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Prevalence of vestibular dysfunction and associated factors in South Korea

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ABSTRACT

Objective: To report the nationwide prevalence of dizziness and vestibular dysfunction in the Korean population and determine the associated factors.

Design: Cross-sectional analysis of a nationwide health survey.

Methods: We obtained data from the 2009 to 2010 Korea National Health and Nutrition Examination Surveys, which were cross-sectional surveys of the South Korean civilian, non-institutionalised population aged 40 years and older (N=3267). A field survey team performed interviews and physical examinations. Structured questionnaires were handed out and balance function tests using the modified Romberg test of standing balance on firm and compliant support surfaces were performed on participants. Failure on the modified Romberg test was regarded to indicate vestibular dysfunction.

Results: The prevalence of dizziness during the past year was 16.70% (95% CI 14.65% to 18.76%). The presence of vestibular dysfunction was noted in 1.84% (95% CI 1.18% to 2.51%). In addition, the prevalence of experiencing falls and positional dizziness were 1.46% (95% CI 0.87% to 2.06%) and 1.73% (95% CI 1.17% to 2.29%), respectively. Multivariable analysis revealed that dizziness was associated with increased age, female gender, hearing loss and stress. Vestibular dysfunction was associated with increased age, history of dizziness and hearing loss.

Conclusions: Vertigo and dizziness are the greatest contributors to the burden of disability in the aged population. Screening for dizziness and vestibular dysfunction, and management of associated factors might be important for improving compromised quality of life due to postural imbalance caused by vestibular problems.

Strengths and limitations of this study

- This is a nationwide health survey for the prevalence of dizziness and vestibular dysfunction, and associated factors.
- The prevalence of dizziness and vestibular dysfunction in Korea was 16.70% and 1.84%, respectively.
- Dizziness was associated with increased age, female gender, hearing loss and stress. Vestibular dysfunction was associated with increased age, history of dizziness and hearing loss.
- As this is a cross-sectional analysis, only associated factors for dizziness and vestibular dysfunction were identified, and risk factors could not be investigated.

INTRODUCTION

Dizziness and vertigo are frequent and disabling symptoms in primary care units but remain unexplained in 40–80% of patients.[1–4] Dizziness and vertigo may have serious individual and social effects, causing interruption of daily activities in 40% of affected individuals.[5] The significant effects of dizziness and vertigo have supported the need for an epidemiological investigation.[3 6–12] Understanding the prevalence of these conditions and identifying associated factors from a large-scale study would greatly contribute to patient care and relief of the social burden of dizziness and vertigo. The epidemiological survey of dizziness and vestibular dysfunction in the general population has rarely been carried out. The prevalence of dizziness for 1 year has been reported to range from 6.1% to 27%.[9 10] The prevalence of vestibular dysfunction has also been reported with wide variability: 3.1–4.9% for 1 year prevalence,[5 8] and 35.4% in a cross-sectional study from the USA.[6] This wide variability in population-based studies may be attributed to the different survey periods, diverse target populations and variable protocols.

The present study was undertaken to report the national prevalence of dizziness and vestibular dysfunction in South Korea, based on survey data obtained from the Korea National Health and Nutrition Examination Survey (KNHANES) 2009–2010, and to investigate the associated factors. Identification and modification of associated factors would help to reduce the incidence and/or severity of dizziness and, in turn, facilitate the efficient allocation of public health resources aimed at reducing the negative effects of dizziness in everyday life.

METHODS

Study population and data collection

The KNHANES is an ongoing cross-sectional survey of the non-institutionalised population of South Korea. Every year, 10 000–12 000 individuals in about 4600 households are selected from a panel to represent the population, using a multistage clustered and stratified random sampling method that is based on national census data. The participation rate of selected households in the past several cycles of KNHANES has been high, ranging from 79% to 84%. Survey sample weights were used in all analyses to produce estimates that were representative of the non-institutionalised civilian Korean population.

A total of 3267 individuals, representative of the 10 309 130 individuals ≥40 years of age in the country, participated in a survey of balance problems from 2009 to 2010. Among them, 1378 male participants represented 5 040 114 males and 1889 female participants represented 5 269 016 females.

Written informed consent was obtained from all the participants prior to the survey and approval for this research was given by the Institutional Review Board of the Samsung Medical Center (IRB number 2013-02-031).

Balance survey and neurological examination

Participants were asked whether they had experienced dizziness or imbalance ('Have you had dizziness or imbalance?'), positional dizziness ('Have you had severe vertigo when you rotate your head in supine position or when you sit up from bed or lie down in the morning?') and falls in the absence of external forces ('Have you ever fallen without any external factors?') in the past 12 months. To assess the balance function, we performed a modified Romberg test of standing balance on firm and compliant support surfaces. Participants were asked to stand on a firm surface with their feet 10 cm apart for at least 15 s in the same position as in the computerised dynamic posturography (CDP), with their arms crossed, without bending their knees or moving their bodies to maintain balance. They were not allowed to move their feet and had their eyes open (condition 1), then closed (condition 2). Next, we assessed the effect of eliminating somatosensory input on postural stability by repeating the same procedure but on an 18 cm thick, medium-density foam pad (polyurethane, 22 kg/m^3) with eyes open (condition 3), and then closed (condition 4), for at least 20s. The balance of each individual was scored on a pass/fail basis. Participants failed the balance test if they moved their feet, unfolded their hands, opened their eyes, or required the operator to intervene to maintain their balance. Romberg test on a foam pad with participants' eyes closed (condition 4) can provide information on the vestibular system's contribution to postural stability because motion related to visual input is eliminated and somatosensory inputs are masked in this condition. Therefore, failure on the modified Romberg test from vestibular origin was defined as a state in which the participant passed test conditions 1–3 and did not pass test condition 4, and the participant was regarded as having vestibular dysfunction.

Participants were also asked whether they had experienced subjective hearing loss and tinnitus. The pure tone air-conduction threshold was measured in a soundproof booth using an automatic audiometer (GSI SA-203, Entomed Diagnostics AB, Lena Nodin, Sweden). Unilateral or bilateral hearing loss (HL) was defined as more than 25 dB HL in the average of air-conduction hearing thresholds at 0.5, 1, 2 and 3 kHz in one ear or both ears.[13]

Analysis of associated factors

Potential factors from the health examination and interview were evaluated for their association with the prevalence of dizziness and vestibular dysfunction in a total of 3267 participants aged 40 years or older (1378 males and 1889 females) surveyed from 2009 to 2010. The evaluation included basic demographic factors, cardiovascular risk factors and other diseases that could cause falling. The factors that could be affected by dizziness or vestibular dysfunction were also evaluated (tables 1 and 2). Potential associated factors were evaluated using univariable analysis. Clinically important variables with a p value <0.05 were selected for multivariable analysis using a logistic regression model. Osteoporosis was evaluated in only those over 50 years of age and could not be included in the multivariable analysis. Variables with multicollinearity problems were not included in the logistic regression model.

Statistical analysis

The prevalence and 95% CIs for dizziness and vestibular dysfunction were calculated. In the univariable and multivariable analysis, logistic regression analysis (using PROC SURVEYLOGISTIC in SAS) was used to test the association between dizziness/vestibular dysfunction and associated factors in a complex sampling design. p Values and 95% CIs for OR were corrected using Bonferroni's method, due to multiple testing. If the OR is equal to 1, there is no association between given variables of interest and dizziness/vestibular dysfunction. If the OR is higher than 1 (or lower than 1), the associated factor is positively (or negatively) related to dizziness/vestibular dysfunction. To reflect national population estimates, sample weights were applied in all analyses. All p values were two sided, and p values <0.05 were considered to indicate statistical significance. Statistical analyses were performed using SAS V.9.3 (SAS Institute, Cary, North Carolina, USA).

RESULTS

The prevalence of dizziness and vestibular dysfunction

Among the 3267 participants aged 40 years or older, 627 had experienced dizziness in the past 12 months; the

Table 1 Analysis of factors associated with 'dizziness' in participants over 40 years of age (N=3267)

				Univariable analysis			Multivariable analysis†		
	Per cent*	Dizziness (+)	Dizziness (–)	p Value	OR	95% CI	p Value	OR	95% CI
Demographic characteristics									
Age, years (mean)									
40–49 (%)	42.48	13.19	86.81		Referent			Referent	
50–59 (%)	29.00	12.87	87.13	1.00	0.97	0.65 to 1.46	1.00	0.97	0.63 to 1.49
60–69 (%)	17.44	23.89	76.11	<0.001	2.07	1.34 to 3.19	0.02	1.85	1.07 to 3.18
≥70 (%)	11.07	28.90	71.10	<0.001	2.68	1.73 to 4.15	0.005	2.10	1.20 to 3.68
Gender									
Male (%)	48.89	11.33	88.67		Referent			Referent	
Female (%)	51.11	21.84	78.16	<0.001	2.19	1.72 to 2.79	<0.001	1.82	1.38 to 2.41
Body weight (mean)‡		60.28	63.80	<0.001	0.97	0.96 to 0.98	0.09	0.99	0.97 to 1.00
BMI (mean)‡		23.76	24.12	0.07	0.96	0.93 to 1.00			
WC (mean)‡		81.62	82.98	0.02	0.98	0.97 to 1.00			
WC/height (mean)‡		0.51	0.51	0.51	2.08	0.23 to 18.60			
Annual household income (mean)‡		4025.84	5072.45	0.22	0.98	0.95 to 1.01			
Level of education (college graduate or not)									
No (%)	77.62	17.94	82.06	0.007	0.65	0.47 to 0.89	0.91	0.98	0.69 to 1.39
Otolaryngological conditions (physical examination and questionnaire)									
Tinnitus									
Yes (%)	21.50	29.49	70.51	<0.001	2.75	2.15 to 3.51			
Annoying tinnitus									
No (%)	65.80	30.61	69.39	0.50	0.85	0.54 to 1.35			
Subjective hearing loss									
Yes (%)	2.31	39.39	60.61	<0.001	3.37	1.95 to 5.84			
Unilateral hearing loss									
Yes (%)	9.58	21.94	78.06	0.06	1.46	0.99 to 2.16			
Bilateral hearing loss									
Yes (%)	5.85	30.14	69.86	<0.001	2.29	1.54 to 3.40			
Unilateral or bilateral hearing loss									
Yes (%)	15.43	25.04	74.96	<0.001	1.87	1.43 to 2.44	0.03	1.43	1.03 to 1.98
Data obtained from the questionnaire									
Alcohol consumption (frequency, more than 2–4 times/month)									
No (%)	40.86	18.76	81.24	0.06	0.78	0.60 to 1.01			
Alcohol consumption (frequency, more than 2 times/month)									
No (%)	61.66	16.85	83.15	0.84	0.97	0.75 to 1.26			
Alcohol consumption (frequency, more than 4 times/month)									
Yes (%)	24.38	20.08	79.92	0.02	1.36	1.05 to 1.75	0.37	1.12	0.87 to 1.45
Smoking, current									
No (%)	77.60	17.97	82.03	0.01	0.64	0.46 to 0.91			
Smoking, past									
No (%)	55.54	20.37	79.63	<0.001	0.54	0.42 to 0.70			
History of angina pectoris									
Yes (%)	2.34	20.13	79.87	0.46	1.27	0.67 to 2.37			
Diagnosis of angina pectoris									
Yes (%)	0.36	57.36	42.64	0.002	6.76	2.05 to 22.27	0.06	3.72	0.95 to 14.52

Continued

Table 1 Continued

				Univariable analysis			Multivariable analysis†		
	Per cent*	Dizziness (+)	Dizziness (–)	p Value	OR	95% CI	p Value	OR	95% CI
Diagnosis of stroke									
Yes (%)	1.76	20.94	79.06	0.42	1.33	0.66 to 2.66			
Diagnosis of glaucoma									
Yes (%)	0.67	23.53	76.47	0.59	1.51	0.33 to 6.92			
Depressive mood									
Yes (%)	14.08	29.80	70.20	<0.001	2.49	1.85 to 3.36			
Limitation of activity due to depressive mood or anxiety									
Yes (%)	0.83	56.74	43.26	<0.001	6.70	3.30 to 13.63			
Diagnosis of depression									
Yes (%)	3.95	28.27	71.73	0.007	2.03	1.22 to 3.41			
Stress									
Yes (%)	24.18	24.49	75.51	<0.001	1.96	1.52 to 2.52	<0.001	1.99	1.53 to 2.58
EQ-5D index (mean)‡		0.89	0.95	<0.001	0.01	0.01 to 0.04			
EuroQol (mean)‡		66.06	76.09	0.09	0.99	0.97 to 1.00			
Laboratory data									
Obesity									
No (%)	64.55	17.72	82.28	0.08	0.81	0.64 to 1.03			
Hypertension									
Yes (%)	33.70	19.81	80.19	0.01	1.39	1.08 to 1.78	0.81	1.03	0.78 to 1.36
Diabetes									
Yes (%)	12.58	15.67	84.33	0.58	0.92	0.67 to 1.25			
Hypercholesterolaemia									
Yes (%)	16.35	18.71	81.29	0.31	1.18	0.86 to 1.63			
Hypertriglycemia									
No (%)	81.03	17.52	82.48	0.04	0.72	0.52 to 0.98			
Dyslipidaemia									
No (%)	70.12	17.27	82.73	0.28	0.87	0.67 to 1.12			
Osteoporosis									
Yes (%)	19.21	27.37	72.63	<0.001	1.79	1.35 to 2.38			
Anaemia									
Yes (%)	8.40	21.58	78.42	0.07	1.42	0.97 to 2.07			
Retinopathy									
Yes (%)	21.55	18.33	81.67	0.30	1.16	0.88 to 1.52	0.15	0.78	0.56 to 1.09
Macular degeneration									
Yes (%)	5.33	27.38	72.62	0.002	1.97	1.30 to 2.99	0.10	1.58	0.91 to 2.74

Some factors showing statistical significance on univariable analysis, such as WC, tinnitus, subjective hearing loss and depression were not included in the logistic regression model due to multicollinearity problems.
The univariable and multivariable analyses were performed using a logistic regression model.
*Sample weights applied.
†Clinically important variables with p values <0.05 in the univariable analysis were included in the multivariable analysis.
‡Continuous variables are presented as means.
BMI, body mass index; WC, waist circumference.

Table 2 Analysis of factors potentially associated with 'vestibular dysfunction' in participants over 40 years of age (N=3267)

	Per cent*	Vestibular dysfunction (+)	Vestibular dysfunction (–)	Univariable analysis			Multivariable analysis†		
				p Value	OR	95% CI	p Value	OR	95% CI
Demographic characteristics									
Age, years (mean)†									
40–49 (%)	42.48	0.25	99.75		Referent			Referent	
50–59 (%)	29.00	0.46	99.54	1.00	1.82	0.65 to 5.04	1.00	1.62	0.22 to 12.20
60–69 (%)	17.44	3.37	96.63	<0.001	13.83	6.51 to 29.36	0.02	8.29	1.31 to 52.33
≥70 (%)	11.07	9.19	90.81	<0.001	40.11	15.42 to 104.35	0.01	15.32	1.53 to 153.59
Gender									
Male (%)	48.89	1.17	98.83		Referent			Referent	
Female (%)	51.11	2.49	97.51	0.008	2.14	1.22 to 3.77	0.35	1.37	0.71 to 2.63
Body weight (mean)‡		56.46	63.34	<0.001	0.93	0.90 to 0.97	0.07	0.97	0.93 to 1.00
BMI (mean)‡		22.90	24.08	0.04	0.88	0.77 to 0.99			
WC (mean)‡		80.50	82.80	0.07	0.97	0.94 to 1.00			
WC/height (mean)‡		0.51	0.51	0.80	1.88	0.01 to 250.91			
Annual household income (mean)‡		2605.59	4940.71	0.008	0.79	0.66 to 0.94	0.40	0.97	0.90 to 1.04
Level of education (college graduate or not)									
No (%)	77.62	2.19	97.81	0.04	0.30	0.09 to 0.97	0.49	1.62	0.41 to 6.46
Otolaryngological conditions (physical examination and questionnaire)									
Fall history									
Yes (%)	1.46	10.26	89.74	0.002	6.57	2.00 to 21.40			
History of dizziness									
Yes (%)	16.70	5.35	94.65	<0.001	4.90	2.86 to 8.41	0.002	2.75	1.48 to 5.12
Positional dizziness									
Yes (%)	1.73	5.73	94.27	0.02	3.36	1.17 to 9.64			
Tinnitus									
Yes (%)	21.50	2.50	97.50	0.22	1.52	0.78 to 2.95			
Annoying tinnitus									
Yes (%)	34.20	3.03	96.97	0.53	1.37	0.52 to 3.64			
Subjective hearing loss									
Yes (%)	2.31	11.28	88.72	<0.001	7.71	3.31 to 17.95			
Unilateral hearing loss									
Yes (%)	9.58	4.64	95.36	<0.001	3.09	1.73 to 5.55			
Bilateral hearing loss									
Yes (%)	5.85	8.95	91.05	<0.001	6.91	3.73 to 12.82			
Unilateral or bilateral hearing loss									
Yes (%)	15.43	6.27	93.73	<0.001	6.39	3.32 to 12.31	0.02	2.30	1.16 to 4.56
Data obtained from the questionnaire									
Alcohol consumption (frequency, more than 2–4 times/month)									
No (%)	40.86	2.05	97.95	0.54	0.82	0.44 to 1.54			
Alcohol consumption (frequency, more than 2 times/month)									
Yes (%)	38.34	2.25	97.75	0.30	1.43	0.72 to 2.82			
Alcohol consumption (frequency, more than 4 times/month)									

Continued

Table 2 Continued

	Per cent*	Vestibular dysfunction (+)	Vestibular dysfunction (–)	Univariable analysis p Value	OR	95% CI	Multivariable analysis† p Value	OR	95% CI
Yes (%)	24.38	2.97	97.03	0.06	2.04	0.97 to 4.26			
Alcohol consumption (volume, more than 5–6 cups/event)									
Yes (%)	55.64	1.88	98.12	0.88	1.05	0.56 to 1.99			
Alcohol consumption (volume, more than 7–9 cups/event)									
Yes (%)	44.83	2.24	97.76	0.22	1.48	0.79 to 2.78			
Alcohol consumption (volume, more than 10 cups/event)									
Yes (%)	36.41	2.49	97.51	0.10	1.71	0.90 to 3.25			
Smoking, current									
No (%)	77.60	2.07	97.93	0.09	0.51	0.23 to 1.11			
Smoking, past									
No (%)	55.54	2.21	97.79	0.15	0.62	0.32 to 1.19			
Diagnosis of angina pectoris									
Yes (%)	2.34	3.61	96.39	0.26	2.04	0.29 to 7.07			
Limitation of activity due to heart problem									
Yes (%)	0.36	2.82	97.18	0.68	1.55	0.19 to 12.44			
Diagnosis of stroke									
Yes (%)	1.76	3.14	96.86	0.46	1.75	0.41 to 7.52			
Diagnosis of glaucoma									
Yes (%)	0.67	2.79	97.21	0.68	1.60	0.17 to 14.66			
Depressive mood									
No (%)	85.92	1.96	98.04	0.20	0.59	0.26 to 1.32			
Limitation of activity due to depressive mood or anxiety									
Yes (%)	0.83	3.27	96.73	0.10	1.81	0.89 to 3.72			
Diagnosis of depression									
Yes (%)	3.95	1.96	98.04	0.90	1.07	0.36 to 3.13			
Stress									
No (%)	75.82	1.90	98.10	0.67	0.87	0.46 to 1.63			
EQ-5Dindex (mean)‡		0.82	0.94	<0.001	0.01	0.00 to 0.04			
EuroQol (mean)‡		68.55	74.52	0.09	0.99	0.97 to 1.00			
Laboratory data									
Obesity									
No (%)	64.55	2.15	97.85	0.14	0.60	0.30 to 1.18			
Hypertension									
Yes (%)	33.70	3.46	96.54	<0.001	3.47	2.13 to 5.67	0.23	1.39	0.81 to 2.36
Diabetes									
Yes (%)	12.58	3.78	96.22	0.006	2.47	1.29 to 4.73	0.20	1.59	0.79 to 3.21
Hypercholesterolaemia									
No (%)	83.65	1.87	98.13	0.79	0.90	0.42 to 1.94			
Hypertriglycemia									
Yes (%)	18.97	2.73	97.27	0.14	1.69	0.85 to 3.35			
Dyslipidaemia									

Continued

Table 2 Continued

	Per cent*	Vestibular dysfunction (+)	Vestibular dysfunction (−)	Univariable analysis			Multivariable analysis†		
				p Value	OR	95% CI	p Value	OR	95% CI
Yes (%)	29.88	2.06	97.94	0.57	1.18	0.66 to 2.11			
Osteoporosis									
Yes (%)	19.21	5.97	94.03	0.001	2.67	1.50 to 4.76			
Anaemia									
Yes (%)	8.40	3.51	96.49	0.12	2.12	0.83 to 5.44			
Retinopathy									
Yes (%)	21.55	3.59	96.41	0.002	2.69	1.43 to 5.07	0.56	1.25	0.59 to 2.65
Macular degeneration									
Yes (%)	5.33	3.93	96.07	0.04	2.33	1.04 to 5.22	0.42	0.64	0.21 to 1.80

Some factors showing statistical significance in univariable analysis such as BMI, positional vertigo and subjective hearing loss were not included in the logistic regression model due to multicollinearity problems.
The univariable and multivariable analyses were performed using a logistic regression model.
*Sample weights applied.
†Clinically important variables with p values <0.05 in the univariable analysis were included in the multivariable analysis.
‡Continuous variables are presented as means.
BMI, body mass index; WC, waist circumference.

prevalence of dizziness was 16.70% (95% CI 14.65% to 18.76%). The prevalence of experiencing falls and positional dizziness was 1.46% (95% CI 0.87% to 2.06%) and 1.73% (95% CI 1.17% to 2.29%), respectively. Seventy-five participants showed vestibular dysfunction, representing a prevalence of 1.84% (95% CI 1.18% to 2.51%).

Analysis of associated factors

In the univariable analysis, dizziness was associated with several factors (table 1). Among the variables significantly associated with dizziness, age, gender, body weight, level of education, objective hearing loss (unilateral or bilateral), alcohol consumption, angina pectoris, emotional stress, hypertension, retinopathy and macular degeneration were selected for the multivariable analysis. We did not include variables with multicollinearity problems such as waist circumference, volume of alcohol consumption, depressive mood, limitation of activity due to depressive mood or anxiety, and a diagnosis of depression in the logistic regression model. Quality of life (QOL) was not included in multivariable analysis either, since QOL is known to be affected by dizziness. In the multivariable analysis, age (p=0.02, OR 1.85; 95% CI 1.07 to 3.18 for 60–69; p=0.005, OR 2.1; 95% CI 1.20 to 3.68 for ≥70), gender (p<0.001, OR 1.82; 95% CI 1.38 to 2.41), objective hearing loss (unilateral or bilateral) (p=0.03, OR 1.43; 95% CI 1.03 to 1.98) and emotional stress (p<0.001, OR 1.99; 95% CI 1.53 to 2.59), remained as independent factors associated with dizziness (table 1).

For vestibular dysfunction, several factors were associated with univariable analysis (table 2). Among the variables significantly associated with vestibular dysfunction, age, gender, body weight, annual household income, level of education, history of dizziness, objective hearing loss (unilateral or bilateral), hypertension, diabetes mellitus, retinopathy and macular degeneration were selected for the multivariable analysis. We did not include variables with multicollinearity problems such as body mass index, fall history, positional dizziness, subjective hearing loss, unilateral hearing loss and bilateral hearing loss in the logistic regression model. The multivariable analysis demonstrated that age (p=0.02, OR 8.29; 95% CI 1.31 to 52.33 for 60–69; p=0.01, OR 15.32; 95% CI 1.53 to 153.59 for ≥70), history of dizziness (p=0.002, OR 2.75; 95% CI 1.48 to 5.12) and objective hearing loss (unilateral or bilateral) (p=0.02, OR 2.30; 95% CI 1.16 to 4.56) were associated with vestibular dysfunction (table 2).

DISCUSSION

Reliable epidemiological information is a key factor for provision of appropriate healthcare, preventive screenings and rehabilitative services. This report is the first nationwide epidemiological study in South Korea to investigate the prevalence and factors associated with

Table 3 Prevalence of dizziness and vestibular dysfunction in previous reports

Authors	Year	Sample	Method of evaluating dizziness	Method of evaluating vestibular dysfunction	Prevalence of dizziness (prevalence period)	Prevalence of vestibular dysfunction (prevalence period)
Kroenke and Price[3]	1981–1984	USA, 13 538 persons 18 years of age or older	Interview survey		23.2% (lifetime)	
Nakashima *et al*[10]	1991	Japan, 7685 persons 20 years of age or older	Postal questionnaire-based survey		6.1% (undefined period)	
Yardley *et al*[12]	Not described	UK, 2064 persons 18–64 years of age	Postal questionnaire-based survey		23.3% (1 month)	
Hannaford *et al*[7]	1998	Scotland, 15 788 persons 18 years of age or older	Postal questionnaire-based survey		*20.3% †29.7% ‡11.3% (lifetime)	
Neuhauser *et al*[5]	2003	Germany, 4869 persons 18 years of age or older	Telephone interview survey	Telephone interview survey	22.9% (1 year)	4.9% (1 year)
Agrawal *et al*[6]	2001–2004	USA, 5086 persons 40 years of age or older	Interview survey	Modified Romberg test		35.4% (cross-sectional survey)
Lai *et al*[8]	2006	Taiwan, 16 838 659 persons 18 years of age or older		National health insurance claims database survey		3.1% (1 year)
Mueller *et al*[9]	2008–2010	Germany, 4080 persons 65 years of age or older	Telephone interview survey		27.0% (1 year)	
Mendel *et al*[29]	Not described	Sweden, 2547 persons 18 years of age or older	Postal questionnaire-based survey		21.0% (1 year)	
Present study	2009–2010	South Korea, 3267 persons 40 years of age or older	Interview survey	Modified Romberg Test	16.70% (1 year)	1.84% (cross-sectional survey)

*Dizziness that makes surrounding objects seem to spin around.
†Unsteadiness, light-headedness or feeling faint.
‡Dizziness that makes respondents feel they are moving.

dizziness and vestibular dysfunction based on representative data from a government-centred survey.

Prevalence of dizziness and vestibular dysfunction

Several population-based studies have attempted to estimate the prevalence of dizziness. Their results are described in table 3. As the methods of evaluating dizziness, age distribution and survey period of each study vary, substantial differences in prevalence of dizziness may exist, and, subsequently, direct comparisons among the studies are difficult. However, except for the result from the Japanese questionnaire-based survey (6.1%), the prevalence of dizziness from the previous studies ranged from 15% to 30%. Since appropriate evaluation of vestibular function is, practically, difficult in a mass study, fewer studies have investigated the prevalence of vestibular dysfunction, while more have examined the prevalence of subjective dizziness. The first method was a neurological interview for individual participants, which was performed by the German National Telephone Health Interview Survey (GNT-HIS).[14] Although this method may have reached an appropriate category of dizziness by using structured history-taking, it could not collect the subjects' objective health information related to dizziness, such as blood pressure, complete blood count and balance function. The next method reviewed data from a national health insurance claims database, and was used in a Taiwanese study.[8] Even though the diagnoses might have been precise, this method inevitably missed subjects who were not covered by insurance. The last method was the modified Romberg test on firm and compliant support surfaces, which was used in this study and in the National Health and Nutrition Examination Survey of the USA, 2001–2004 (NHANES).[6] The modified Romberg test is a simple objective test that can be conducted without a trained examiner, the diagnostic value of which has been verified in several studies. Cohen *et al* reported that the modified Romberg test could distinguish between subjects with and without vestibular dysfunction.[15] Agrawal *et al*[16] also reported that individuals who failed the modified Romberg test condition 4 were at a high risk of falling. Recently, Hong *et al*[17] reported that the sensitivity and specificity of this method for diagnosing vestibular dysfunction were 63% and 90%, respectively, compared to condition 5 of the sensory organisation test in CDP. Therefore, vestibular dysfunction can be best evaluated using the modified Romberg test as a field evaluation tool in a large-scale survey.

The prevalence of vestibular dysfunction from these studies is described in table 3. As the present study used data from a cross-sectional survey, it is reasonable that the prevalence of 1.84% in this report is slightly lower than that of the GNT-HIS (4.9%) and of the Taiwanese study (3.1%). On the other hand, it is more difficult to explain the large difference between the results of the present study and those from the US survey (35.4%), which was also a cross-sectional survey. The difference may be attributable to the sensitivity of the test methods used for each study. Both studies adapted the modified Romberg test on firm and compliant support surfaces to evaluate vestibular dysfunction, but the test methods were slightly different. In the US NHANES, participants were asked to stand with their feet together with heels and great toes touching. However, in the present study, participants were asked to stand with their feet 10 cm apart, as described in the test protocol of Computerised Dynamic Posturography (CDP) in the vestibular laboratory. The results of four test conditions of the balance test using a foam pad correlated well with those of CDP.[17] Standing with feet apart also increased the test compliance of the participants and reflected more realistic balance function of daily living. Another difference was the thickness of the foam pad. The purpose of using a foam pad during the Romberg test is to mask somatosensory input during the test. Since a 3-inch-thick medium density foam pad was used in US NHANES, a commercially available medium density (22 kg/m^3) 6 cm thick foam pad was checked for its feasibility before launching of this survey. However, all the participants could easily feel the surface and proprioception was not masked enough. Therefore, we investigated the sensitivity, specificity and ORs of the modified Romberg test depending on the thickness of foam pad under different conditions[17] and, finally, we adopted an 18 cm thick, medium-density foam pad for field test to evaluate vestibular function. These disparities in sensitivity of test seem to be the main cause of the difference between the two surveys.

Factors associated with dizziness and vestibular dysfunction

Several studies have noted an association between age and dizziness.[6–8 12 14] The US NHANES reported that age was significantly associated with vestibular dysfunction.[6] GNT-HIS also reported that moderate-to-severe dizziness or vertigo increased with age and the prevalence reached 37% in the age group 60 years and older.[14] Hannaford *et al*[7] showed that problems of balance increased with age. Our study also showed that the prevalence of dizziness and vestibular dysfunction in the '60–69 years' and 'more than 70 years' age segments is significantly higher than for those in the '40–49 years' age segment. In multivariable analysis, dizziness and objective vestibular dysfunction assessed by the modified Romberg test showed a significant association with age (tables 1 and 2). The increase in prevalence with age can be explained by changes associated with the ageing of the vestibular system such as reduction of vestibular hair cells, degeneration of the cupula and otolith, and the ascending vestibular pathway.[18–20]

Female preponderance among individuals with dizziness has also been demonstrated in other studies. In a report from the UK, women were more likely to report dizziness than men (OR=1.66, 95% CI 1.32 to 2.07).[12] GNT-HIS and the Taiwanese study also showed a female preponderance.[8 14] However, the presence of vestibular

dysfunction was not different between male and female participants in the NHANES.[6] In the multivariable analysis of our study, the female gender was associated with dizziness (p<0.001, OR=1.82, 95% CI 1.38 to 2.41), while this association was not significant for vestibular dysfunction (tables 1 and 2).

It is not surprising that vestibular function is associated with hearing due to the anatomical proximity of the cochlea and vestibular organ, which also share a neural and vascular supply. GNT-HIS demonstrated that tinnitus had an independent effect on vestibular vertigo in multivariable analysis.[14] NHANES showed that individuals with vestibular dysfunction were significantly more likely to have hearing loss.[6] We also demonstrated an association between dizziness/vestibular dysfunction and hearing function. Objective hearing loss (unilateral or bilateral) remained an independent factor associated with both dizziness and vestibular dysfunction on multivariable analysis (tables 1 and 2).

Several studies have suggested variable association of cardiovascular risk factors with dizziness. GNT-HIS showed an association of vestibular vertigo with hypertension and hyperlipidaemia on multivariable analysis. However, diabetes, cardiovascular disease (angina pectoris, myocardial infarction or stroke), obesity and smoking had non-significant associations on multivariable analysis.[14] Among the cardiovascular risk factors of the NHANES, diabetes, hypertension and smoking were significant on univariable analysis, but only diabetes showed a significant association with vestibular dysfunction on multivariable analysis.[6] Although the issues of over-nutrition and morbid obesity associated with balance problems have been reported in the literature,[21–23] a previous large-scale study did not demonstrate an association between obesity and problems of balance.[11] In this study, none of the cardiovascular risk factors were associated with dizziness or vestibular dysfunction on multivariable analysis. Japanese studies have also shown that vertigo is not associated with metabolic syndrome, which is strongly related to cardiovascular disease.[24 25]

Several studies have reported evidence supporting an association between dizziness and psychological factors such as depression, anxiety and stress. GNT-HIS reported that depression was associated with vestibular vertigo.[14] Likewise, another study reported that dizziness was associated with anxiety and depressive distress.[26] In some reports, the prevalence of depression and anxiety approached 20% and 30%, respectively, in vertiginous individuals.[27 28] The present study also evaluated the associations of psychological factors. Although depression was not included in the multivariable analysis due to the multicollinearity problem, stress (p<0.001, OR 1.99; 95% CI 1.53 to 2.58) showed a strong association with dizziness. While psychological well-being has shown significant association with dizziness in the aged population, vestibular dysfunction was not associated with psychological factors.

Lastly, the association between dizziness and vestibular dysfunction was analysed (table 2), and a history of dizziness remained as an independent factor for vestibular dysfunction in the multivariable analysis (p=0.0053, OR 2.56; 95% CI 1.32 to 4.95). These results confirm that vestibular dysfunction diagnosed by the modified Romberg test correctly reflects participants' vestibular vertigo.

Although this is a large-scale study based on representative data from a government-centred process, the cross-sectional nature of the survey precluded the incidence estimates and risk factor analysis. Instead, we could obtain only prevalence rate and associated factors of dizziness and vestibular dysfunction, and this is a limitation of this study.

Conclusions

We demonstrated that the prevalence of dizziness during the past year and the prevalence of vestibular dysfunction were 16.70% and 1.84%, respectively. The multivariable analysis revealed that dizziness was associated with increased age, female gender, hearing loss and emotional stress. Vestibular dysfunction was associated with increased age, history of dizziness and hearing loss. As it has been reported that vertigo and dizziness were the greatest contributors to the burden of disability in the aged population,[9] screening for dizziness and vestibular dysfunction, and parallel interventions to modify the associated factors, are required in a rapidly ageing society.

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