Author(s): Rantakokko, Merja; Mänty, Minna; Rantanen, Taina

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Mobility decline in old age

Running title: Mobility decline in old age

Merja Rantakokko PhD †, Minna Mänty PhD ‡, Taina Rantanen PhD†

Corresponding author:

Taina Rantanen,

Gerontology Research Centre and Department of Health Sciences, P.O.Box 35 (viv)

FI-40014 University of Jyväskylä, Finland.

e-mail: taina.rantanen@jyu.fi, tel. 358 40 805 3590, fax 358 14 260 4600

Other Authors:

Merja Rantakokko

Gerontology Research Centre, Department of Health Sciences, P.O.Box 35 (viv)

FI-40014 University of Jyväskylä, Finland.

e-mail: Merja.Rantakokko@jyu.fi, Tel. 358 40 805 3589

Minna Mänty

Center for Healthy Aging, Institute of Public Health, Faculty of Health Sciences,

University of Copenhagen, Denmark

e-mail: Mrma@sund.ku.dk

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ABSTRACT

Mobility is important for community independence. With increasing age underlying pathology increases the risk of mobility decline. Some people may be genetically more vulnerable to declining mobility. Understanding the process of mobility decline is paramount to finding ways to promote mobility in old age. In addition to targeting individuals, promoting mobility requires also community actions.

SUMMARY FOR CONTENT PAGE

With increasing age the risk of mobility decline increases. Genetic factors, aging processes and pathology, physiological impairments and environmental factors contribute to the process.

Key words (5-7):

Aging, physical activity counseling, person-environment interaction, muscle strength, falls, walking, prevention

Character count: 36 281

References 37

INTRODUCTION

The proportion of people over 80 years is growing rapidly. To guarantee sustainability of health and social care systems while also enhancing quality of life, it is important to find ways to promote the functional capacity of older people. Mobility is a key issue in maintaining independence in old age. Mobility refers to a person's ability to move him- or herself independently and safely from one place to another. Limitations in mobility increase with advancing age, and are often the first noticeable signs of further functional decline. Loss of mobility hinders the ability to manage tasks of daily life and eventually leads to need for help and an increased risk of institutionalization (6, 18).

One of the major challenges in the prevention of functional decline and disability is identification of the optimal target population (2). In particular, with respect to primary prevention, it is of paramount to identify persons who are not yet disabled but who are at high risk for disability progression in the near future. Thus the knowledge of the process of the mobility decline is highly important.

In the present work, mobility limitation is defined as difficulties in walking. Mobility limitation in older persons can be assessed either through self-report or through performance-based measures. Performance-based measures rely on a rater's assessment of a subject's performance of a specific mobility task, measured in a controlled environment. Self-report measures are subject-completed, relying on self-perception of mobility status. They typically assess the subject's performance difficulties, restrictions, or need for assistance associated with functional activity.

There is great variability in the process of mobility decline among older people. Mobility decline may be sudden and catastrophic for some and slowly progressive for others (5). Sudden mobility decline is usually a result of a traumatic event, such as an injurious fall, while slow progressive mobility decline is a consequence of worsening health conditions, such as arthritis(5). If decline in mobility progresses slowly, the early stages of functional decline prior to the onset of task difficulty, older persons may be able to compensate for underlying impairments or physiological decrements by modifying their task performance, and thus maintain their everyday function without strong perception of difficulty (1). This early stage of functional decline has been termed as preclinical mobility limitation, and refers to a stage between good mobility and manifest mobility limitation (3, 4, 14).

Environmental factors can work as a threat or an opportunity to maintain functional capacity among older people. The effect of environmental factors on mobility depends of the interaction between environment and individual. If individual competence and demands of the environment are in balance, person is able to obtain optimal functioning. This balance is called person-environment (P-E) fit. When this balance is lost and P-E misfit occurs, difficulties emerge (9).

In the present article, the purpose is to provide new insight into the process of mobility decline in older people. We present recent findings of our study centre of the individual and environmental factors on the pathway to mobility limitations among older people.

MOBILITY DECLINE IN THEORY

A widely recognized theoretical model explaining development of mobility decline in epidemiological studies is the disablement process model by Nagi (17) and later expanded by Verbrugge and Jette (36), which shows the disablement process pathway from pathology to disability. Pathology, referring to physiological abnormalities, such as chronic diseases or injury but also to physiological changes with advancing age, affects specific body systems and may result in impairments such as decreased muscle strength and balance or sensory impairments. These impairments usually lead to functional limitation, which in turn may finally cause disability. In addition, the disablement process model outlines intra-individual and extra-individual factors that can either reduce or increase functional limitations. While the main pathway emphasizes the physiological process, intra-individual factors focus on lifestyle and behavioral changes, psychosocial attributes and coping, and activity accommodations. Extra-individual factors include factors such as built, physical and social environment. In addition, different predisposing risk factors, such as certain demographic, social, lifestyle and behavioral characteristics of an individual may have a direct or indirect effect on the development of functional limitations.

During recent years there has been a growing interest on the role of the environmental factors in the development of mobility decline. Environmental gerontology studies the relationship between aging persons and their physical and social environment, and how these relationships shape health, functioning and quality of life in old age. The ecological model of ageing (also known as the "Competence-Press model") (9) is a widely accepted model of the person-environment relationship in environmental gerontology.

There are similarities between the ecological model of ageing and disablement process model. The person-environment perspective of the disablement process model emphasizes that the environment and the individual are of equal importance in the disability process. The environment is seen on the "demand" side and the person on the "capability" side of the model, similarly as in the ecological model of ageing. Both theories emphasize that disability occurs when there is a misfit between the environment and the individual. In both models a challenging environment is seen as a threat or as an opportunity to maintain functional capacity.

Although these two theories share similar content, there are a few differences between them. The disablement process model shows the pathway from pathology to disability, seeking to outline the underlying physiological changes and contributing factors, while the ecological model of ageing shows the interplay between the individual and the environment from a general perspective and sees the relationship as a dynamic process, explaining the mechanisms behind the interaction. The ecological model of aging has a strong psychological emphasis, while the disablement process model emphasizes the physiological changes. Combining these two models may provide a good base to contemplate the process of mobility decline.

PREDICTORS OF MOBILITY DECLINE

Physiological predictors of mobility decline

In long-term, most chronic conditions and aging will have a detrimental influence on mobility though various mechanisms influencing the musculoskeletal, neurological or cardio-respiratory system. In this chapter, we will discuss two important predictors of mobility loss, namely pain and obesity.

Musculoskeletal pain is common among older people and is associated with impaired balance and mobility decline (12). The pathway from musculoskeletal pain to mobility decline is not clear. It has been suggested that severe pain in lower body decreases physical activity which may lead to decline in muscle strength and development of mobility limitations (33). However, Karttunen & Lihavainen et al. (2011) found that even after adjusting for the potential factors on the pathway, such as self-rated health, depressive symptoms, different chronic conditions and muscle strength, musculoskeletal pain almost doubled the risk for mobility limitations among older people (7). Also Leveille et al (2007) found that musculoskeletal pain had a direct effect on mobility limitations, independent of the main disablement pathway via impairments and functional limitation (11). Presumably different pathways are present depending on the underlying cause of pain. For example, hip fracture a common, severe fall-related injury among older people causes persistent pain in many cases. After hip fracture, along with protracted pain, muscle strength and power of the fractured leg remain poor. This leads to muscle power asymmetry of the lower extremities and subsequent mobility decline even though the fracture in itself may recover (22).

Obesity is a rising health problem in Western countries as well as in non-industrial countries. However, the influence of obesity on mobility decline in old age has only recently gained more systematic scientific attention. People with excess weight can be considered to carry a mechanical load, which increases the energy expenditure placing increased demands on aerobic capacity and muscle strength compared to normal weight individuals doing similar physical tasks. In a 22-year follow-up, we observed that those people who were overweight in midlife but did not have any impairment had approximately double the risk of future mobility limitation compared to normal weight people (35). However, when overweight was accompanied with two or more impairments, the risk of old age mobility limitation was more than 6-fold compared to those with normal body weight in midlife. The increased risk of mobility limitation among obese and overweight people was partly explained by their increased inflammation and low muscle strength (34).

It is possible that some people may be genetically more vulnerable to mobility loss and weight gain than others. Twin and family studies provide an opportunity to examine how large a proportion of individual differences are explained by genetic factors. Among monozygotic twins, who share all their genes, phenotypic differences are due to differences in environment, i.e. behavior, living habits, work or living conditions. Among dizygotic twins the genetic resemblance is 50 %, and consequently phenotypic differences may results from genetic or environmental differences between the members of the pair. We studied among older female twins the proportion of genetic factors underlying individual differences in changes in body mass index (BMI) over 30-years and how whether the same genetic factors may underlie mobility in old age. We observed that the inverse association of BMI and mobility was explained by shared genes in terms that the genes predisposing people to obesity in middle and old age increased the risk of mobility limitation in later life (19, 20).

Muscle strength and sensory impairments in the process of mobility decline

Impairments most commonly studied in relation to mobility decline are those that are directly influencing walking, namely muscle strength and balance. In our early studies, we reported that muscle strength correlates with mobility (26) and that the strength requirements for a standard stair mounting task are similar for men and women of different ages (28). We also reported on strength thresholds for walking (27) and identified the minimum required knee extension strength for walking 1.22 m/s and a reserve capacity threshold for the same walking speed. The most commonly used measure of muscle strength in large studies is hand-grip strength. Hand-grip strength represents overall muscle strength and predicts mobility decline over 25 years. (31). Sallinen et al. (2010) determined thresholds of hand-grip strength for likelihood of mobility decline in older people and found that the overall hand-grip strength threshold of mobility decline was 37 kg for men and 21 kg for women. There were differences in the thresholds according to BMI among men. Men with higher BMI had higher cut points, but for women the cut point did not depend on BMI. (32).

Many studies have focused on the independent effects of various impairments on mobility decline. However, co-impairments, which mean that person has multiple impairments simultaneously, may have even greater impact on mobility decline than the sum of single impairments involved because people become unable to compensate for one impairment with good capacity in another body system (29). For example, in a three-year prospective study the risk of severe walking limitation was more than five times greater in the group with balance and strength impairments compared with the group with no impairments. Among those who had balance impairment but normal strength, the risk of severe walking disability was three-fold. Among those with good balance, strength impairment did not increase the risk of severe walking limitation (30).

There is only limited information on other impairments, e.g. sensory impairments influencing mobility of older people. We observed that impairments in sensory functions, such as in vision and hearing, affect mobility decline in older people. Viljanen et al. (2009) found that people with hearing impairment had twice the risk for developing mobility limitation in a three year follow-up, compared to people with intact hearing (37). Auditory information may be more important for safe outdoor mobility than traditionally considered. For example, hearing loss may hinder dividing attention between traffic, discussion, maintaining postural balance and walking thus potentially increasing risk of falls and other accidents. Sensory impairments may accelerate the process of mobility decline by restricting participation to out-of-home activities.

Kulmala et al (2009) found that people with co-existing vision and hearing impairments had over four-fold risk and people with co-existing impairments in vision, hearing and balance almost 30-fold risk for falls, compared to people with no vision impairment (8).

Falling and consequences to mobility

Falling and fall related injuries are common among older people, often leading to a sudden and catastrophic disability. Approximately 20% to 40% of community-dwelling individuals older than 65 years fall every year and about half of those who fall do so repeatedly (21). Known individual risk factors for falls include higher age and health related issues such as gait problems, muscle weakness, dizziness and other disease-related conditions. In addition, environmental factors are playing a major role in falls (21). Whether falls irrespective of related serious injuries have a negative impact on mobility among older people has been little investigated with prospective studies. We suggest that falls may also lead to progressive development of mobility decline, without following injury. We studied whether there is a difference in the development of mobility decline between indoor and outdoor fallers (Table 2). In our study among older women, women with indoor falls were over three times more likely to develop difficulties in walking 2 km by the end of the 3-year follow-up compared to those with no falls. Outdoor falls did not increase the risk for future mobility limitation (16). A significant proportion of the increased risk of mobility decline among those who sustained at least one indoor fall was due to their higher baseline obesity, lower walking activity and higher prevalence of chronic conditions. Among women who sustained indoor falls, were obese and reported low walking activity the risk for developing mobility limitation was 17-fold compared to women with none of the risk factors (16).

Preclinical mobility limitation

In the early stages of functional decline prior to the onset of task difficulty, older persons may be able to compensate for underlying impairments or physiological decrements by modifying their task performance, and thus maintain their everyday function without strong perception of difficulty. For example, a person may reduce his or her walking pace or use a mobility aid in order to manage a certain walking distance without perceiving difficulty in doing so. This stage of functional decline, that is, change in the method, frequency, or time used in task performance have been conceptualized as *preclinical mobility limitation*, a stage between good mobility and manifest mobility limitation (3, 4), (14) (Figure 1). Our study showed, that self-reported preclinical mobility limitation was associated with declines in measured physical performance and it was highly predictive of further mobility decline (14). Older adults who were reporting baseline preclinical mobility limitation had up to 6-fold higher task specific risk for progressing to major manifest mobility limitation during a 2-year follow-up compared with participants with no limitation at baseline (Table 1) (14). Further, our 12-month prospective fall surveillance suggested that preclinical mobility limitation combined with a fall history is predictive of future falls (15). These results together with previous evidence by Fried et al (3, 4) indicate that self-reported preclinical mobility limitation is a useful measure for early identification of persons at high-risk for mobility decline, offering an opportunity for early intervention.

PERSON-ENVIRONMENT INTERACTION IN THE PROCESS OF MOBILITY DECLINE

Environmental factors and mobility decline

People with mobility limitations report more barriers in their environment than people without limitations. However, most studies have been limited to cross-sectional analyses and have thus been unable to reveal the temporal order in the association. Our recent study among community-dwelling older people showed that perceived barriers to mobility in the outdoor environment preceded onset of difficulty in walking 2 km and 0.5 km (24). People who reported long distances to everyday services and lack of resting places as barriers in the outdoor environment had approximately twofold risk for incident difficulty in 2 km and 0.5 km walking (Figure 2) (24). Demanding environment may restrict out-of-home activities in older people, leading to physical inactivity and eventually further decline in functional capacity. In our study, lower physical activity explained a substantial part of the association between environment and mobility decline but not all of it. It is possible that among older people modifying walking habits and perceiving the environment as more demanding coincide because the environment no longer supports their level of functional capacity.

Fear of moving outdoors as predictor of mobility decline

Fear of moving outdoors is an example of negative affect resulting from mismatch between environmental press and individual competence (9). Recently, we found that over half of the community-dwelling older people are afraid of moving outdoors. Fear of moving outdoors is defined as an emotional condition that can lead to avoidance of outdoor activities that are well within a person's functional health capacity (25). We found that persons who reported fear of moving outdoors but no mobility limitation at baseline, were three to almost five times more likely to develop mobility limitation during the following six months and the difference in mobility limitation persisted throughout the 3.5 -year follow-up (Figure 3). Fear-related avoidance of activities may accelerate the process of mobility decline because of the consequences of physical inactivity and reduced participation in out-of-home activities (25).

PREVENTION OF MOBILITY DECLINE

Many different types of physical activity programs, ranging from simple home exercise programs to intense highly supervised hospital or center based programs, have been used to improve mobility in older people. Although physical activity and exercise are widely promoted as effective means to enhance physical functioning of older persons, it is less certain how these promising results can be adapted for use in everyday clinical practice. Physical activity counseling is an example of a low cost educational intervention to promote physical activity, where the participant is encouraged to exercise and provided with advice about possibilities to exercise (10). As many older adults use healthcare services regularly, educational physical activity counseling in primary health care settings may be an effective means of increasing physical activity and further slowing down the age-related deterioration in mobility.

Randomized controlled trial (RCT) of the effects of physical activity counseling on physical activity and mobility was performed in our study centre at 2003-2006. The study protocol is described in detail elsewhere (10). Briefly, the study was a 2-year RCT among 75-81-year-old people. The intervention included a single individual physical activity counseling session followed up with telephone contacts every four months for two years. Data were collected in the laboratory at baseline and after two years. During the intervention, intermediate changes were assessed in telephone interviews semiannually. In addition, post-intervention telephone interviews were conducted semiannually for 1.5-years. Thus the total follow-up time was 3.5-years.

During the intervention, the proportion of participants reporting difficulties in advanced (walking 2 km) and basic mobility (walking 0.5 km) increased in the intervention and control groups, but significantly less in the intervention group (Figure 4).(13) At the end of the 2-year intervention, the treatment effect on advanced mobility was significant (OR 0.84, 95% CI 0.70 – 0.99) and the effect on basic mobility was parallel but non-significant (OR 0.87, 95% CI 0.69 – 1.09). The positive effect of the intervention was mainly due to prevention of walking difficulty, rather than recovery from the walking difficulty. In advanced mobility, the treatment effect remained significant (OR 0.82, 95% CI 0.68 – 0.99) after the post-intervention 1.5-year follow-up, whereas in basic mobility, the effect gradually disappeared (OR 1.09, 95% CI 0.87 – 1.37). At the 2-year follow-up point, the NNT for advanced mobility was 15. This indicates that to prevent one person from developing difficulty or to recover from baseline difficulty, 15 persons had to receive counseling(13).

CONCLUSION

Mobility is important for maintaining community independence into old age. Aging changes, pathology, individual vulnerabilities and environmental barriers increase the risk of mobility decline. Mobility decline may happen gradually over many years or it may occur overnight due to a catastrophic event such as a hip fracture. To optimize the opportunities for good mobility in old age a spectrum of actions should be considered including both up-stream and down-stream interventions. First of all, all individuals should have access to physical exercise. This is not yet self-evident for older people because e.g. ageism, financial constraints or physical barriers may prevent participation. Communities should be accessible and neighborhoods should include features which facilitate mobility, i.e. resting places or green areas. Attention should be paid to preventive interventions trying to minimize the risk factors for mobility decline, such as obesity, sensory impairments, falls or physical inactivity. Special interventions should target risk groups. For example, older people who are recovering from an injury or a disease should receive rehabilitation. In all, young and middle-aged people could prevent their future risk of mobility decline by aiming to increase their physiological reserve, younger older people may slow down aging declines by being active, learning new mobility skills and through good treatment of diseases. Among older old people specific interventions, rehabilitation and supportive environments become increasingly important.

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FIGURE LEGENDS

FIGURE1

Process of mobility decline, Mänty et al. 2007. (Reprinted from (14). Copyright © 2007 Elsevier. Used with permission.)

FIGURE 2

The rates of incident walking difficulty in groups based on perceived barriers in the outdoor environment among community-living people aged 75- to 81- years without difficulties in walking at baseline. Follow-up time was 3.5 years with examinations taking place every 6 months. Barriers in the outdoor environment studied were lack of resting places and long distances (Distances), hilly terrain and poor street conditions (Terrain) and noisy traffic and dangerous crossroads (Traffic). (Modified from (23) Copyright © 2011 own).

FIGURE 3

Unadjusted prevalence of perceived difficulty in walking 0.5 km (n=266) and 2km (n=214) among 75- to 81-year-old people without difficulty at baseline who were followed up every six months for 3.5 years. P-value indicates statistical significance over the follow-up. OR=Odds Ratio. (Adapted from (25). Copyright © 2009 John Wiley and Sons. Used with permission.)

FIGURE 4

Proportion of participants with difficulty in advanced and basic mobility at semiannual follow-up points during the counseling intervention and 1.5-year postintervention follow-up. The p-values indicate the statistical significance of the treatment effects (groupxtime interaction) observed in the generalized estimating equation models. (Reprinted from (13). Copyright © 2009 Oxford University Press. Used with permission.)

FIGURE 1

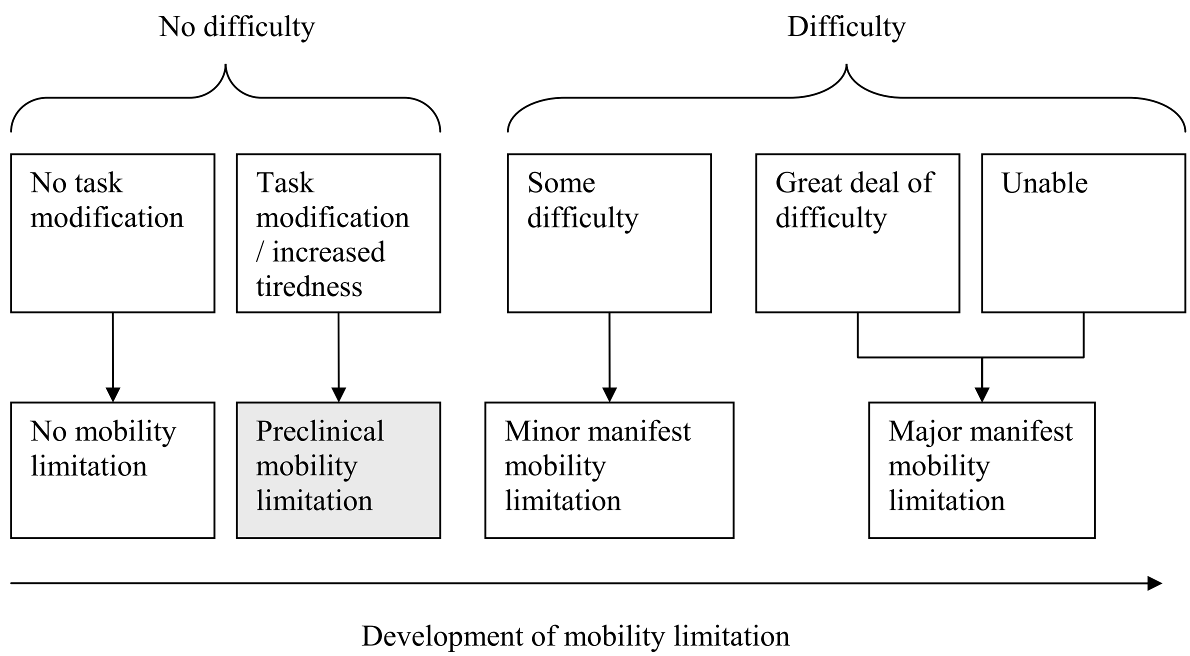
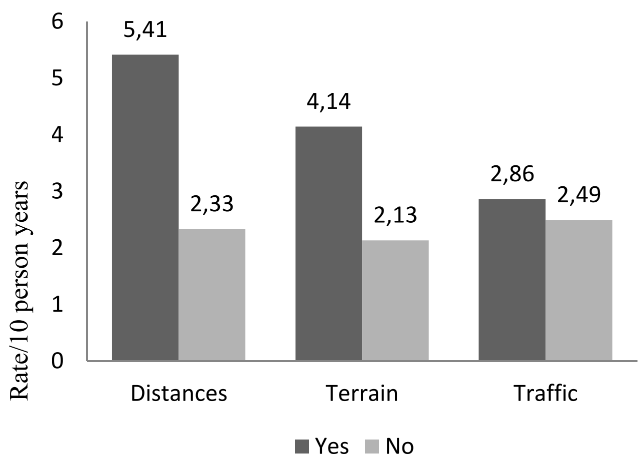

No difficulty
Difficulty
No task modification
Task modification / increased tiredness
Some difficulty
Great deal of difficulty
Unable
No mobility limitation
Preclinical mobility limitation
Minor manifest mobility limitation
Major manifest mobility limitation
Development of mobility limitation

FIGURE 2

2 km walking



0.5 km walking

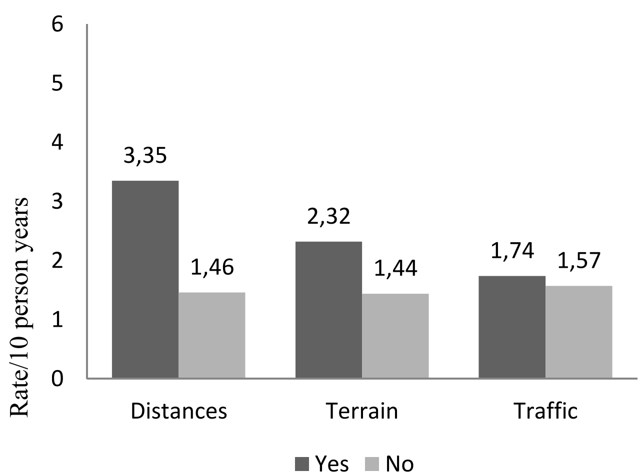


FIGURE 3

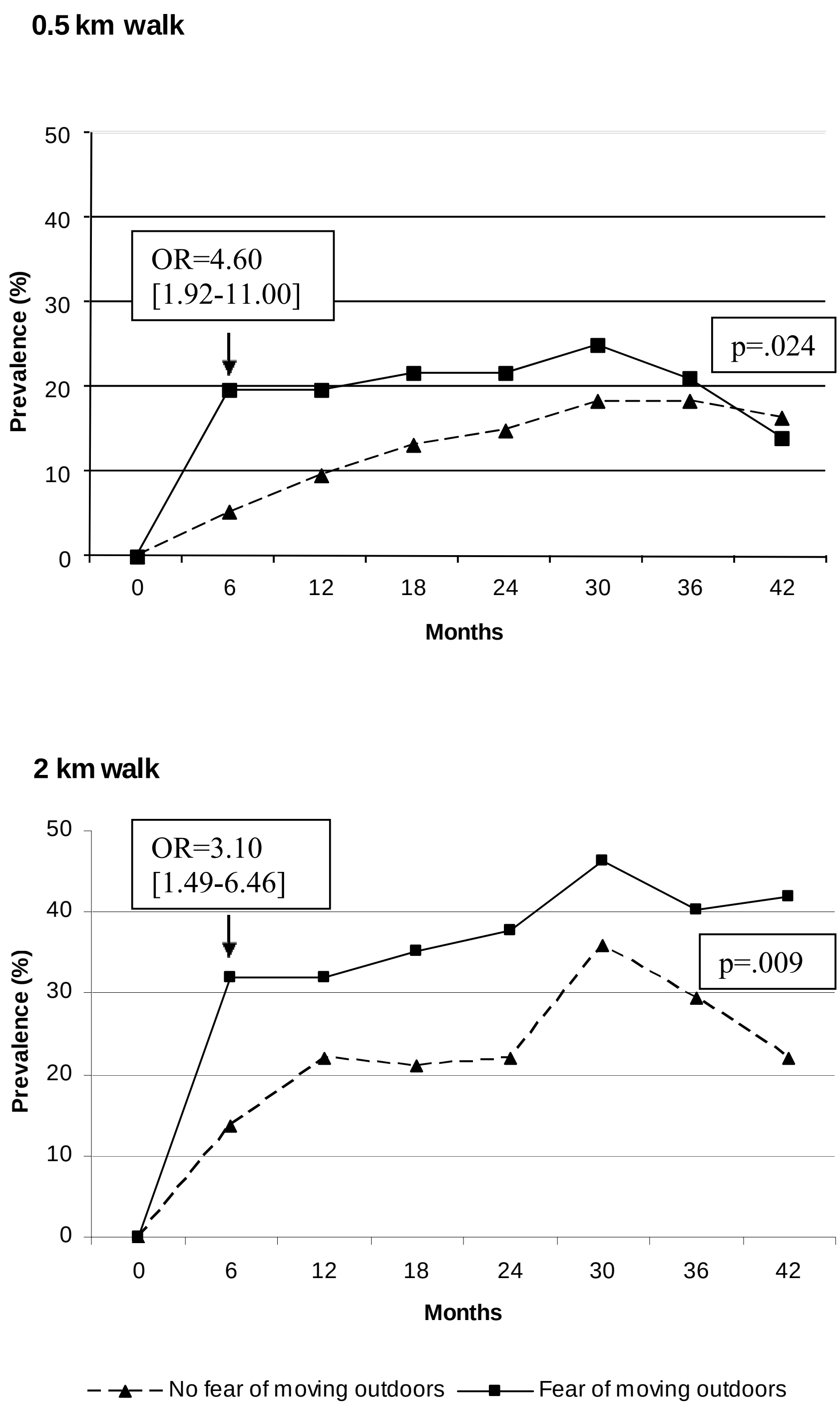

0.5 km walk
OR=4.60
[1.92-11.00]
p=.024
Prevalence (%)
Months
0
6
12
18
24
30
36
42
0
10
20
30
40
50
2 km walk
OR=3.10
[1.49-6.46]
p=.009
Prevalence (%)
Months
No fear of moving outdoors
Fear of moving outdoors

FIGURE 4

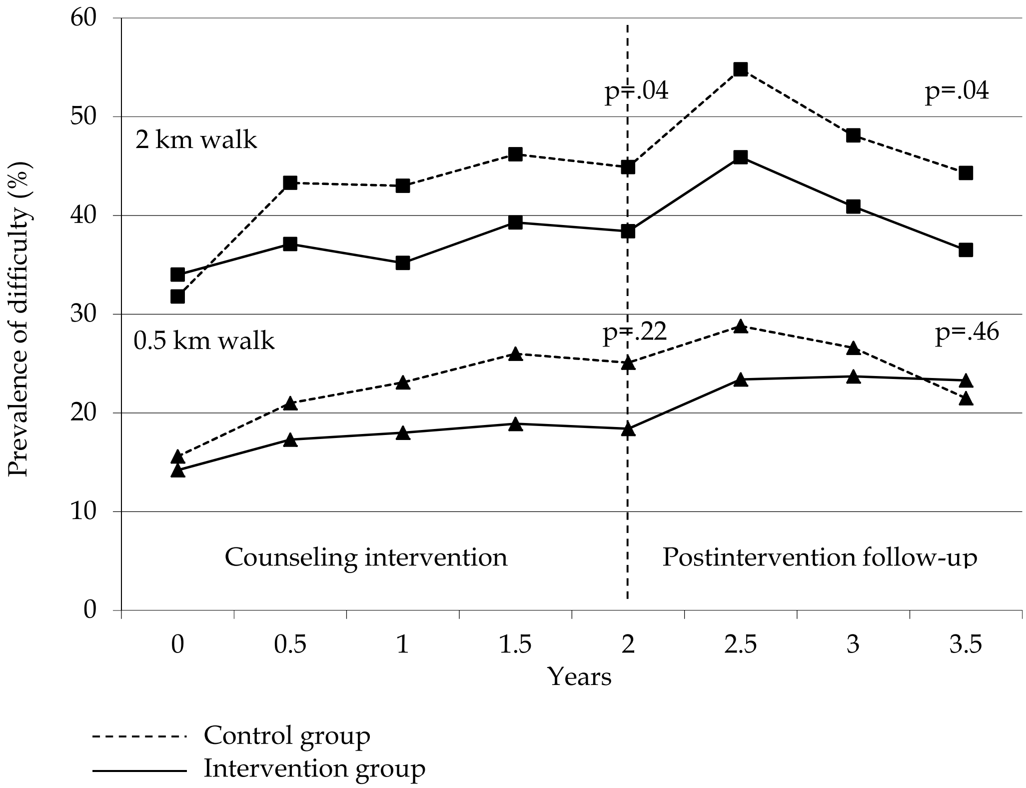

60
50
40
30
20
10
0
Prevalence of difficulty (%)
2 km walk
0.5 km walk
p=.04
p=.04
p=.22
p=.46
Counseling intervention
Postintervention follow-up
0
0.5
1
1.5
2
2.5
3
3.5
Years
Control group
Intervention group

TABLE 1 Risk Ratios (RR) and their 95% Confidence Intervals (CI) for the onset of major manifest limitation for the 2-km walk, 0.5-km walk, and climbing stairs among participants with preclinical or minor manifest mobility limitation compared with participants with no limitation at baseline. (Adapted from (14). Copyright © 2007 Elsevier. Used with permission.)

	Risk for developing major manifest limitation					
	Model I*		Model II†		Model III‡	
Mobility at baseline	RR	95% CI	RR	95% CI	RR	95% CI
2 km walk						
Preclinical limitation	5.8	2.6 - 12.9	5.0	2.2 - 11.2	2.9	1.2 - 6.6
Minor manifest limitation	17.8	7.6 - 41.9	17.1	7.0 - 41.5	8.9	3.6 - 21.6
0.5 km walk						
Preclinical limitation	2.5	1.2 - 5.1	2.3	1.1 - 4.6	1.4	0.7 - 2.9
Minor manifest limitation	13.2	6.1 - 28.4	10.3	4.8 - 22.0	5.4	2.3 - 12.2

* Model adjusted for gender and age.

† Model adjusted for gender and age and osteoarthritis, rheumatoid arthritis, diabetes, chronic obstructive pulmonary disease, ischemic heart disease, myocardial insufficiency, sciatica, and depressive symptoms.

‡ Model adjusted for gender and age and osteoarthritis, rheumatoid arthritis, diabetes, chronic obstructive pulmonary disease, ischemic heart disease, myocardial insufficiency, sciatica, and depressive symptoms as well as weight, height, walking speed, and muscle power.

TABLE 2 Logistic regression models for future mobility limitation among those with indoor or outdoor falls as compared to women with no falls. The Odds Ratios (OR) indicate the association between falls and future mobility limitation. A marked change in OR indicates that the respective covariate underlies the association. (Reprinted from (16). Copyright © 2009 Oxford University Press. Used with permission.)

	Indoor fallers	Outdoor fallers
	OR (95% CI)	OR (95% CI)
Base model*	3.20 (1.27-8.06)	1.07 (0.43-2.63)
Base model adjusted for[†]		
Number of chronic conditions	2.97 (1.14-7.73)	1.10 (0.44-2.74)
Number of prescribed medications	2.94 (1.13-7.65)	1.04 (0.42-2.57)
Muscle power (W/kg)	3.52 (1.41-8.81)	1.20 (0.48-3.00)
Maximal walking speed (m/s)	3.34 (1.30-8.58)	1.33 (0.51-3.43)
Balance (Velocity moment, mm^2/s)	3.10 (1.28-7.52)	1.07 (0.43-2.64)
Education (years)	3.05 (1.20-7.76)	1.07 (0.43-2.63)
Low walking activity[‡]	2.63 (1.04-6.64)	1.12 (0.44-2.85)
MMSE[‖]	3.25 (1.28-8.27)	0.97 (0.38-2.47)

Obesity¶	2.66 (1.05-6.73)	1.08 (0.43-2.69)
Visual loss**	3.08 (1.22-7.76)	1.07 (0.43-2.64)
Hearing impairment††	3.08 (1.19-7.93)	1.01 (0.40-2.53)
Fall history	3.08 (1.22-7.82)	1.05 (0.43-2.57)
Fear of falling	3.34 (1.32-8.44)	1.10 (0.45-2.72)
Serious fall injuries	3.39 (1.32-8.70)	1.14 (0.45-2.76)

* Adjusted for age

† The base model was adjusted one at a time for known and suspected fall risk factors.

‡ Walking activity < 1.6 km (one mile) per day

‖ Mini Mental State Examination score

¶ Body Mass Index (kg/m2) ≥30

** Visual acuity <1.0

†† Hearing threshold level of the better ear > 21 dB.