains, 4 were male and 9 were female. Age distribution by group is shown in Table 1. While 35 patients had hearing loss, the hearing of 28 patients was within normal limits.

The mean gain values ranged from 0.79 to 0.91 across the semicircular canals. Normality analyses revealed that most variables deviated significantly from a normal distribution according to the Shapiro–Wilk test ($p< 0.05$), with the exception of vHIT-LA (vHIT left anterior), which demonstrated borderline normality. Therefore, median and interquartile range values were additionally reported to provide a robust representation of the data distribution (Table 2).

In the analyses performed, there was no statistically significant correlation between age and vHIT values in Spearman's correlation analysis. Weak negative correlations were determined, but they were not statistically significant ($p>0.05$), (table 3).

PTA (pure tone average) was calculated as the mean of 500, 1,000, 2,000, and 4,000 Hz thresholds using Spearman's correlation analysis. The composite hearing measure was calculated as the PTA. Correlation analysis of composite hearing measures showed predominantly weak-to-moderate negative associations between hearing loss and vHIT gain values. Significant negative correlations were identified only between right lateral canal gain and right ear PTA, and between left posterior canal gain and left ear

Table 1. Age distribution by group.

Age					
vHIT	**Mean**	**N**	**Std. Deviation**	**Median**	**Range**
normalgain	69.58	50	5.548	69.00	18
reducedgain	69.38	13	5.424	67.00	16
Total	69.54	63	5.480	68.00	18

Table 2. Descriptive statistics and normality tests of vHIT gain values (N = 63).

Variable	Mean ± SD	Median (IQR)	Min–Max	95% CI	Shapiro–Wilk p
vHIT-RP	0.79 ± 0.18	0.84 (0.14)	0.05–1.05	0.75–0.84	<0.001
vHIT-LP	0.80 ± 0.18	0.85 (0.17)	0.00–1.07	0.76–0.85	<0.001
vHIT-LA	0.90 ± 0.12	0.91 (0.14)	0.54–1.15	0.87–0.93	0.033
vHIT-LL	0.82 ± 0.22	0.89 (0.16)	0.04–1.06	0.76–0.87	<0.001
vHIT-RA	0.91 ± 0.13	0.91 (0.14)	0.48–1.12	0.87–0.94	<0.001
vHIT-RL	0.82 ± 0.18	0.88 (0.24)	0.32–1.07	0.77–0.86	<0.001

SD, standard deviation; IQR, interquartile range; CI, confidence interval; vHIT-RP, vHIT right posterior; vHIT-LP, vHIT left posterior; vHIT-LA, vHIT left anterior; vHIT-LL, vHIT left lateral; vHIT-RA, vHIT right anterior; vHIT-RL, vHIT right lateral

PTA. No significant correlations were found for the remaining canal-ear pairings. Specifically, right lateral canal gain showed a significant negative correlation with right ear PTA thresholds (r = −0.256, p = 0.043), while left posterior canal gain demonstrated a significant association with left ear PTA values (r = −0.282, p = 0.026). In contrast, anterior canal gains did not show statistically significant relationships with composite hearing measures. These findings suggest that vestibular dysfunction, particularly involving the lateral and posterior canals, is associated with increased overall hearing impairment (Table 4).

Audiometric thresholds were compared between the presbyvestibulopathy and control groups using the independent-samples Mann–Whitney U test. No statistically significant differences were observed between the two groups across any tested frequency for either ear (all p> 0.05). These findings indicate that audiometric hearing thresholds did not differ significantly between individuals with reduced vHIT canal gain and those with normal gain values (Table 5).

Table3. Correlations between age and vHIT values.

		vHIT_RA	vHIT_LA	vHIT_RL	vHIT_LL	vHIT_RP	vHIT_LP
Age	Spearman's rho	-0.074	-0.052	-0.188	-0.136	-0.054	-0.077
	p-value	0.627	0.731	0.210	0.368	0.721	0.611
	N	63	63	63	63	63	63

vHIT-RP, vHIT right posterior; vHIT-LP, vHIT left posterior; vHIT-LA, vHIT left anterior; vHIT-LL, vHIT left lateral; vHIT-RA, vHIT right anterior; vHIT-RL, vHIT right lateral

Table 4. The correlations between audiometric and vHIT values.(*p<0,05)

vHIT Canal	Hearing Variable	r (Spearman)	p-value
Right Lateral (RL)	Right PTA	−0.256	0.043*
Left Posterior (LP)	Left PTA	−0.282	0.026*
Right Anterior (RA)	Right PTA	−0.199	0.122
Left Anterior(LA)	Left PTA	−0.188	0.141
Left Lateral (LL)	Left PTA	−0.073	0.573
Right Posterior (RP)	Right PTA	−0.126	0.329

Table 5. Comparison of audiometric thresholds between presbyvestibulopathy and control groups

Frequency (Hz)	Ear	Total N	Mann–Whitney U	Z	P
500	Right	63	376.0	−0.317	0.751
1,000	Right	63	367.0	−0.587	0.557
2,000	Right	63	322.5	−1.266	0.205
4,000	Right	63	362.0	−0.658	0.511
8,000	Right	63	414.0	0.138	0.890
500	Left	63	345.5	−0.918	0.359
1,000	Left	63	368.5	−0.562	0.574
2,000	Left	63	362.5	−0.654	0.513
4,000	Left	63	372.5	−0.498	0.619
8,000	Left	63	401.5	−0.054	0.957

Test: Independent-samples Mann–Whitney U; Grouping variable: vHIT canal gain status (presbyvestibulopathy vs. control); Statistical significance:p< 0.05



DISCUSSION

Dizziness in the elderly is a multifactorial disorder. On the one hand, loss of balance in the elderly can cause falls, resulting in morbidities reaching severe levels, reduced quality of life, and problems such as depression and introversion. According to a study, dizziness is one of the strongest contributors to the disability burden after age 65 (8). Therefore, this problem in the elderly should be considered and diagnosed early. It has been reported that while 15% of balance disordersin those over 70 are due to vestibular causes, 20–70% are due to causes other than the vestibular system (4). According to Ciorba, although most balance disorders in the elderly are non-vestibular, recent studies have investigated the effects of aging on the vestibular system in patients who develop morbidity from falls at advanced age (1). Biju et al. reported that the vestibular system plays a vital role in the risk of falling in patients with Alzheimer's disease, and that better semicircular canal function is associated with a lower risk of falling (9). A previous study reported that the prevalence of subnormal vHIT gain meeting presbyvestibulopathy criteria was significantly higher in individuals aged ≥70 years compared to those aged 60–69 years (4.83% vs. 0.50%), whereas low-frequency vestibular measures such as caloric testing did not differ significantly between age groups, suggesting that high-frequency vestibular function is more vulnerable to aging (10). Our study evaluated semicircular canal function using vHIT in patients over 60 years of age without a history of vertigo attacks and examined whether canal gain loss was associated with hearing loss. We determineda weak negative correlation between age and vHIT values.

The study by Li et al. reported a prevalence of vestibular disorders among healthy older adults aged 26–92 years of 50% (11). The results of Agrawal's study are also similar to those of Li's study (12). According to our vHIT results in healthy adults over 60 years of age without acute vertigo attacks, 20% of all patients had low channel gain. The high rate in Li's and Agrawal's study may be due to their use of VEMP, whereas our evaluation method was vHIT.

While the functional slowdown of the vestibular system with increasing age has been demonstrated by many studies, aging in vestibular organs has also been shown histopathologically in a few studies. Ross et al. reported, using electron microscopy, progressive degeneration of the saccule and utricle otoconia (13). Rosenthall revealed degeneration of the vestibular epithelium, including lipofuscin inclusion granules, vacuoles, and replacement of hair cells with scars and fibrosis (14). Moreover, histopathological studies have indicateda significant, continuous decrease in type I and II vestibular hair cells from birth to age 100, and an age-related linear decrease in the vestibular neuron population in the Scarpa ganglion (15,16). Furthermore, Iwasaki et al. have highlighted cellular loss in vestibular organs (9). In our study, although it was weak, a negative correlation was observed between age and vHIT channel gains.

With increasing age, weakening may occur in more than one system in the human body. Correia et al. reported that two-thirds of older adults aged 57–85 years had two or more sensory deficits(17). Armstrong et al. have demonstrated that in older patients, there is a high prevalence of multisensorial impairment, involving not only vision and hearing but also the vestibular system, leading to increased disability overall. In addition, the same study concluded that the prevalence of various combinations of sensory impairments was significantly higher than expected and suggested that these impairments may share a common effect. They considered that this might be due to a common biological mechanism and/or risk factor, especially aging (18). As reported by Yesantharao et al., dual olfactory and balance dysfunction is associated with an increased incidence of falls in older adults (19). Moreover, the role of genetic factors in presbystasis has been hypothesized, as in presbycusis (20).

Liljas investigated multisystem aging from another perspective, finding that multisensory disorders were linked to poorer quality of life and a higher likelihood of depressive symptoms (21). In our study, there was a negative, albeit weak to moderate, correlation between hearing loss and vHIT gains. In other words, vHIT gains decreased with age, suggesting that the auditory and vestibular systems may age together.

Spearman's correlation analysis revealed predominantly weak-to-moderate negative associations between vHIT canal gain values and pure-tone audiometric thresholds. Significant negative correlations were observed, particularly between lateral and posterior semicircular canal gains and mid-to-highfrequency hearing thresholds. The absence of significant correlations for the left lateral (LL) and right posterior (RP) canals may reflect canal-specific variability, inter-individual heterogeneity, and the limited sample size of the present study. In addition, vHIT gain and pure-tone audiometric thresholds represent different functional domains, and a uniform relationship cannot be expected across all canal-ear pairings. These findings suggest that vestibular dysfunction, particularly involving the lateral and posterior semicircular canals, may parallel cochlear deterioration at mid-to-high frequencies, indicating a potential shared degenerative process affecting both the auditory and vestibular systems.

The observed negative correlations between vHIT gain values and pure-tone audiometric thresholds, predominantly at mid-to-high frequencies, support the concept of concurrent age-related degeneration of the cochlear and vestibular end organs. Presbycusis is known to primarily affect high-frequency hearing due to progressive hair cell loss and neural degeneration within the cochlea. Similarly, emerging evidence suggests that age-related vestibular decline, often termed presbystasis, preferentially involves the lateral and posterior semicircular canals. The significant associations identified in this study, particularly involving lateral and posterior canal gains, are consistent with this pattern and may reflect parallel degenerative mechanisms affecting vestibular hair cells, afferent pathways, or shared microvascular supply.

Our results demonstrate significant, albeit modest, negative correlations between vHIT gain values in the lateral and posterior semicircular canals and mid-to-highfrequency hearing thresholds. These findings support the hypothesis that age-related cochlear and vestibular impairments may progress concurrently, reinforcing the concept of a combined audiovestibular aging process rather than isolated sensory decline.

Despite significant correlations between vHIT gain values and audiometric thresholds, no statistically significant differences in hearing thresholds were observed between the presbyvestibulopathy and control groups. This apparent discrepancy can be attributed to the fundamental differences between correlation and group comparison analyses. Correlation analysis evaluates continuous relationships across the full range of measurements, whereas categorizing vestibular function into dichotomous groups may reduce statistical power and mask subtle associations. In addition, the generally weak-to-moderate magnitude of the observed correlations suggests that small effect sizes may not be sufficient to produce detectable group-level differences. These findings support the notion that age-related vestibular decline may occur independently of overt peripheral hearing threshold changes, particularly in the early or subclinical stages of presbyvestibulopathy.

Many studies also emphasize the beneficial effects of vestibular rehabilitation programs on presbystasis and on reducing the risk of falling. Tuunainen et al., in their study evaluating the effects of various rehabilitation programs, found that even self-rehabilitation improved postural stability, but only the guided training program reduced the risk of falling (22). Anguera et al. reported that



presbystasis is multifactorial and that a balance should be established among these different pathophysiological causes, and that treatment should be as comprehensive as possible. It has also been proven that rehabilitation in people with multisensory disorders is effective even on the emotional component (23).

Conclusion

In conclusion, this study demonstrates significant negative correlations between vHIT gain values and pure-tone audiometric thresholds in specific canal-ear pairings. These findings support a possible coexistence of presbycusis and presbystasis, although the association was not uniform across all canals. Therefore, in patients presenting with presbycusis, vHIT testing performed in appropriate clinical settings may allow the early diagnosis of presbystasis, thereby enabling early initiation of rehabilitation and helping to prevent potential complications. These results support the concept of concurrent age-related degeneration of auditory and vestibular systems and reinforce the emerging framework of presbyvestibulopathy accompanying presbycusis. Recognition of this combined audiovestibular decline may have important implications for diagnosis, risk stratification, and management of balance-related morbidity in the aging population.

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