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Original Article

Relationships among hearing loss, cognition and balance ability in community-dwelling older adults

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Abstract. [Purpose] The purpose of this study was to determine the relationships among hearing loss, cognition, and balance ability in elderly individuals. [Subjects and Methods] In total, 46 elderly individuals over 65 years of age who were attending senior welfare centers participated in this study. Through a hearing test, the speech frequency pure tone average in the better ear was checked. We set a criterion of hearing loss if the better ear hearing level (BEHL) value was 25 dB or more. Cognition ability was evaluated using the Korean mini-mental state examination (K-MMSE). Dynamic balance ability was evaluated by the timed up and go (TUG) test, and static balance ability was tested using a one-leg stance test (OLST). [Results] The ages of the subjects were all related to BEHL, TUG, K-MMSE, and OLST. BEHL had a negative correlation with OLST, whereas it had no correlation with K-MMSE or TUG. The hearing loss group had a significantly shorter OLST time than the normal hearing group. [Conclusion] As elderly individuals get older, their hearing and cognition, as well as their balance abilities deteriorate. The results of this study indicate there is a significant correlation between hearing loss and static balance.
Key words: Hearing loss, Cognition, Balance ability

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INTRODUCTION

In general, declines in bodily function and cognition due to aging are considered normal and part of an inevitable process[1)]. Aging also affects auditory reactions during walking[2)]. Age-related hearing loss is bilateral symmetrical hearing loss resulting from aging[3)]. It seriously affects quality of life. Particularly, hearing loss causes social isolation, depression, and loss of self-esteem in older adults[4, 5)]. In the United States, hearing loss is the most common chronic condition of older people after hypertension and arthritis[6)], and it was reported that almost two-thirds of elderly people over 70 years of age are affected by hearing loss[7)]. Such a high prevalence of hearing loss is of concern in Korea, where the elderly population aged 65 or over is increasing significantly, and was 12.66% of the total population as of Aug 2014[8)].

Hearing is an important variable to be considered in the assessment of cognitive function[9)], and hearing loss is associated with incident dementia[10)]. It has been reported that among the elderly, hearing loss is associated with falls, and gait speed also slows when hearing loss is high[11)]. On the other hand, other studies have suggested that hearing loss is not a major risk factor of a fall[12)], and the absence of correlation between the auditory and vestibular systems has also been suggested[13)].

Generally, as people get older, hearing, cognition, and balance abilities deteriorate. However, the relationships among hearing loss, cognition and balance ability have not been fully established. Therefore, this study was conducted to determine the relationships among hearing loss, cognitive function and balance ability in community-dwelling older adults.

SUBJECTS AND METHODS

Twenty-nine males and 17 females (46) elderly individuals aged over 65 years old who were attending a senior welfare center in the local community of Pohang City were enrolled in this study. The general characteristics of the study subjects are as follows: the mean age, height, and weight of the subjects were 75.96 (6.37) years old, 161.78 (8.61) cm, 63.74 (8.86) kg, respectively. Suitable subjects for this study were recruited through an advertisement. Subjects were informed of the purpose, procedure, and method of the study and they gave their consent to participation in this study. This study received approval from the institutional review board of Daegu University. Individuals with asymmetric hearing loss whose pure tone average (PTA) difference measured by audiometry was larger than 10 dB in both ears[14)], persons who used hearing aids, persons who had difficulty walking independently, persons who used walking aid tools, person

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Table 1. Correlations among age, hearing, cognition, and balance in older adults

	BEHL	K-MMSE	TUG	OLST
Age	0.533**	−0.421**	0.495**	−0.409**
BEHL		−0.262	0.179	−0.387**

**p < 0.01
BEHL: Better ear hearing level at 0.5-4 kHz; K-MMSE: Korean mini mental state examination; TUG: Timed up and go; OLST: One-leg stance test

Table 2. Differences in cognition and balance ability according to the presence of hearing loss

	Normal hearing (n = 16)	Hearing loss (n = 30)
K-MMSE (score)	27.1±3.2 (26.2)	26.6±2.6 (22.1)
TUG (sec)	8.7±1.4 (23.1)	9.0±2.0 (23.7)
OLST (sec)	18.1±12.0 (29.1)	9.8±7.7 (20.5)*

All values are means±SD (mean rank). *p < 0.05
K-MMSE: Korean mini mental state examination; TUG: Timed up and go; OLST: One-leg stance test

who experienced pain during standing with one foot or walking, persons who had neurological diseases, such as stroke, persons who had surgical operations on the lower limbs or spine in the past six months, or persons who complained of chronic dizziness were excluded from the study.

Audiometry was performed by a professional audiologist using an Entomed SA 204 audiometer (Entomed, Sweden) with TDH-39 headphones (Madsen Electronics, Denmark). The first test was conducted with tones of 0.25, 0.5, 1, 2, 4, and 8 kHz, and then the better ear hearing level (BEHL) threshold was established by checking the speech-frequency PTA of the threshold at 0.5, 1, 2, and 4 kHz. According to the criteria suggested by the World Health Organization (WHO), hearing losses of 25 dB or less are considered normal, 26–40 dB slight, 41–60 dB moderate, 61–80 dB severe, and 81 dB or more are categorized as profound hearing loss[15]. Thus, we set the criterion of hearing loss as a BEHL value in excess of 25 dB.

Cognition was assessed using the Korean mini-mental state examination (K-MMSE)[16]. This examination tool is widely used as a simple dementia test tool in South Korea, and the MMSE has been modified for Korean cultural characteristics. This test comprises five subscales and the total score is 30 points. In general, when the total score is over 24 points, it is judged as normal.

Balance ability was measured using the timed up and go (TUG) test and the one-leg stance test (OLST). The TUG test aims to determine the dynamic balance abilities of elderly persons. This test is fast and requires no special equipment or training, so it is widely used in clinical practice[17]. The subjects were seated in a chair with a back support and arm rests, and a cone-shaped object was put in front of them at a distance of 3 m. Then, the subjects stood up from the chair and walked at a normal comfortable gait speed to the cone-shaped object, walked around it, then walked back and sat in the chair. A stopwatch was used to record the time. After one practice, subjects performed two TUG tests and the results were recorded. We used the average time of the two trials as the TUG time. The OLST examines static balance ability. This test is cheap and easy to perform, is economical with time, does not require any special equipment, and little test training is required[18]. Subjects stood on one leg and if the raised foot touched the floor or the other leg, or if the other foot moved, the test was stopped and the time recorded. Subjects performed the test three times. The longest time of the three trials was chosen for the analysis.

Data were analyzed using PASW Statistics version 18. Descriptive data are reported as the mean and standard deviation or number of subjects (n). Pearson's correlation coefficient was calculated to assess the relationships among age, BEHL value, K-MMSE, TUG, and OLST. The Mann-Whitney U test was used to determine the differences in cognition and balance ability between the hearing loss and normal hearing groups. A p-value < 0.05 was considered statistically significant.

RESULTS

The measured average values of the subjects were as follows: PTA of the right ear was 36.1 (13.4) dB and that of the left ear was 35.6 (13.9) dB, while the BEHL value was 33.6 (13.1) dB. The total K-MMSE score was 26.8 (2.8). The TUG time was 8.9 (1.8) seconds, and that of the OLST score was 12.7 (10.1) seconds. Furthermore, the distribution of subjects according to hearing grade were: 16 normal, 18 slight, 9 moderate, and 3 with severe hearing loss. Therefore, the normal hearing group comprised 16 subjects and the hearing loss group comprised 30.

Table 1 shows the correlation analysis results of the age, BEHL, K-MMSE, TUG, and OLST values of the subjects. Age significantly correlated with BEHL (0.533, $p < 0.01$), K-MMSE (−0.421, $p < 0.01$), TUG (0.495, $p < 0.01$), and OLST (−0.409, $p < 0.01$). BEHL showed a significant negative correlation with OLST (−0.387, $p < 0.01$), whereas no correlation was found with K-MMSE (−0.262, $p > 0.05$) or TUG (0.179, $p > 0.05$). A comparison of the results of the normal hearing and hearing loss groups revealed there was no significant difference in the TUG times ($p > 0.05$), whereas the OLST time showed a significant difference between the normal hearing and hearing loss groups; the average rank of the normal hearing group was 29.1, and that of the hearing loss group was 20.5 (Table 2).

DISCUSSION

This study aimed to determine the relationships among age-related hearing loss, cognition, and static and dynamic balance abilities in elderly persons over 65 years old who were living in the local community of Pohang City.

Changes in hearing and cognition, as well as in balance abilities are considered normal as people get older. In this study, age showed a significant correlation with hearing loss. Lin et al.[7] conducted audiometry with 717 older adults. They reported a 63.1% prevalence of hearing loss, defined as a decline in speech frequency PTA in the better ear of more

than 25 dB. Enrietto et al.[13] conducted a longitudinal study with 57 older adults and reported that the pure tone threshold increased by about 1 dB every year. Another study found evidence of changes in cognitive functions which were related to aging[19]. In the present study, K-MMSE decreased as age increased, indicating cognitive function declines with aging. In relation to aging and balance, Bohannon[20] conducted a meta-analysis to verify the normative reference times for TUG of elderly persons. The mean TUG times were 8.1 seconds for persons aged 60 to 69 years, 9.2 seconds for persons aged 70 to 79 years, and 11.3 seconds for persons aged 80 to 99 years. Briggs et al.[18] conducted a timed balance test with 71 non-institutionalized elderly women. They reported that the OLST time decreased significantly as age increased. With respect to age related decreases in the balance function, Fukuda[21] explained that it is related to delays in central processing. In the present study, the TUG time increased as age increased ($r = 0.495$, for age and TUG), while the OLST time decreased as the age increased ($r = -0.409$, for age and OLST). These results indicate that as age increases, dynamic and static balance abilities decrease.

In relation to hearing loss and cognition, a previous study suggested that the risk of dementia increases with hearing loss severity, and that over one-third of the risk of incident dementia was associated with hearing loss[10]. Naramura et al.[22] reported that hearing level significantly correlate with age, hearing severity score, and MMSE and self-rating depression scale (SDS) values. Purchase-Helzner et al.[12] investigated the relationship of hearing loss and osteoporotic fractures and attempted to determine cognitive impairment by means of a modified MMSE version. They reported that poor cognitive function was found in 13% of the normal hearing group, in 14.2% of the mild hearing loss group, and in 12.8% of the severe hearing loss group. This result indicates there was no significant cognitive impairment associated with hearing loss. In the present study, the correlation coefficient for BEHL and K-MME was $r = -0.262$, showing there was no correlation between hearing and cognition function. Thus, it will be necessary to conduct a longitudinal study using a larger sample size to further test this hypothesis in the future.

In relation to hearing loss and balance, Li et al.[11] evaluated gait speed using hearing and a 20-foot (6.1 meter) walk way with 1,180 adult subjects aged 50–69 years. They reported that gait speed slowed by 0.05 m/s with every 25 dB of hearing loss, indicating a correlation between gait speed and hearing loss. In addition, Viljanen et al.[23] studied whether a mean hearing acuity (BEHL 0.5–4 kHz) can prevent a fall, as well as whether it is correlated with postural balance. They reported that subjects with poor hearing acuity showed a greater risk of fall and worse postural control. On the other hand, Purchase-Helzner et al.[12] studied the relationship between hearing and risk factors of fractures and falls. They reported that the annual fall rate had no correlation with hearing grade, and that hearing grade showed no significant difference in relation to total hip bone mineral density, in accordance with age and BMI. In addition, Enrietto et al.[13] verified the age-related changes in the auditory and vestibular systems. However, they found no significant correlations between the PTAs of the auditory test and vestibular test results. In our study, as hearing loss became worse, OLST times became shorter, a negative correlation ($r = -0.387$). However, OLST time did not correlate with TUG, which is measure of dynamic balance ability. Moreover, the OLST time was significantly shorter in the hearing loss group than in normal group, which indicates hearing is related to static balance ability.

The present study showed that the hearing, cognition, and balance abilities of elderly individuals declines as they get older. It also verified that static balance deteriorates with hearing loss. However, no correlations among hearing, dynamic balance, and cognitive functions were found. A possible explanation for this result is that there was only a small number of subjects with moderate and severe hearing loss. Thus, it will be necessary to add more subjects with moderate to severe hearing loss in a future study. It is evident that hearing loss has a negative effect on cognitive functions and balance abilities. Therefore, it is desirable that elderly persons start hearing loss treatment as early as possible, to minimize decreases in cognitive functions and balance abilities due to hearing loss. Also, balance training and exercises should be considered to improve the quality of life and to prevent falls by the elderly. Future research will need to determine the relationships of other physical abilities with hearing loss, cognition, and balance abilities in various living environments, as well as the effects of hearing aids.

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