

**This is an electronic reprint of the original article.  
This reprint *may differ* from the original in pagination and typographic detail.**

**Author(s):** Viljanen, Anne; Kulmala, Jenni; Rantakokko, Merja; Koskenvuo, Markku; Kaprio, Jaakko; Rantanen, Taina

**Title:** Fear of falling and coexisting sensory difficulties as predictors of mobility decline in older women

**Year:** 2012

**Version:**

**Please cite the original version:**

Viljanen, A., Kulmala, J., Rantakokko, M., Koskenvuo, M., Kaprio, J., & Rantanen, T. (2012). Fear of falling and coexisting sensory difficulties as predictors of mobility decline in older women. *Journals of Gerontology. Series A: Biological Sciences & Medical Sciences*, 67(11), 1230-7. <https://doi.org/10.1093/gerona/gls134>

All material supplied via JYX is protected by copyright and other intellectual property rights, and duplication or sale of all or part of any of the repository collections is not permitted, except that material may be duplicated by you for your research use or educational purposes in electronic or print form. You must obtain permission for any other use. Electronic or print copies may not be offered, whether for sale or otherwise to anyone who is not an authorised user.

## **Fear of Falling and Coexisting Sensory Difficulties as Predictors of Mobility Decline in Older Women**

Anne Viljanen PhD<sup>\*</sup>, Jenni Kulmala PhD<sup>\*</sup>, Merja Rantakokko PhD<sup>\*</sup>, Markku Koskenvuo MD, PhD<sup>§</sup>, Jaakko Kaprio MD, PhD<sup>§, ||, †</sup>, Taina Rantanen PhD<sup>\*</sup>

<sup>\*</sup>Department of Health Sciences, Gerontology Research Centre, University of Jyväskylä, Jyväskylä, Finland

<sup>§</sup>Department of Public Health, Hjelt Institute, University of Helsinki, Helsinki, Finland

<sup>||</sup>Department of Mental Health and Substance Abuse Services, National Institute for Health and Welfare, Helsinki, Finland

<sup>†</sup>Institute of Molecular Medicine, University of Helsinki, Helsinki, Finland

### **Corresponding author:**

Anne Viljanen

Gerontology Research Centre

P.O Box 35 (Viveca)

FIN-40014 University of Jyväskylä

Phone: +358-40-8053603

E-mail:anne.viljanen@jyu.fi

**Running title:** Fear, sensory difficulties and mobility

## **ABSTRACT**

### **BACKGROUND**

Mobility decline, the coexistence of several sensory difficulties and fear of falling (FOF) are all common concerns in older people; however, knowledge about the combined effect of FOF and coexisting sensory difficulties on mobility is lacking.

### **METHODS**

Data on self-reported FOF, difficulties in hearing, vision, balance, and walking 2km were gathered with a structured questionnaire among 434 women aged 63-76 years at baseline and after a three-year follow-up. Logistic regression models were used for analyses.

### **RESULTS**

Every third participant reported difficulties in walking 2km at baseline. In cross-sectional analysis the odds ratio (OR) for difficulties in walking 2km was higher among persons who reported FOF compared to persons without FOF and the odds increased with the increasing number of sensory difficulties. Persons who reported FOF and who had three sensory difficulties had almost five-fold odds (OR 4.7, 95%CI 1.9-11.7) for walking difficulties compared to those who reported no FOF and no sensory difficulties. Among the 290 women without walking difficulties at baseline, 54 participants developed difficulty in walking 2km during the three-year follow-up. OR for incident walking difficulty was 3.5 (95%CI 1.6-7.8) in participants with FOF and with 2-3 sensory difficulties compared to persons without FOF and with at most one sensory difficulty at baseline.

### **CONCLUSIONS**

Older women who have several coexisting sensory difficulties combined with FOF are particularly vulnerable to mobility decline. Avoidance of walking as a result of FOF is likely to be reinforced when multiple sensory difficulties hinder reception of accurate information about the environment, resulting in accelerated decline in walking ability.

## **INTRODUCTION**

Walking is a cornerstone of independent living in the community and an important element of quality of life for older persons (1). Walking is a multifactorial motor skill, which relies on fluent co-operation between the sensory, neural, musculoskeletal, and cardio-respiratory organ systems in relation to the demands of the environment (2,3). Walking difficulties have been associated with several chronic systemic diseases, as well as declines in strength and postural balance (4,5). Decreased vision (6,7) and hearing have also been associated with poor mobility (8), although not in all studies (9,10). Multiple chronic diseases or deficits may have an additive and possibly even synergistic impact on mobility (11,12). Coexisting sensory difficulties, for example vision, hearing and balance difficulties, may have a considerably greater debilitating effect on mobility than a single sensory difficulty alone, because of the loss of possible compensatory sensory resources.

Fear of falling (FOF) is defined as “a lasting concern about falling that leads to an individual avoiding activities that he/she remains capable of performing”(13). FOF and mobility problems are interrelated problems as each has shown to be a risk factor for the other (14,15). The main consequences of FOF are an increased risk for falling, the restriction and avoidance of activities, and, ultimately, deteriorated physical and mental performance as well as decreased quality of life (14-18).

Knowledge on the role of sensory difficulties on FOF is limited, and the results of studies vary depending on the methods used. Poor vision has been identified as one of the risk factors for FOF (19,20), although opposite results have also been reported (15,21). Similarly both positive (22,23) and negative findings (19,24) have been presented on the association between postural balance and FOF. Studies on the association between hearing and FOF are scarce, and none have found support for this possible relation (20,21), although some studies have demonstrated an association between hearing and falls, and hearing and walking difficulties (8,25).

Mobility problems, FOF and sensory difficulties are all commonly mentioned concerns and health problems by older people. Although previous studies have suggested that sensory difficulties or FOF may manifest as deteriorated walking performance (5,6,7, 26 ), no previous studies have demonstrated the association between coexisting sensory difficulties and FOF or the combined effect of FOF and sensory difficulties on mobility. First, we

investigated cross-sectionally whether FOF, difficulties in vision, hearing and balance correlate with walking difficulties. Second, we examined the effects of coexisting sensory difficulties and FOF with walking difficulties. Finally, we examined prospectively whether sensory difficulties and FOF, either alone or together, predict development of new difficulties in walking during a three-year follow-up among well-functioning community-dwelling older women.

## **METHODS**

### **Participants**

The Finnish Twin Study on Aging (FITSA) contains 434 women who were aged 63 to 76 years during the baseline measurements in winter of 2000 to 2001. Participants were recruited through the nationwide Finnish Twin Cohort, which comprises all same-sex twin pairs born before 1958 with both co-twins alive in 1975. The recruitment procedure has been described in detail elsewhere (8,27). Briefly, both individuals in the twin pair had to be willing to participate and to be able to travel to the research laboratory in Jyväskylä, in central Finland, from their town of residence. Consequently, the present sample consists of well-functioning older women. A follow-up study was conducted three years later with 419 women responding to the postal questionnaire on mobility difficulties. During the follow-up, 7 participants died and 8 participants dropped out for health reasons (97% participation rate). For prospective analyses 290 women with no walking difficulties at baseline were included. The study was approved by the Ethics Committee of the Central Finland Health Care District.

### **Walking difficulties**

Self-rated walking difficulties were assessed at baseline and at follow-up by means of a structured questionnaire with the question: “Do you have difficulties in walking two kilometers without resting?” The response options were: “No difficulties”, “Minor difficulties”, “Major difficulties”, and “Unable”. Participants who reported minor or major difficulties or being unable to walk two kilometers were categorized as having self-reported difficulties in walking two kilometers.

### **Fear of falling**

FOF was assessed at baseline by the question “Are you afraid of falling?” Possible answers to the question were: "Never", "Occasionally", "Often", or "Constantly ". The participant was categorized as having FOF, if she reported FOF at least occasionally. FOF was used as a

dichotomous variable (yes/no FOF) as there were very few subjects with FOF more often than occasionally.

### **Sensory functions**

Perceived sensory functions were assessed at baseline using questionnaires. Hearing was assessed by the question “Do you have difficulties hearing, when you have a conversation with several people simultaneously?” The response options were: “No difficulties”, “Sometimes, minor difficulties”, and “Yes, major difficulties”. These were subsequently dichotomized into “No difficulties” and “Any difficulties”. Vision was assessed by the question “How well can you see from a distance?” The response options were: “Well”, “Reasonably well”, “Poorly”, and dichotomized into “Well” and “Not well”. Balance was assessed by the question “Are you dizzy or do you suffer from poor balance?” The response options were: “Rarely or never”, “Sometimes, causing me some distress”, “Often, causing me much distress”, and dichotomized into “Rarely or never” and “At least sometimes”. The number of sensory difficulties was calculated by summing the responses describing the presence of difficulties in vision, hearing and balance (0-3).

### **Descriptive variables**

Self-reported chronic conditions and use of medications were confirmed by a physician during the baseline clinical examination. The Mini-Mental state examination (MMSE) was used to test cognitive capacity. Body mass index (BMI) was calculated by dividing measured body weight by height squared ( $\text{kg}/\text{m}^2$ ). Information about total length of education (years) was gathered using a structured questionnaire.

### **Statistical analysis**

The proportions of participants with hearing, vision or balance difficulties, number of sensory difficulties and FOF in persons with or without walking difficulties were tested with the Wald test adjusted for within-pair dependency resulting from the sampling of twin pairs (28,29). Sensory difficulties according to FOF were tested in a similar way. Also mean differences in age, cognitive function, number of chronic diseases, number of prescribed medications, weight, height and BMI in two walking categories, and the proportions of participants with any cardiovascular disease, diabetes mellitus or rheumatoid arthritis were tested using the adjusted Wald test. These tests are the equivalent of the chi-square test and t-test for unrelated individuals.

Logistic regression models were used to analyse whether sensory difficulties or FOF were associated with walking difficulties at baseline and whether having sensory difficulties and FOF at baseline predicts onset of new walking difficulties at follow-up three years later. Combined effects of sensory difficulties and FOF on present or onset walking difficulties were also analysed using logistic regression models with persons without sensory difficulties or FOF as the reference group. All the regression models were adjusted for age and clustering of twins with twin pairs (28). In addition, the models for the combined effects of sensory difficulties and FOF on walking difficulties were further adjusted, one by one, for number of chronic diseases, number of medications, height, weight, BMI, education, any cardiovascular disease, diabetes mellitus and rheumatoid arthritis. The modelling was performed using Stata statistical software (Stata Corp., College Station, TX). P-values of  $<0.05$  were considered as statistically significant.

## RESULTS

A third ( $n= 138$ , 32%) of women reported difficulties in walking 2 km at baseline. Participants with walking difficulties reported more often FOF (52% vs. 34%,  $p=.001$ ) and balance difficulty (49% vs. 27%,  $p<.001$ ) than participants without walking difficulties. Altogether 51% of participants with walking difficulties reported two or three sensory difficulties compared to 32% of participants without walking difficulties ( $p$ -value for the trend =  $<.001$ ). Participants with walking difficulties were also older, had higher weight, were less educated, had more chronic diseases, used more prescribed medications and had more often cardiovascular disease, diabetes mellitus or rheumatoid arthritis than participants without walking difficulties. Participants with and without walking difficulties did not differ according to height, MMSE score or prevalence of vision or hearing difficulty. (Table 1.) Participants with FOF more often reported balance difficulties (46% vs. 26%,  $p<.001$ ), vision difficulties (51% vs. 35%,  $p=.001$ ), hearing difficulties (55% vs. 41%,  $p=006$ ), and coexisting sensory difficulties than participants without FOF. (Table 2.) Altogether 113 (26%) participants had no sensory difficulties, 154 (36%) had one, 122 (28%) had two, and 42 participants (10%) had three sensory difficulties.

At baseline women with FOF had a two-fold age-adjusted odds (OR 2.1, 95% CI 1.4-3.3) for walking difficulties compared to those without FOF. In women with one sensory difficulty the age-adjusted OR for walking difficulties was 1.3 (95% CI 0.7-2.2), in those with two

sensory difficulties 2.1 (95% CI 1.2-3.9), and in those with three sensory difficulties 3.5 (95% CI 1.7-7.3), compared to persons with no sensory difficulties. (Table 1.)

The combined effect of FOF and sensory difficulties on walking difficulties at baseline is presented in figure 1. The proportion of participants who reported difficulties in walking 2 kilometres was 18% in persons who reported no FOF and no sensory difficulties. The proportion increased to 50% in persons who had no FOF but who reported three sensory difficulties. Among persons with FOF, corresponding proportions were 34% and 54%. Age-adjusted OR for difficulties walking 2 km was higher among persons with than without FOF, and the odds increased along with the number of sensory difficulties. Persons with both FOF and three sensory difficulties had an almost five-fold age-adjusted odds (OR 4.7, 95% CI 1.9-11.7,  $p=.001$ ) for walking difficulties compared to those with no FOF and no sensory difficulties. Further adjustment for covariates (number of chronic diseases, number of medications, height, weight, BMI, education, any cardiovascular disease, diabetes mellitus and rheumatoid arthritis) had only a marginal effect on the results.

Among the 290 women without walking difficulties at baseline, 54 participants developed difficulty in walking 2 km during the three-year follow-up. Walking difficulties developed for 13% of participants without FOF at baseline compared to 30% of participants with FOF ( $p=.002$ ). Women with FOF at baseline had a three-fold age-adjusted risk (OR 2.9, 95% CI 1.6-5.4) for incident walking difficulties compared to those without FOF. Furthermore, the age-adjusted OR for incident walking difficulties was 2.2 (95% CI 1.0-5.1) in women with one sensory difficulty, 2.5 (95% CI 1.1-5.8) in those with two, and 2.7 (95% CI 0.8-9.5) in those with three sensory difficulties compared to persons with no sensory difficulties. (Table 3.)

The combined effect of baseline FOF and sensory difficulties on incident walking difficulties is presented in figure 2. Age-adjusted OR for incident walking difficulties was 1.2 (95% CI 0.5-3.2,  $p=.700$ ) in participants without FOF and with 2-3 sensory difficulties at baseline, 2.8 (95% CI 1.3-6.1,  $p=.010$ ) in participants with FOF and at most one sensory difficulty, and 3.5 (95% CI 1.6-7.8,  $p=.002$ ) in participants with FOF and 2-3 sensory difficulties compared to persons without FOF and with at most one sensory difficulty. Further adjustment for the covariates mentioned above had only a marginal effect on results. Participants who had 0 or 1,



and those with 2 or 3 sensory difficulties were analyzed together in order to obtain a sufficient number of participants in each category.

## **DISCUSSION**

According to this study, FOF and presence of multiple coexisting sensory difficulties substantially increased the risk of mobility decline in older women. We also showed that sensory difficulties correlate with FOF.

In response to sensory difficulties people may adopt behaviors that have pernicious consequences on their functioning. The results of this study support the theory that FOF may act as an exacerbating behavioral factor, which increases mobility decline in sensory-impaired persons (30). Although we were unable to disentangle the temporal order of FOF and sensory functions, it is reasonable to think that sensory difficulties lead to FOF rather than other way round. Our prospective analyses showed that single sensory difficulties did not increase the risk of walking difficulties. It is possible that people may adjust to a gradually declining sensory function and learn to compensate for the deficiency by utilizing information from other sensory modalities. However when multiple sensory difficulties were present together with FOF, the risk of developing walking difficulties was substantially increased. When the number of sensory difficulties increases it becomes more and more difficult for the person to receive accurate information about the environment. This may eventually lead to FOF, avoidance of walking in unfamiliar environments and consequently accelerated decline in walking ability. The suggested chain of events should be confirmed in future studies with multiple follow-ups.

Previous studies have indicated a reciprocal association between FOF and walking difficulties (15). Namely, an individual who has mobility difficulties may start to fear falling, or, alternatively, FOF may cause mobility difficulties either directly through reduced gait performance or because of possible activity restriction (26). FOF may also be an early sign of impending difficulties in mobility. It is possible that a person who does not feel confident in mobility reports FOF, and later on difficulties in mobility emerge.

Currently, it is agreed that FOF is multifactorial in etiology, and deserves further attention (14). The factors contributing to FOF are numerous, but the exact causes remain unclear. Several previous studies have confirmed findings that FOF is associated with poorer health

and functional status (14,18). The results of this study support the previous findings that vision (19,20) and balance difficulties (22,23) are associated with FOF. Furthermore, this study demonstrated an association between FOF and hearing difficulty as well as between FOF and presence of multiple sensory difficulties. We are not aware of other studies on the effects of coexisting sensory difficulties on FOF, although coexisting sensory difficulties are common in older people and have been shown significantly to increase, for example, the risk of falls (31). Maintaining an upright stance is a process where the correct output of the musculoskeletal system relies on the interaction of vestibular, somatosensory, and visual inputs, and the adaptation of these inputs to the demands of the task and environment (32-34). Furthermore some previous studies have demonstrated that hearing acuity is also related to postural balance and falls (25,35,36). The probability of balance problems (32-34,37) and falls (31,38) increases along with the number of underlying systems affected. Lack of sensory information about the environment, together with FOF, may manifest as a more cautious and unstable way of walking. Up to a certain point a person may compensate for a sensory difficulty by relying on other senses, but when several sensory difficulties are present the ability to compensate is diminished or even lost. It is obvious that perceived balance problems are associated with FOF, but it is noticeable that also the lack of environmental information because of vision or hearing difficulties may jeopardize a person's confidence in maintaining balance and therefore be associated with FOF.

Several studies (for a review, see Zijlstra et al.) (39) have indicated that FOF may lead to a debilitating spiral of loss of confidence, restriction on physical and social activities, physical frailty, falls and eventually loss of independence. It is important therefore to try to influence the factors or their predictors that are responsible for this downward spiral. The results of this study suggest that interventions targeted at improving vision, hearing and balance may also reduce FOF. A regular ophthalmic examination and audiometric screening followed by appropriate treatment and rehabilitation, such as surgery, use of spectacles or a hearing aid could help prevent FOF in older people. Furthermore, attention should be paid to the prevention and appropriate treatment of accompanying illnesses, such as diabetes and cardiovascular diseases, which may also negatively affect sensory systems.

This study comprised a population-based sample of well-functioning, community-dwelling women. To be recruited, the women had to be able to travel, often hundreds of kilometers, to the research centre from their town of residence for the baseline measurements. Therefore,

the present sample was composed of relatively healthy older people. FOF was determined by using a single question instead of activity related multi-dimensional questionnaires, and this may partly have affected the results. It has been argued that a one-item FOF measure may accurately capture the generalized dimension of fear across many different situations and activities (40). Results of this study are based on self-reported evaluations of sensory functions and mobility. Although self-reports are often criticized because of their subjectivity, they provide important information about the difficulties people perceive in their everyday environment, and are thus clinically highly relevant.

The validity of the results of this study is supported by the fact that the prevalence of self-reported walking and sensory difficulties, as well as FOF, in this twin-sample were in line with the previous non-twin population-based studies. However, the exact comparison of the studies is very challenging due to the different methods and samples used. For example, the prevalence figures of FOF vary from 3% to 85% between different studies (14). The prevalence of FOF, assessed using the same single question, is lower in this study sample than reported in an earlier study among older persons (40% vs. 54%) (41). Also walking difficulties were reported less often in this than in an earlier study (32% vs. 47%) (42). The prevalence of self-reported hearing difficulties (46%) is comparable with the figures presented by Chia et al. (43) who reported that 51% of the middle-aged or older participants felt that they have a hearing loss. According to the large National Health and Nutrition Examination Survey –study the prevalence of audiometrically assessed hearing loss was 63% (44). Furthermore, 25% of the participants of that study rated their vision as fair or poor (45) and dizziness or difficulty with balance was reported by 27% (46). The corresponding percentages in our study were 42% and 34%.

Due to limited number of participants with severe difficulties in sensory functions or walking, or constant FOF, the variables were dichotomized and thus the severity of difficulties or FOF could not be taken into account in analyses. It is possible, that if the sample had consisted of participants with more severe walking or sensory difficulties or more constant FOF, an even stronger association between sensory functions, FOF and mobility would have emerged. Furthermore, results of the prospective analyses should be interpreted with some caution because of the limited amount of participants developing walking difficulties during the follow-up. Further studies with larger, more heterogeneous study populations are warranted.

To conclude, this study indicated that mobility decline in old age was attributable to the combined effect of coexisting sensory difficulties and FOF. The results suggest that coexisting of multiple sensory difficulties may hinder older people from receiving compensatory information about their body position and the environment, thus increasing the FOF and jeopardizing outdoor mobility. Regular screening of sensory functions followed by appropriate actions can be recommended to prevent both the development of FOF and consequent mobility decline, although further knowledge on the effectiveness of preventive actions is needed.

### **FUNDING**

This work was supported by the Academy of Finland (grant number 251723) and the Finnish Cultural Foundation (grant number AFB59C1). Jaakko Kaprio is supported by the Academy of Finland Centre of Excellence in Complex Disease Genetics (grant numbers: 213506, 129680).

### **ACKNOWLEDGEMENTS**

We are indebted to all the participants for their commitment to the study.

## REFERENCES

1. Rantakokko M, Iwarsson S, Kauppinen M, Leinonen R, Heikkinen E, Rantanen T. Quality of life and barriers in the urban outdoor environment in old age. *J Am Geriatr Soc.* 2010;58:2154-2159.
2. Snijders AH, van de Warrenburg BP, Giladi N, Bloem BR. Neurological gait disorders in elderly people: clinical approach and classification. *Lancet Neurol.* 2007;6:63-74.
3. Frank JS, Patla AE. Balance and mobility challenges in older adults: implications for preserving community mobility. *Am J Prev Med.* 2003;25:157-163.
4. Alexander NB. Gait disorders in older adults. *J Am Geriatr Soc.* 1996;44:434-451.
5. Tiedemann A, Sherrington C, Lord SR. Physiological and psychological predictors of walking speed in older community-dwelling people. *Gerontology.* 2005;51:390-395.
6. Laitinen A, Sainio P, Koskinen S, Rudanko SL, Laatikainen L, Aromaa A. The association between visual acuity and functional limitations: findings from a nationally representative population survey. *Ophthalmic Epidemiol.* 2007;14:333-342.
7. West CG, Gildengorin G, Haegerstrom-Portnoy G, Schneck ME, Lott L, Brabyn JA. Is vision function related to physical functional ability in older adults? *J Am Geriatr Soc.* 2002;50:136-145.
8. Viljanen A, Kaprio J, Pyykko I, Sorri M, Koskenvuo M, Rantanen T. Hearing acuity as a predictor of walking difficulties in older women. *J Am Geriatr Soc.* 2009;57:2282-2286.
9. Laforge R, Spector W, Sternberg J. The Relationship of Vision and Hearing Impairment to One-Year Mortality and Functional Decline. *J Aging Health.* 1992;4:126-148.
10. Lin MY, Gutierrez PR, Stone KL, et al. Vision impairment and combined vision and hearing impairment predict cognitive and functional decline in older women. *J Am Geriatr Soc.* 2004;52:1996-2002.
11. Guralnik JM, Ferrucci L, Balfour JL, Volpato S, Di Iorio A. Progressive versus catastrophic loss of the ability to walk: implications for the prevention of mobility loss. *J Am Geriatr Soc.* 2001;49:1463-1470.
12. Rantanen T, Guralnik JM, Ferrucci L, Leveille S, Fried LP. Coimpairments: strength and balance as predictors of severe walking disability. *J Gerontol A Biol Sci Med Sci.* 1999;54:M172-6.
13. Tinetti ME, Powell L. Fear of falling and low self-efficacy: a case of dependence in elderly persons. *J Gerontol.* 1993;48:35-38.

14. Scheffer AC, Schuurmans MJ, van Dijk N, van der Hooft T, de Rooij SE. Fear of falling: measurement strategy, prevalence, risk factors and consequences among older persons. *Age Ageing*. 2008;37:19-24.
15. Friedman SM, Munoz B, West SK, Rubin GS, Fried LP. Falls and fear of falling: which comes first? A longitudinal prediction model suggests strategies for primary and secondary prevention. *J Am Geriatr Soc*. 2002;50:1329-1335.
16. Deshpande N, Metter EJ, Lauretani F, Bandinelli S, Guralnik J, Ferrucci L. Activity restriction induced by fear of falling and objective and subjective measures of physical function: a prospective cohort study. *J Am Geriatr Soc*. 2008;56:615-620.
17. Li F, Fisher KJ, Harmer P, McAuley E, Wilson NL. Fear of falling in elderly persons: association with falls, functional ability, and quality of life. *J Gerontol B Psychol Sci Soc Sci*. 2003;58:P283-90.
18. Legters K. Fear of falling. *Phys Ther*. 2002;82:264-272.
19. Murphy SL, Dubin JA, Gill TM. The development of fear of falling among community-living older women: predisposing factors and subsequent fall events. *J Gerontol A Biol Sci Med Sci*. 2003;58:M943-7.
20. Martin FC, Hart D, Spector T, Doyle DV, Harari D. Fear of falling limiting activity in young-old women is associated with reduced functional mobility rather than psychological factors. *Age Ageing*. 2005;34:281-287.
21. Kempen GI, van Haastregt JC, McKee KJ, Delbaere K, Zijlstra GA. Socio-demographic, health-related and psychosocial correlates of fear of falling and avoidance of activity in community-living older persons who avoid activity due to fear of falling. *BMC Public Health*. 2009;9:170.
22. Kressig RW, Wolf SL, Sattin RW, et al. Associations of demographic, functional, and behavioral characteristics with activity-related fear of falling among older adults transitioning to frailty. *J Am Geriatr Soc*. 2001;49:1456-1462.
23. Vellas BJ, Wayne SJ, Romero LJ, Baumgartner RN, Garry PJ. Fear of falling and restriction of mobility in elderly fallers. *Age Ageing*. 1997;26:189-193.
24. Reelick MF, van Iersel MB, Kessels RP, Rikkert MG. The influence of fear of falling on gait and balance in older people. *Age Ageing*. 2009;38:435-440.
25. Viljanen A, Kaprio J, Pyykko I, et al. Hearing as a predictor of falls and postural balance in older female twins. *J Gerontol A Biol Sci Med Sci*. 2009;64:312-317.

26. Rochat S, Bula CJ, Martin E, et al. What is the relationship between fear of falling and gait in well-functioning older persons aged 65 to 70 years? *Arch Phys Med Rehabil.* 2010;91:879-884.
27. Kaprio J, Koskenvuo M. Genetic and environmental factors in complex diseases: the older Finnish Twin Cohort. *Twin Res.* 2002;5:358-365.
28. Williams RL. A note on robust variance estimation for cluster-correlated data. *Biometrics.* 2000;56:645-646.
29. Rao JNK, Scott AJ. On chi-squared tests for multiway contingency tables with cell proportions estimated from survey data. *Annals of Statistics.* 1984;12:46-60.
30. Verbrugge LM, Jette AM. The disablement process. *Soc Sci Med.* 1994;38:1-14.
31. Kulmala J, Viljanen A, Sipila S, et al. Poor vision accompanied with other sensory impairments as a predictor of falls in older women. *Age Ageing.* 2009;38:162-167.
32. Woollacott M, Shumway-Cook A. Attention and the control of posture and gait: a review of an emerging area of research. *Gait Posture.* 2002;16:1-14.
33. Shumway-Cook A, Woollacott M. Attentional demands and postural control: the effect of sensory context. *J Gerontol A Biol Sci Med Sci.* 2000;55:M10-6.
34. Horak FB. Postural orientation and equilibrium: what do we need to know about neural control of balance to prevent falls? *Age Ageing.* 2006;35:ii7-ii11.
35. Baloh RW, Ying SH, Jacobson KM. A longitudinal study of gait and balance dysfunction in normal older people. *Arch Neurol.* 2003;60:835-839.
36. Gerson LW, Jarjoura D, McCord G. Risk of imbalance in elderly people with impaired hearing or vision. *Age Ageing.* 1989;18:31-34.
37. Pollock AS, Durward BR, Rowe PJ, Paul JP. What is balance? *Clin Rehabil.* 2000;14(4):402-406.
38. Crews JE, Campbell VA. Vision impairment and hearing loss among community-dwelling older Americans: implications for health and functioning. *Am J Public Health.* 2004;94:823-829.
39. Zijlstra GA, van Haastregt JC, van Rossum E, van Eijk JT, Yardley L, Kempen GI. Interventions to reduce fear of falling in community-living older people: a systematic review. *J Am Geriatr Soc.* 2007;55:603-615.
40. Lachman ME, Howland J, Tennstedt S, Jette A, Assmann S, Peterson EW. Fear of falling and activity restriction: the survey of activities and fear of falling in the elderly (SAFE). *J Gerontol B Psychol Sci Soc Sci.* 1998;53(1):P43-50.

41. Zijlstra GA, van Haastregt JC, van Eijk JT, van Rossum E, Stalenhoef GI, Kempen GI. Prevalence and correlates of fear of falling, and associated avoidance of activity in the general population of community-living older people. *Age Ageing* 2007;36:304-309.
42. Schumway-Cook A, Ciol M, Yorkston KM, Hoffman JM, Chan L. Mobility limitations in the Medicare population: Prevalence and sociodemographic and clinical correlates. *J Am Geriatr Soc.* 2005;53:1217-1221.
43. Chia E, Wang JJ, Rochtchina E, Cumming RR, Newall P, Mitchell P. Hearing impairment and health-related quality of life: the Blue Mountains Hearing Study. *Ear Hearing.* 2007;28:187-195.
44. Lin FR, Thorpe R, Gordon-Salant S, Ferrucci L. Hearing loss prevalence and risk factors among older adults in the United States. *J Gerontol A Biol Sci Med Sci.* 2011; 66:582-590.
45. Steinman BA, Allen SM. Self-reported vision impairment and its contribution to disability among older adults. *J Aging Health.* 2011 Sep 28. [Epub ahead of print] DOI: 10.1177/0898264311422600.
46. Agrawal Y, Carey JP, Della Santina CC, Schubert MC, Minor LB. Disorders of balance and vestibular function in US adults. *Arch Intern Med.* 2009;169:938-944.



**Table 1. Characteristics of Participants with or without Walking Difficulty at Baseline (n=434)**

Variable	No Walking difficulty n=296		Walking difficulty n=138		Wald test p*	Logistic regression models for walking difficulty	
	mean	SD	mean	SD		OR (95% CI) <sup>§</sup>	p <sup>§</sup>
Age (years)	68.3	3.3	69.4	3.5	.007	1.10 (1.03-1.18)	.007
Number of chronic diseases	1.6	1.2	2.8	1.6	<.001	1.81 (1.50-2.17)	<.001
Number of prescribed medications	1.8	1.7	2.6	2.4	<.001	1.22 (1.10-1.36)	<.001
Weight (kg)	68.6	10.7	73.4	13.8	.001	1.04 (1.02-1.06)	<.001
Height (cm)	158.8	6.3	158.0	5.7	.264	0.99 (0.95-1.02)	.484
Body mass index (kg/m <sup>2</sup> )	27.3	4.2	29.5	5.5	<.001	1.11 (1.06-1.17)	<.001
Education (years)	8.9	3.2	8.1	2.7	.039	0.92 (0.85-1.00)	.061
MMSE (score)	27.1	2.2	26.6	2.5	.056	0.93 (0.85-1.01)	.089
	n	%	n	%	p*	OR (95% CI) <sup>§</sup>	p <sup>§</sup>
Fear of falling	101	34	72	52	.001	2.11 (1.37-3.25)	.001
Balance difficulty	79	27	68	49	<.001	2.60 (1.70-3.97)	<.001
Vision difficulty	115	39	66	48	.090	1.43 (0.93-2.21)	.100
Hearing difficulty	129	44	71	52	.094	1.31 (0.87-1.96)	.189
Number of sensory difficulties					<.001		
None	88	30	25	18		Reference	
One	112	38	42	31		1.25 (0.71-2.20)	.442
Two	75	25	47	35		2.13 (1.17-3.87)	.014
Three	20	7	22	16		3.48 (1.67-7.25)	.001
Cardiovascular disease	146	49	91	66	.001	1.94 (1.28-2.94)	.002
Diabetes mellitus	11	4	14	10	.044	2.77 (1.14-6.75)	.025
Rheumatoid arthritis	5	2	13	9	.003	5.92 (2.04-17.20)	.001

\* Statistical significance of differences between groups (Wald tests). Wald tests are adjusted for interdependency between the twins.

§Odds Ratios (OR) and their 95% Confidence Intervals (CI), and statistical significances for the walking difficulties (Logistic regression models). Logistic regression models are adjusted for interdependency between the twins and for age.

**Table 2. Sensory Difficulties According to Fear of Falling (FOF) at Baseline (n=434)**

Variable	No FOF		FOF		p*
	n=261		n=173		
	n	%	n	%	
Balance difficulty	67	26	80	46	<.001
Vision difficulty	92	35	89	51	.001
Hearing difficulty	106	41	94	55	.006
Number of sensory difficulties					<.001
None	84	32	29	17	
One	102	39	52	30	
Two	59	23	63	37	
Three	14	5	28	16	

\* Statistical significance of differences between groups (Wald tests). Wald tests are adjusted for interdependency between the twins.

**Table 3. Baseline Characteristics of Participants with or without Incident Walking Difficulty after Three-year Follow-up (n=290)**

Variable	No incident walking difficulty n=236		Incident walking difficulty n=54		Wald test p*	Logistic regression models for incident walking difficulty	
	mean	SD	mean	SD		OR (95% CI) <sup>§</sup>	p <sup>§</sup>
Age (years)	68.2	3.1	68.6	3.7	.371	1.04 (0.95-1.15)	.367
Number of chronic diseases	1.5	1.2	2.1	1.3	.005	1.43 (1.13-1.82)	.003
Number of prescribed medications	1.5	1.4	2.6	2.4	.001	1.40 (1.19-1.66)	<.001
Weight (kg)	67.4	10.2	73.4	11.6	.001	1.05 (1.02-1.09)	.001
Height (cm)	159.1	6.3	157.8	6.5	.200	0.97 (0.92-1.02)	.229
Body mass index (kg/m <sup>2</sup> )	26.7	3.9	29.5	4.7	<.001	1.17 (1.09-1.26)	<.001
Education (years)	9.0	3.3	8.6	2.5	.330	0.96 (0.88-1.05)	.349
MMSE (score)	27.2	2.2	26.8	2.1	.193	0.92 (0.81-1.05)	.235
	n	%	n	%	p*	OR (95% CI) <sup>§</sup>	p <sup>§</sup>
Fear of falling	71	30	30	56	.002	2.91 (1.56-5.43)	.001
Balance difficulty	61	26	17	31	.422	1.31 (0.68-2.54)	.418
Vision difficulty	87	37	27	50	.069	1.74 (1.00-3.05)	.051
Hearing difficulty	100	43	28	52	.220	1.41 (0.77-2.59)	.260
Number of sensory difficulties					.078		
None	76	32	9	17		Reference	
One	86	37	23	43		2.22 (0.97-5.09)	.060
Two	58	25	17	31		2.47 (1.05-5.83)	.039
Three	15	6	5	9		2.73 (0.78-9.53)	.116
Cardiovascular disease	107	45	35	65	.011	2.21 (1.18-4.12)	.013
Diabetes mellitus	4	2	7	13	.012	9.18 (3.27-25.79)	<.001
Rheumatoid arthritis	5	2	0	0	.026	-	-

\* Statistical significance of differences between groups (Wald tests). Wald tests are adjusted for interdependency between the twins.

§ Odds Ratios (OR) and their 95% Confidence Intervals (CI), and statistical significances for the incident walking difficulties (Logistic regression models). Logistic regression models are adjusted for interdependency between the twins and for age.

## **FIGURE LEGENDS**

Figure 1. Odds ratios (OR) and their 95% confidence intervals for walking difficulties according to fear of falling and number of sensory difficulties at baseline (Logistic regression model). Logistic regression model is adjusted for interdependency between the twins and for age.

Figure 2. Odds ratios (OR) and their 95% confidence intervals for incident walking difficulties in three-year follow-up according to baseline fear of falling and number of sensory difficulties (Logistic regression model). Logistic regression model is adjusted for interdependency between the twins and for age.

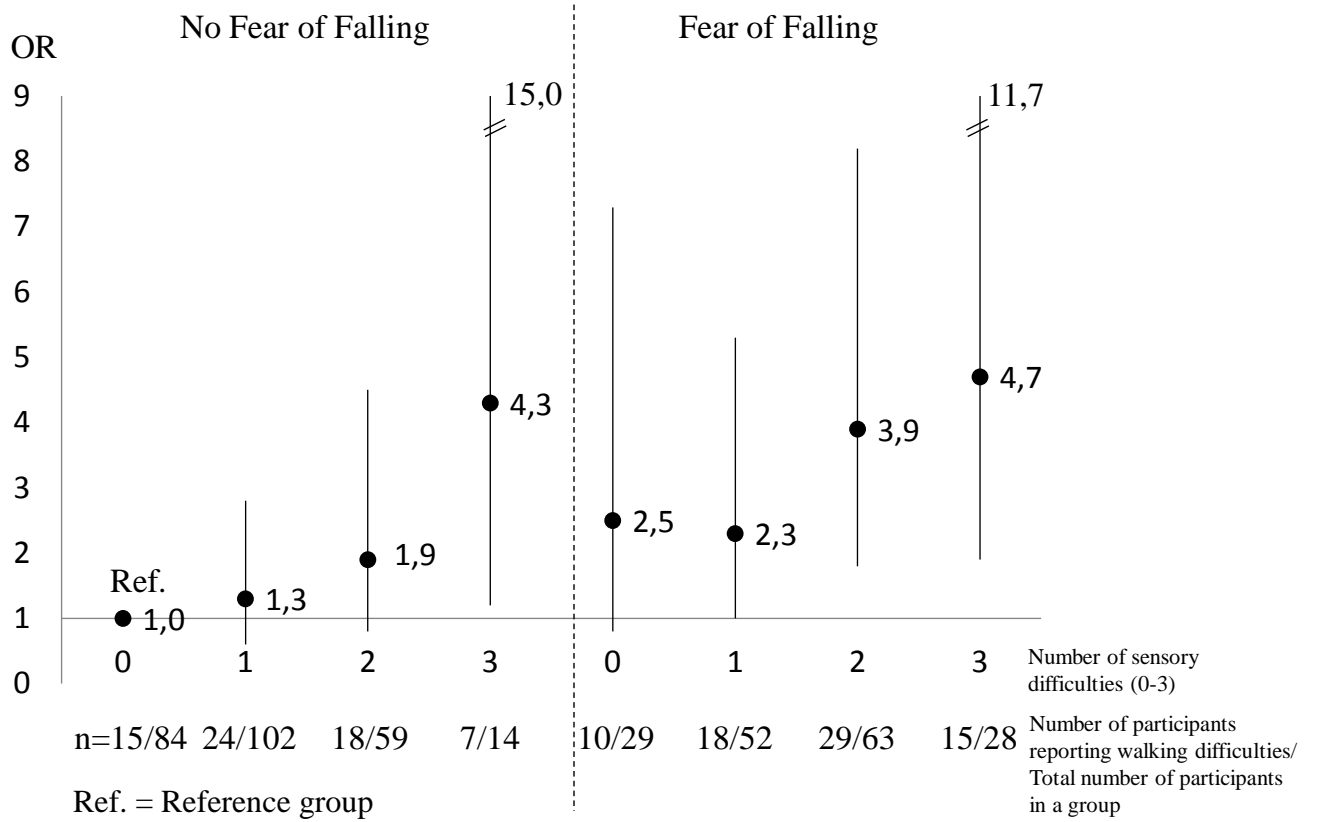


Figure 1.

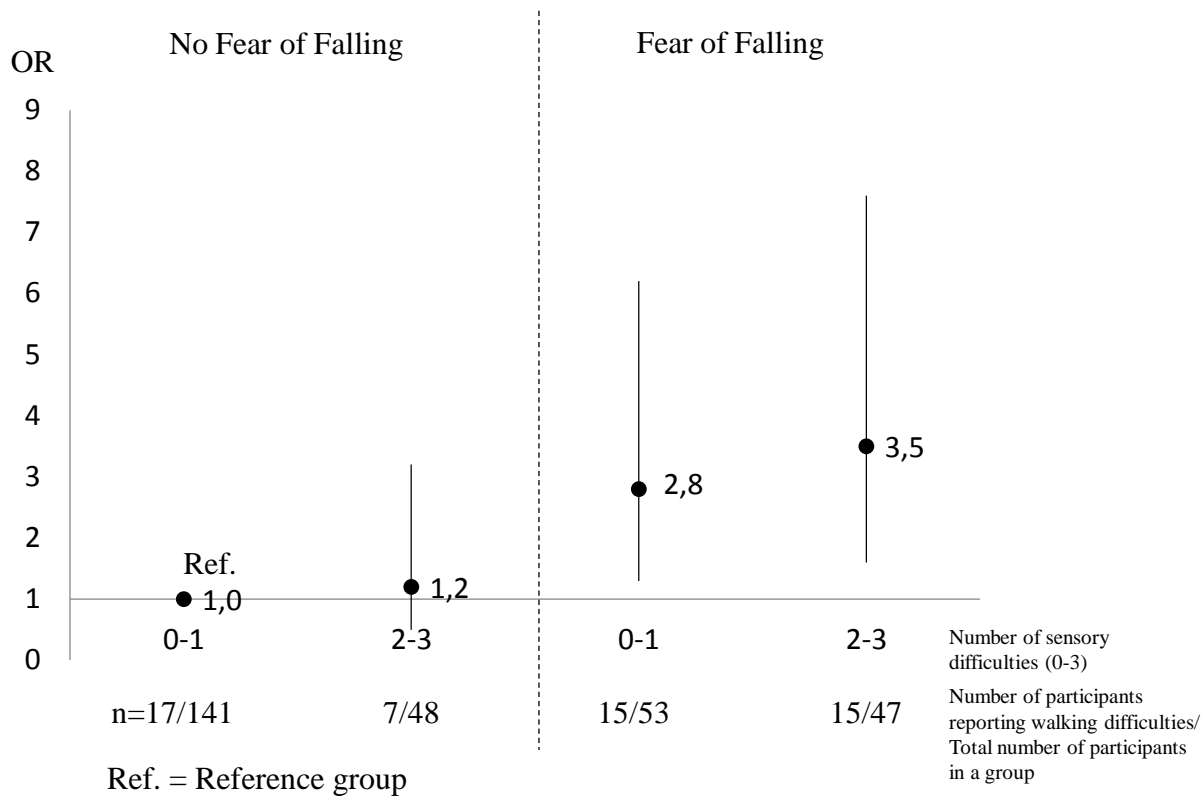


Figure 2.