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**Title:** Self-Reported Hearing Status Is Associated with Lower Limb Physical Performance, Perceived Mobility, and Activities of Daily Living in Older Community-Dwelling Men and Women

**Year:** 2015

**Version:**

**Please cite the original version:**

Mikkola, T., Polku, H., Portegijs, E., Rantakokko, M., Rantanen, T., & Viljanen, A. (2015). Self-Reported Hearing Status Is Associated with Lower Limb Physical Performance, Perceived Mobility, and Activities of Daily Living in Older Community-Dwelling Men and Women. *Journal of the American Geriatrics Society*, 63(6), 1164-1169. <https://doi.org/10.1111/jgs.13381>

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**Self-Reported Hearing Is Associated with Lower-Limb Physical Performance, Perceived Mobility, and Activities of Daily Living in Older Community-Dwelling Men and Women**

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Funding sources and related paper presentations

This work was funded by the Academy of Finland [grant number 263729]. The LISPE project is funded by the Academy of Finland, the Future of Living and Housing [ASU-LIVE; grant

number 255403] program and Finnish Ministry of Education and Culture. AV is financially supported by a personal grant from the Academy of Finland [grant number 251723].

The results were presented in part at the conference Hearing Across the Lifespan, June 5-8 2014, Cernobbio, Italy.

Running head: Hearing, physical performance, and mobility

## STRUCTURED ABSTRACT:

**BACKGROUND:** Poor hearing is common in older adults and it may have negative consequences which extend beyond communication.

**OBJECTIVES:** To explore the associations of self-reported hearing problems with physical performance and self-reported difficulties in mobility and activities of daily living (ADL) in community-dwelling older adults.

**DESIGN:** Cross-sectional cohort study

**SETTING:** Community

**PARTICIPANTS:** 848 men and women aged 75-90 years

**MEASUREMENTS:** Structured face-to-face interviews to assess perceived hearing problems in the presence of noise, mobility difficulties (moving indoors, stair-climbing, 0.5 km walk and 2 km walk) and difficulties in ADLs and instrumental ADLs. The Short Physical Performance Battery (SPPB) test was administered. Age, years of education, cognitive functioning, and self-reported cardiac, circulatory, and locomotor diseases were used as covariates.

**RESULTS:** Compared to persons who reported good hearing, persons who reported major hearing problems had a lower SPPB total score indicating poorer performance (mean 9.8 vs. 10.9,  $p=0.009$ ) and more difficulties in ADLs (mean 1.8 vs. 1.4,  $p=0.002$ ) and IADLs (mean 4.6 vs. 3.4,  $p=0.002$ ) after controlling for covariates. They also had higher odds for more difficulty in stair-climbing (OR 2.8,  $p<0.001$ ) and walking 2 km (OR 2.1,  $p=0.003$ ) and tended to have more difficulty in walking 0.5 km (OR 1.7,  $p=0.050$ ) but not in moving indoors ( $p=0.177$ ). Persons who reported only some hearing problems did not differ from those who reported good hearing in any of the variables studied.

**CONCLUSION:** Perceived major hearing problems among older adults may contribute to

poorer lower limb performance, and difficulties in mobility and ADL. Longitudinal studies are needed in order to disentangle whether poor hearing is a risk factor for decline in physical performance.

**Key words:** *Aging, hearing, physical performance, mobility, ADL*

## INTRODUCTION

Hearing impairment is a major health concern in older adults affecting more than 50% of adults aged 70 and older.<sup>1, 2</sup> In addition to complicating interaction with other people, poor hearing may have consequences which extend beyond communication. Impaired hearing may make walking more uncertain, since acoustic cues assist in perception of the environment while moving.<sup>3</sup> Persons with hearing impairment may also reduce their participation in social activities.<sup>4, 5</sup> This in turn may negatively affect their physical performance via reduced overall physical activity.

Good physical performance is essential for older adults' independent functioning<sup>6-8</sup> and safe moving<sup>9, 10</sup> in every-day life. The associations between hearing and physical performance have been investigated in only a few studies. Goins and colleagues found no association between self-reported hearing loss and scores for the Short Physical Performance Battery among American Indians aged 55 and older.<sup>11</sup> Two studies in older adults have shown that compared to those with normal hearing, persons with audiometrically determined hearing impairment have a slower walking speed.<sup>12, 13</sup> These studies included participants younger than 77 years. Furthermore, self-reported mobility, ADL and IADL have been shown to be poorer in older persons with hearing problems in some studies but not all.<sup>13-19</sup> Further, studies which have specifically analyzed adults aged 75 and older have not found any association between hearing and ADL.<sup>17, 19</sup>

Given the growing prevalence of hearing problems with increasing age, it is vitally important to study the correlates of hearing difficulties in old adults. The primary purpose of the present study was to explore the associations between self-reported hearing problems and physical performance in community-dwelling older adults. We also studied the association of self-reported hearing problems with perceived mobility difficulties and difficulties in activities of daily living.

## **METHODS**

### **Design and sample**

The analyses made use of cross-sectional data gathered for the Life-Space Mobility in Old Age (LISPE) project, which is a study of community-dwelling older adults. The project has been described in detail elsewhere.<sup>20</sup> Briefly, a sample of 2 550 older persons between 75 and 90 years of age and living in the municipalities of Muurame and Jyväskylä, both located in Central Finland, was drawn from the population register. A telephone interview was used to screen eligible participants based on the inclusion criteria, which were: living independently, residing in the recruitment area, being able to communicate, and willingness to participate in the study. The final data set comprised 848 individuals who participated in structured interviews and objective assessments of physical performance in their homes. The LISPE project was approved by the ethical committee of the University of Jyväskylä. The subjects signed an informed consent at the start of the home interview.

### **Hearing**

Hearing was assessed by the following question: “Do you have difficulty hearing when conversing with another person in a noisy environment?”<sup>4</sup> The response categories were 1) No difficulty, 2) Sometimes, some difficulty, and 3) Yes, major difficulty. The participants were asked to estimate their level of difficulty when using a hearing aid if they had one.



## Physical performance

Lower-limb physical performance was assessed using the Short Physical Performance Battery (SPPB).<sup>21, 22</sup> The battery comprises three tests that assess standing balance, walking speed over 2.44 meters (m/s), and timed chair rises (five times, s). Each test was rated from 0 to 4 points. In the rating of the walking speed and chair stands tests, established age- and gender-specific cut-off points were used.<sup>21</sup> A sum score was calculated (range 0-12, higher scores indicating better physical performance) when at least two tests were completed. A SPPB total score was missing in 9 participants, balance in 30 participants, walking speed in 24 participants and chair stands time in 48 participants. The absolute values for walking speed and chair stands time, instead of sub scores, are used in the analyses of the individual SPPB tests.

## Perceived mobility

The participants were asked to rate the level of difficulty in four mobility tasks, namely moving indoors, stair-climbing, 0.5 km walk, and 2 km walk. Five response categories were used ranging from able without difficulty to unable even with the help of another person.<sup>20</sup>

## Functional ability

Functional status was assessed using a 14-item self-report questionnaire for Activities of Daily Living<sup>23</sup> comprising 5 ADL and 9 IADL tasks. Participants were asked to rate their ability to perform each task on a 5-point scale ranging from able without difficulty (0 points) to unable even with help of another person (4 points). ADL and IADL scores were calculated by summing the scores for the individual ADL and IADL tasks.

## Potential confounders

Age and gender were obtained from the population register. Cognitive function was assessed using the Mini-Mental State Examination (MMSE).<sup>24</sup> The participants were asked whether they had sufficient financial resources relative to their needs, and how many years of education they had completed.<sup>20</sup> Body mass index (BMI, kg/m<sup>2</sup>) was calculated based on self-reported height and weight. Self-reported diseases were obtained from a list of 22 physician-diagnosed chronic diseases and an open question.<sup>25</sup> Diseases that could theoretically be linked to hearing problems and physical performance, namely diabetes, cancer, and locomotor, rheumatic, cardiac, circulatory, and neurological diseases, were chosen as potential covariates.

## Data analysis

The associations of hearing with physical performance and the ADL/IADL sum scores were analyzed using generalized linear models with the gamma log-link option for the response variable owing to the non-normal distributions of the response variables. Since this analysis cannot handle response variables with zero values, the value one was added into the SPPB and ADL/IADL sum scores. The associations of hearing problems with the SPPB balance sub score and self-reported mobility were studied using ordinal logistic regression analysis. Moving indoors was an exception: this variable had to be dichotomized due to a low number of observations in the categories indicating greatest disability and consequently binary logistic regression analysis was used. In the generalized linear models and ordinal regression analysis, p-values are given for comparisons between the group with good hearing and all the other groups. In all models, the inclusion criterion for the possible confounders was an association ( $p \leq 0.20$ ) with both the predictor and the response variable. Of the potential confounders, age, years of education, cognitive functioning, and cardiac, circulatory, and locomotor diseases met this criterion for all response variables and were used as covariates in all analyses. The data were analyzed using IBM SPSS Statistics for Windows version 20.0 (IBM Corp., Armonk, NY, USA). Statistical significance was set at p-value  $< 0.05$ .

## RESULTS

Background characteristics of the participants are given in Table 1.

### SPPB

When examining the associations between hearing problems and the SPPB total score, the crude models showed that persons reporting major hearing problems had a significantly lower SPPB total score than those reporting good hearing (estimated marginal mean 9.5 vs. 10.9,  $p < 0.001$ ). Persons reporting some hearing problems did not differ in their SPPB total score from those reporting good hearing (10.6 vs. 10.9,  $p = 0.17$ ). Adjustment (age, years of education, cognitive functioning, and cardiac, circulatory, and locomotor diseases) did not materially change the results of persons with major (9.8 vs. 10.9,  $p = 0.009$ ) or some (10.7 vs. 10.9,  $p = 0.459$ ) hearing problems compared to those with good hearing (Fig. 1).

Hearing problems were also associated with the SPPB subtests. In the crude and adjusted model, persons reporting major hearing problems had significantly slower walking speed than those reporting good hearing (0.75 vs. 0.90 m/s,  $p < 0.001$  and 0.80 vs. 0.88 m/s,  $p = 0.008$ , respectively) (Fig. 1). Also, in the crude and adjusted model, persons reporting major hearing problems had significantly longer chair stands time than those reporting good hearing (16.7 vs 13.1s,  $p < 0.001$  and 15.9 vs. 13.2s,  $p < 0.001$ , respectively). In the crude model, persons with some hearing problems had significantly longer chair stands time (13.7

vs. 13.1s,  $p=0.045$ ) and lower odds for a higher balance score (OR 0.44,  $p=0.001$ ) than those reporting good hearing but these differences became non-significant after adjustment (13.7 vs. 13.2s,  $p=0.153$ , and 0.69,  $p=0.150$ , respectively).

### **Perceived mobility**

In the crude models, compared to persons reporting good hearing, those with major hearing problems had statistically significantly higher odds for more difficulties in stair-climbing, 0.5 km walk and 2 km walk (OR 3.9, 2.8, and 3.3, respectively), but not in moving indoors (Table 2). After adjustment, the odds ratios for stair-climbing and the 2 km walk remained statistically significant (OR 2.8 and 2.1, respectively), but the odds ratio for the 0.5 km walk fell to borderline significant (OR 1.7). In the adjusted models, persons with some hearing problems did not significantly differ from those with good hearing in any of the perceived mobility variables.

### **ADL and IADL**

The crude models showed that compared to persons who reported good hearing, persons who reported major hearing problems had significantly more difficulties in ADL and IADL tasks (estimated marginal mean 2.0 vs. 1.4,  $p<0.001$  and 7.1 vs. 3.8,  $p<0.001$ , respectively). Also, the persons who reported some hearing problems had significantly more difficulties in the IADL (4.4 vs. 3.8,  $p=0.038$ ), but not ADL tasks, than persons reporting good hearing.

After adjustment for the covariates, the difference in ADL and IADL scores between persons with major hearing problems and those with good hearing remained statistically significant (1.8 vs. 1.4,  $p=0.002$  and 4.6 vs. 3.4,  $p=0.002$ ).

## DISCUSSION

Our study showed that self-reported hearing problems are associated with physical performance in community-dwelling older adults aged 75-90. Persons who reported major hearing problems had also more difficulties in mobility and basic and instrumental activities of daily living than those who reported good hearing. Persons who reported only some hearing problems did not differ from those who reported good hearing in any of the variables of physical performance, perceived mobility or activities of daily living after controlling for the effects of potential confounders.

To our knowledge, the study by Goins and colleagues is the only previous study that has investigated the associations between hearing and the SPPB.<sup>11</sup> They found no significant association between self-reported hearing loss and SPPB total score among 328 community-dwelling American Indians aged 55 years and older. The purpose of the study by Goins et al. was to examine a variety of health conditions — not just hearing loss alone — and it appears that the sample size in their study was too small to detect differences between hearing groups, although a trend could be seen. The difference between persons with major hearing problems and good hearing in the SPPB total score in the present study can be considered clinically meaningful in older adults.<sup>26</sup>

We also explored the associations between self-reported hearing problems and the individual tests comprising the SPPB, namely balance, walking speed, and chair stands. With

regard to walking speed, our results are in line with those previously reported in younger cohorts. In one study, women with hearing impairment had 0.1 m/s slower walking speed than women with normal hearing,<sup>13</sup> while in another study an increase of 25dB increase in pure-tone average was associated with 0.05m/s slower walking speed.<sup>12</sup> Our finding suggests that the relationship between hearing and walking speed, observed in younger old persons, persists up to age 75 and older. A new finding of the present study was that persons with major hearing problems showed slower performance in the chair stands test than persons with good hearing. However, we found no significant differences in the balance test scores between the hearing groups after adjusting the analyses for relevant confounders. This was unexpected, as hearing and balance can theoretically be linked via proximity of the anatomical structures in the inner ear and, moreover, as pure-tone average and postural sway were correlated in a previous study.<sup>27</sup>

Our results on perceived mobility are supported by previous studies which have shown that self-reported<sup>15</sup> and audiometrically determined<sup>13</sup> hearing impairment is associated with difficulties in mobility tasks. This has not, however, been confirmed in all studies.<sup>16</sup> Our results across different mobility tasks suggest that hearing impairment may be associated with difficulties in physically more demanding tasks. Our results support previous findings among younger old cohorts showing that hearing is associated with ADL/IADL. However, previous studies investigating specifically older cohorts, 75 years and older, have not found significant relationships between hearing and ADL/IADL. It may be that the association of hearing with ADL and IADL is not particularly strong and may be overridden by that of other health conditions, which could explain the variation observed between study populations. Although minor hearing problems were not independently associated with any of the



measures of physical functioning in this cross-sectional analysis, they may nevertheless predict emerging physical disability.

There are several possible explanations for the relationship of hearing with physical performance and mobility. First, pathophysiological processes in the vasculature may negatively influence both hearing and lower limb performance. Second, communication difficulties caused by poor hearing reduce participation in different activities.<sup>4, 5</sup> Reduced general physical activity due to reduced participation might in turn contribute to decline in physical performance. Third, impaired hearing might make moving more uncertain by disturbing perception of the environment.<sup>3</sup> Fourth, according to the analyses, cognitive functioning also played a role in the relationship between hearing and physical performance. Previous studies have suggested that hearing problems may lead to cognitive decline<sup>28</sup> which, in turn, has been found to be associated with mobility decline.<sup>29</sup> Fifth, in persons with poor hearing, more cognitive resources may be engaged in processing auditory information, thereby reducing the resources available for moving.<sup>30</sup>

This study has several strengths. Our sample was population-based and the interviews were carried out in the participants' homes, facilitating the participation of frailer older people. However, persons with mobility problems were more likely to decline participation.<sup>20</sup> Moreover, to be included in the study, the participants were required to be able to communicate during the home interview. This criterion probably decreased the number of persons with severe hearing impairment in this study. It should also be noted that the cross-

sectional design limits any causal relationships that may be drawn among the variables investigated. Unfortunately, we were not able to assess hearing using an audiometer but used self-reports. However, it is not known which hearing parameter, perceived or audiometrically assessed, is the more relevant determinant of functioning in older adults.

In conclusion, older adults with perceived major hearing problem have poorer lower limb performance, mobility and ADL functions than those who perceive their hearing as good. Further studies are needed in order to disentangle whether poor hearing is a risk factor for decline in physical performance and whether audiologic rehabilitation has positive effects on older persons' physical performance and functioning.

## ACKNOWLEDGEMENTS

Gerontology Research Center is a joint effort between the University of Jyväskylä and the University of Tampere.

This work was funded by the Academy of Finland [grant number 263729]. The LISPE project is funded by the Academy of Finland, the future of living and housing [ASU-LIVE; grant number 255403] program and the Finnish Ministry of Education and Culture. AV is financially supported by a personal grant from the Academy of Finland [grant number 251723].

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**Table 1. Background Characteristics of the Participants Reporting Good Hearing, Some Problems, and Major Problems in Hearing When Conversing in a Noisy Environment (N=847).**

	Self-reported hearing						
	Good hearing (N=366)		Some problems (N=393)		Major problems (N=88)		p <sup>a</sup>
	N	%	N	%	N	%	
Gender							0.55
Male	138	38	154	39	29	33	
Female	228	62	239	61	59	67	
Hearing aid owner	13	4	57	15	44	50	<0.001
Sufficient financial resources	165	45	178	54	35	40	0.61
Cardiac disease	127	35	181	46	49	56	<0.001
Circulatory disease	229	63	264	67	63	72	0.19
Diabetes	64	18	68	17	17	19	0.90
Locomotor/rheumatic disease	233	64	262	67	68	77	0.052
Neurological disease	24	7	29	7	8	9	0.70
Cancer	63	17	61	16	12	14	0.66
	Median	IQR	Median	IQR	Median	IQR	p <sup>b</sup>
Age (years)	80	6.9	81	7.4	83	6.6	<0.001



Body mass index (kg/m <sup>2</sup> )	25.9	4.9	25.8	4.6	26.0	4.8	0.88
MMSE score	27	3	27	3	26	4.9	0.002
Years of education	8.5	5	9	6	8	5	0.191

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Note. MMSE, Mini-Mental State Examination

<sup>a</sup>Chi-square test

<sup>b</sup>Kruskal-Wallis H-test

**Table 2. The Odds for More Difficulty in Mobility Tasks by Categories of Self-Reported Problems in Hearing (Logistic Regression Analysis).**

	Difficulty in mobility (%) <sup>a</sup>	Crude			Adjusted <sup>b</sup>		
		OR	95% CI	p	OR	95% CI	p
<b>Moving indoors</b>							
Good hearing	93/7	1			1		
Some problems	94/6	2.6	1.3-5.2	0.009	1.5	0.7-3.2	0.314
Major problems	74/14	0.8	0.4-1.4	0.449	0.7	0.4-1.2	0.177
<b>Stair-climbing</b>							
Good hearing	79/17/4	1			1		
Some problems	74/24/2	1.3	0.9-1.8	0.172	1.1	0.8-1.6	0.537
Major problems	49/41/10	3.9	2.4-6.3	<0.001	2.8	1.7-4.6	<0.001
<b>0.5 km walk</b>							
Good hearing	77/17/6	1			1		
Some problems	76/21/3	1.1	0.8-1.5	0.763	0.9	0.6-1.3	0.509
Major problems	55/34/11	2.8	1.7-4.5	<0.001	1.7	1.0-2.8	0.050
<b>2 km walk</b>							
Good hearing	66/22/12	1			1		
Some problems	55/32/13	1.5	1.1-2.0	0.007	1.3	0.9-1.7	0.145
Major problems	38/24/28	3.3	2.1-5.2	<0.001	2.1	1.3-3.3	0.003

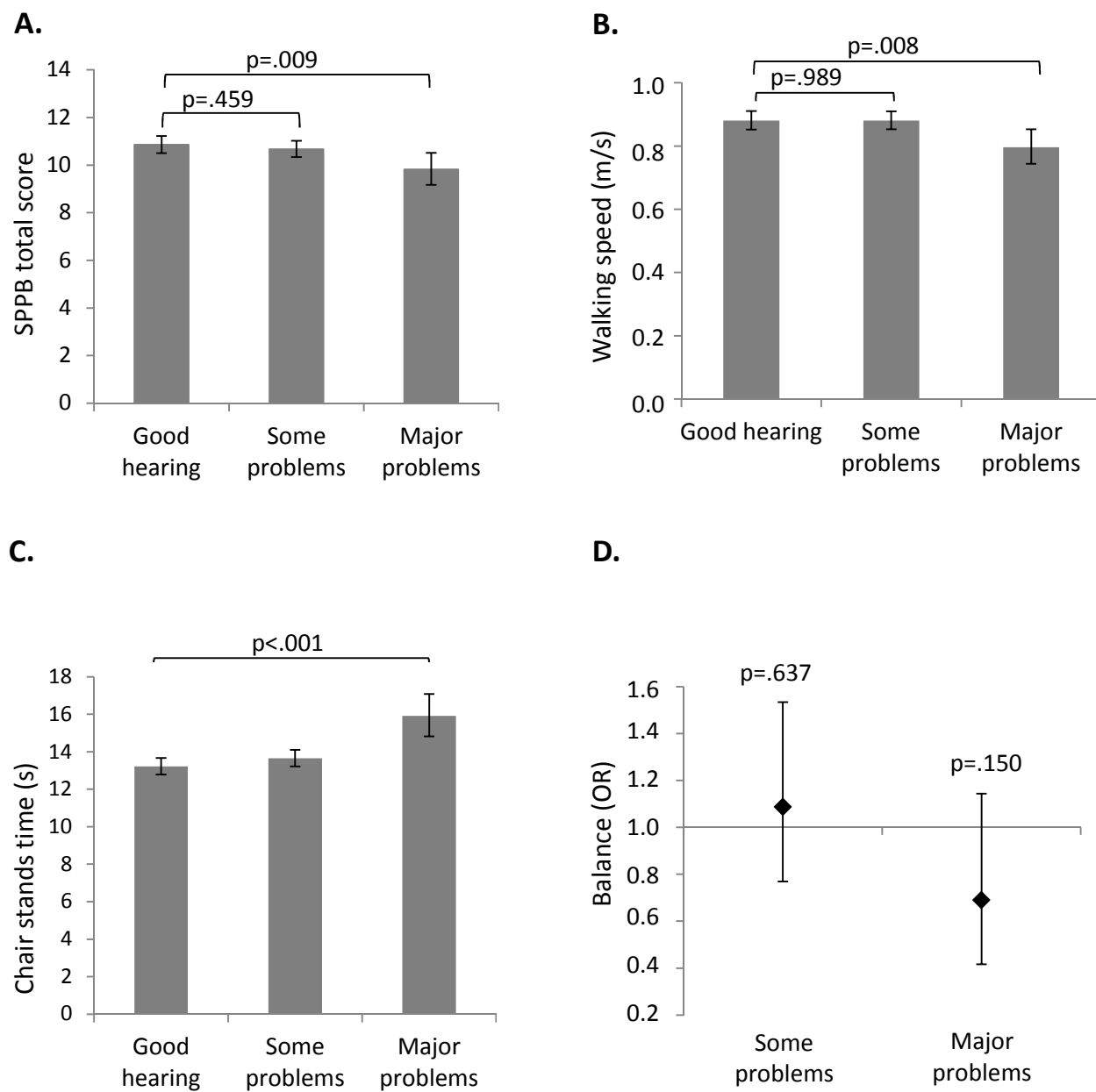
Note. Group with good hearing is the reference group.

<sup>a</sup>Proportions of persons reporting no difficulty/difficulty/unable in the mobility task and proportions for persons reporting no difficulty/difficulty or unable in moving indoors

<sup>b</sup>Adjusted for age, years of education, cognitive functioning, and cardiac, circulatory, and locomotor diseases.

## FIGURES

Fig. 1.



## FIGURE LEGENDS

**Figure 1. A)** Estimated marginal means and 95% CIs of Short Physical Performance Battery (SPPB) total score **B)** habitual walking speed (m/s) **C)** chair stands test time (s) among the three hearing groups. **D)** Odds ratio (OR) and 95%CI for higher score in balance test in groups Some problems in hearing and Major problems in hearing compared to the group Good hearing (OR=1). In SPPB total and balance score, higher scores indicate better performance. Value one is added to the SPPB total score owing to the data analysis method. The analyses are adjusted for age, years of education, cognitive functioning, and cardiac, circulatory, and locomotor diseases.



<b>Royalties</b>		x		x		x		x		x		x
<b>Expert Testimony</b>		x		x		x		x		x		x
<b>Board Member</b>		x		x		x		x		x		x
<b>Patents</b>		x		x		x		x		x		x
<b>Personal Relationship</b>		x		x		x		x		x		x

\*Autho

rs can be listed by abbreviations of their names

For “yes”, provide a brief explanation: \_\_\_\_\_

\_\_\_\_\_

**Author Contributions:** TMM has analyzed and interpreted the data, drafted the manuscript and approved the final version to be published. HP has substantially contributed to the analysis and interpretation of the data and to the critical revision of the manuscript and has approved the final version to be published. EP, MR, TR and AV have substantially contributed to conception,

design and acquisition of the data, critical revision of the manuscript, and approved the final version to be published.

**Sponsor's Role:** none