Published in final edited form as:

Am J Phys Med Rehabil. 2008 May ; 87(5): 354–362.

Psychological, Physical and Sensory Correlates of Fear of Falling and Consequent Activity Restriction in the Elderly: The InCHIANTI Study

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Abstract

OBJECTIVE—To identify psychological, physical and sensory function parameters that are specifically associated with fear of falling (FF) and fear-induced activity restriction in a population-based sample of older adults.

DESIGN—FF, fear-induced activity restriction, cognition, depression, personal mastery, chair stand performance, standing balance, lower limb and grip strength, visual acuity and contrast sensitivity and vibrotactile sensitivity were evaluated in the population-based older cohort (n=926, age ≥ 65) enrolled in the InCHIANTI study.

RESULTS—Nearly 50% participants reported FF. Of these, 65% reported some activity restriction. Personal mastery (p< .001) and chair standing performance (p= .001) were independently associated with FF. In those who did not have depression, personal mastery, standing balance, lower limb strength and visual contrast sensitivity were associated with activity restriction (p<.001 to .011). In those who were depressed, Total FF was the major factor strongly associated with activity restriction (p< .001) with marginal but significant association for cognition (p= .027) and standing balance (p= .015).

CONCLUSION—Psychological and physical factors are independently associated with FF. Presence of depression possibly modulates what factors in addition to fear of falling affect fear-induced activity restriction. A longitudinal study is warranted to substantiate causal relationships.

Keywords

Fear of Falling; Aging; Personal Mastery; Activity Restriction

INTRODUCTION

Fear of falling (FF) is defined as a lasting concern about falling that can lead an individual to avoid activities that he/she remains capable of performing¹. FF has been recognized as a serious

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and common problem in older persons^{2,3} that may not be necessarily preceded by an actual fall⁴. Up to 55% of community dwelling older persons report FF^{5,6} and the prevalence tends to be higher in women⁷, elderly with a previous history of falls⁸ and in persons with certain comorbidities such as rheumatoid arthritis and stroke^{9,10}. Activity restriction, social withdrawal and loss of independence constitute common serious consequences of FF¹¹ which have rendered FF as a legitimate focus for rehabilitation¹².

Some recent literature suggests that FF may not always precipitate activity restriction^{11,13}. Rather, the spectrum of responses to FF may range from increased caution during an activity to complete avoidance. In the short term, curtailment in activities or avoidance may protect against falls. However, in the long term, excessive activity restriction can potentially diminish both physical and mental health of the older person⁷ and may further increase risk of future falls¹³. Paradoxically, few studies have investigated the characteristics of community dwelling older adults that can affect or modulate changes in behavior associated with FF. Murphy et al.⁷ suggested that those who report that fear of falling caused them to cut down on their activities, generally have poorer physical performance, and are more anxious and depressed. In addition, Howland et al.⁵ have reported that these subjects are more likely to report impaired vision and less social support compared to those who do not restrict their activities. However, there are two caveats. First, Murphy et al.⁷ did not control their analysis for the confounding effects of age and sex even though those who reported activity restriction were significantly older and had larger proportion of women. Second, Howland et al.⁵ did not consider differences in physical performance capacity and psychological health that may have influenced their findings. Nonetheless, together these results indicate that certain psychological, physical and sensory function aspects may contribute to fear-induced activity restriction. Considering the detrimental consequences of activity restriction, a comprehensive investigation is warranted to identify potentially modifiable parameters that may contribute to activity restriction as a consequence of FF in addition to the factors contributing to fear of falling itself.

The three aims of this study were to: 1. report the prevalence of FF and fear-induced activity restriction in older adults recruited in the population-based InChianti study; 2. identify psychological, physical and sensory function parameters associated with FF; and 3. identify the specific psychological, physical and sensory function parameters associated with activity restriction in those individuals who report FF. In particular, we tested the hypothesis that a positive emotion of higher personal mastery would be associated with lower fear of falling and fear-induced activity restriction.

METHODS

Participants

The InChianti study is an epidemiological study conducted to understand factors contributing to decline in mobility in late life. The study population is a representative sample of the population living in two towns of the Chianti countryside of Tuscany, Italy. The study design and data collection have been described previously elsewhere¹⁴. Briefly, in 1998, 1270 older persons (age ≥ 65 years) were randomly selected from the population registry of the two sites. Follow-up data were collected after 3 years. The study protocol was approved by the ethical committee of the Italian National Institute of Research and Care of Aging and complies with the Declaration of Helsinki. All participants received a detailed description of the study purpose and procedures and all signed the informed consent.

The present study uses the follow-up data of the study participants who were originally evaluated ($n = 1125$). A total of 926 participants who completed the Survey of Activities and Fear of Falling in the Elderly (SAFE) questionnaire¹⁵ aimed at quantifying FF and activity restriction, were initially included (average age 76.8 ± 7.1 , average BMI 26.45 ± 3.9 , 519

females). Seventy-one participants were excluded due to severe cognitive impairment (MMSE scores < 15)¹⁶. Additionally, 8 participants who used a proxy for the interview were also excluded since they were not administered the psychological measures used in this study. Therefore, the final study population consisted of 848 participants (average age 75.9 ± 6.4 , average BMI 26.49 ± 3.94 , 470 females). Of these, 7% had a history of stroke, 17% had a history of cardiac problems (angina, myocardial infarct or congestive cardiac failure), 21% reported either hip or knee pain and 9.6% had diabetes. A total of 186 participants were between the ages of 65 to 70 years, 491 were between 71 – 80 years, 142 were between 81 – 90 years and 29 were 91 years or older, including 1 participant who was 101 years old.

Outcome measures

Fear of Falling—Fear of falling was quantified by using the Survey of Activities and Fear of Falling in the Elderly (SAFE) questionnaire¹⁵. This scale inquires about fear of falling for an array of 11 activities performed inside and outside the home environment. For each activity, participants were asked to report whether they usually performed that activity. If the response to this first question was affirmative, they were asked if while performing that activity they were afraid of falling and whether compared to three years ago, they were doing that activity less often because of fear of falling. If the response to the first question was negative, they were asked whether they usually did not perform that activity because of fear of falling. Thus, in addition to fear of falling, the SAFE questionnaire also determines activity restriction due to fear of falling¹⁵.

Two summary scores were computed using the yes/no replies to the aforementioned questions. The cumulative score of ‘total fear of falling’ (Total FF) was computed by adding the total number of activities for which the participant was afraid of falling while doing the activity or if they usually did not perform that activity because of fear of falling (range 0 – 11). For those who reported fear of falling (that is, if Total FF > 0), a total ‘activity restriction’ score was calculated. This score was computed by adding the number of activities that, compared to 3 years before, were done less often or were not performed because of fear of falling (range 0 – 11).

Psychological domain—Cognitive function was evaluated by the Mini Mental State Examination (MMSE, range 0–30, higher scores indicate better cognitive functioning)¹⁷. A score below 24 points is used to indicate impaired cognitive function. The Center for Epidemiological Studies Depression scale (CES-D), a 20 item self-report questionnaire, was used to assess depression¹⁸. Scores can range from 0 to 60, with higher scores indicating more depressive symptoms. To evaluate the sense of personal mastery, a short version Pearlin and Schooler Mastery Scale (PSMS)¹⁹ was used (6 items, scores ranging from 5 to 30, higher scores indicate more mastery). Sense of mastery addresses the extent to which a person has a feeling of being in control of his or her own life circumstances and how s/he would react to stresses, difficulties and adversities of life.

Physical domain

Standing balance: A modified version of the test developed for The Frailty and Injuries: Cooperative Studies of Intervention Techniques (FICSIT- 4) trials was used to assess balance²⁰. The original test consists of four different stance positions that are progressively more difficult: (1) parallel: feet side by side, touching; (2) semi-tandem: side of the heel of one foot touching the big toe of the others; (3) tandem: heel of one foot directly in front of and touching the toes of the other foot, and (4) one-legged: standing on one leg. If a subject was unable to maintain the parallel stance (item 1 from original FICSIT-4), s/he was tested with feet side by side but with feet apart and below respective anterior superior iliac spines. If the participant could not maintain this stance either, the participant was allowed to stand with the

feet at any distance apart (free base). Standing balance was tested only in eyes open conditions. The time that each stance could be maintained (1–10 sec) was measured with a stopwatch. The highest possible balance score was 24, with progressive scoring from 0 to 24 (Appendix 1).

Repeated chair stand: The ‘repeated chair stand’ is a screening test to assess the overall performance of the lower limbs²¹. The use of arms or aids such as canes was not permitted. The test consists of measuring the time taken to get up and sit down in a chair 5 times. Maximum time allowed was 50 seconds. Performance was then graded on a scale from 0 to 4, higher scores representing better performance (0: 40–50, 1: 30–39.9, 2: 20–29.9, 3: 10–19.9, 4: < 10 sec).

Strength measurement: The strength of the lower limb muscle groups was measured for hip flexors, hip abductors, knee extensors and ankle dorsiflexors using a hand-held dynamometer²² (Nicholas Manual Muscle Tester, model BK-5474, Fred Sammons, Burr Ridge, IL). The participant was asked to assume a lateral decubitus position except for measuring hip abductor strength, which was done in a supine position. For hip flexors and abductors assessment the dynamometer was placed 10 cm above the superior margin of patella on the anterior and lateral aspects of the thigh, respectively. For measuring knee extensor strength the dynamometer was placed on the anterior surface of the leg 10 cm above the proximal margin of external malleolus. The strength of the ankle dorsiflexors was measured by placing the dynamometer on the intermediate dorsal surface of the foot with the upper edge parallel to a line drawn through the head of the 5th metatarsal. All the measurements were repeated 3 times and the maximum value was noted. Normalized muscle strength was calculated by dividing the strength by the participant’s body mass (kg)²³. A significant correlation was found between the strength of four lower limb muscles ($r = 0.87$ to 0.92). Therefore, average lower limb muscle strength was calculated by averaging over the normalized strength of the 4 muscle groups. Grip strength was measured with a hydraulic dynamometer (Smith and Nephew, Agrate Brianza, Milan, Italy). The participant was seated with the arm of the hand to be tested supported on the table and the elbow flexed to 45°. The average of 2 attempts for each hand was calculated and the higher of the two averages was then normalized for body mass.

Sensory domain—Visual acuity was tested using a standard Snellen eye chart that was placed at a distance of 3 meters²⁴. Visual acuity scores of 0/0 to 11/10 were graded from 0 to 11. A standard Pelli-Robson chart²⁵ test was used to measure contrast sensitivity. The last correctly identified letter was noted and the associated log contrast sensitivity was recorded. The vision testing was completed using binocular vision with participant’s usual corrective lenses. The vibratory stimulus was created with a diapason (128 Hz) on the bony prominence of the 1st metatarsal bone for 10-second duration. The participant was asked to close the eyes and report if s/he perceived the vibration. If the vibration was perceived then the participant was asked to indicate when s/he no longer perceived the vibration. Vibrotactile sensitivity was graded as: 1. normal (10+ seconds); 2. reduced (1–9 seconds); 3. absent²⁶.

Covariates

Body mass index (BMI) (kg/m^2) was calculated from objective measures of weight and height. Social support from 7 categories of people (spouse, son, daughter, sister, brother, daughter-in-law, son-in-law, other relatives, other non relatives) was included to measure the degree of available social support. Participants were asked about the availability of these people (1 = completely available to 4 = not available) in a hypothetical scenario where help or assistance was required. The mean score was calculated with higher scores indicating less support. In addition, participants were asked to report the number of falls in the previous year and fall data were dichotomized as no fall history and at least one fall.

Descriptive variables

The following variables were used for descriptive purposes only. Usual walking speed (m/s) was measured over 7 meters. Participants were asked to report the number of activities of daily living (ADLs: bathing, dressing, eating, getting into and out of bed or chair, walking across a room and using the toilet) for which they required help; and an ADL disability score ranging from 0 to 6 was calculated. Analogously, the disability score for instrumental activities of daily living (IADLs: preparing meals, shopping for groceries, managing money, making phone calls, light housework, heavy housework, getting to places outside of walking distances and managing medications) was recorded (range 0 to 8). The 'number of activities performed' were computed from the total number of activities for which the participants provided affirmative response for the initial question in the SAFE questionnaire¹⁵.

Statistical Analyses

Variables with a skewed distribution were log transformed for the analysis and back-transformed for data presentation. Participants were stratified in four age groups (65–70, 71–80, 81–90 and > 90 years). General Linear Model (GLM) was used to test for the association of age-group and gender on total FF. Relationships between Total FF and variables representing psychological, physical and sensory function domains were assessed using a correlation analysis. Variables with correlational significance of $p < 0.20$ were included in the multiple linear regression model to identify the correlates of Total FF independent of demographics, social support and fall history.

GLM was used to test for the association of age-group and gender on activity restriction as a consequence of FF. Correlates of activity restriction were identified by adding variables representing psychological, physical and sensory function domains in a multiple linear regression model. The analysis was performed by adjusting for all covariates (demographics, social support and fall history) and for Total FF.

Overall 10% values were missing primarily due to technical difficulties or participant refusal. The missing values were replaced by the overall means. All statistical analyses were conducted using SPSS version 13.0. A $p < 0.05$ was considered statistically significant.

RESULTS

Table 1 describes the characteristics of study participants for the total sample and according to Total FF groups obtained from the scores of SAFE scale: no-fear, mild fear (1–4), moderate fear (5–8) and severe fear (9–11). Almost 50% of the total population reported some FF. 'Age group $\times$ sex' analysis showed that FF increased significantly with increasing age and was higher in women (Figure 1. A). There was no 'age group $\times$ sex' interaction. 65% of women and 35% men reported some FF. Those who reported higher FF were older. The proportion of women was significantly higher in groups with higher FF. When controlled for age and sex, participants with higher FF scores were significantly more depressive symptoms, had lower personal mastery, were generally weaker and walked slower. They also reported higher disability in their IADLs and performed fewer activities.

The correlation coefficients of the psychological, physical and sensory parameters ranged between -0.352 to 0.329 (with p values ranging from 0.015 to <0.001). Next, these parameters and covariates (age, sex, BMI, social support and fall history) were included in the multiple linear regression model. After covariate adjustment, personal mastery and repeated chair stand performance were significantly associated with total fear of falling (Table 2).

Almost 65% of those who reported FF also reported fear-induced activity restriction. 'Age group $\times$ sex' analysis showed that activity restriction increased significantly with increasing

age and was higher in women (Figure 1. B). However, when adjusted for Total FF, age groups but not genders were significantly different. Total FF was a significant covariate.

Surprisingly, we found that when Total FF was adjusted for in addition to all other covariates in the regression analysis (Table 3, Model 1), the direction of the association between activity restriction and CES-D was reversed (from positive to negative), suggesting that higher depression was associated with lower activity restriction. To obtain further insight into these findings, depression scores were dichotomized (≤ 20 : no depression; > 20 : clinically relevant depressive symptoms)²⁷ and a 'depression $\times$ Total FF' interaction term was introduced in the regression model. Since the 'depression $\times$ Total FF' was statistically significant (Table 3, Model 2), we conducted depression-stratified analyses.

As expected, in both groups (that is, with and without clinically relevant depressive symptoms) we found a strong independent association of activity restriction with Total FF. However, in the 'non-depressed' group activity restriction was also strongly related to personal mastery, standing balance, lower limb strength and visual contrast sensitivity (Table 4, Model 1). In contrast, in addition to Total FF, the 'depressed' group showed only a marginal association of activity restriction with cognition and standing balance (Table 4, Model 2).

DISCUSSION

More than half of the older population enrolled in the InChianti study reported fear of falling. Personal mastery and chair standing performance were independently associated with fear of falling. Depressive symptoms possibly modulated what factor in addition to fear of falling affect activity restriction. In absence of depression, personal mastery, standing balance, lower limb strength and visual contrast sensitivity were strongly associated with activity restriction. In contrast, in those who were depressed, Total FF was the only factor strongly associated with activity restriction, with cognition and standing balance showing marginal associations.

Prevalence and correlates of fear of falling in InChianti study population

The prevalence of FF in this population is similar to that reported in other studies⁶. Consistent with the literature, FF increased with age and severity of fear was higher in women⁴. More than 70% of those who reported FF, had no falls in the previous year.

At least 3 longitudinal studies have reported an association between feelings of personal mastery with subsequent decline in physical function of older persons²⁸. To our knowledge, this is the first study that examined the possible role of personal mastery in the affective phenomenon of fear of falling. Our findings suggest that the improvement in balance confidence for avoiding falls achieved through educational interventions that promote coping strategies²³, could be mediated through improved personal mastery.

Severity of depressive symptoms was not directly associated with FF. The association with depression has been reported before by many researchers in diverse cohorts^{4,11}. However, no previous studies have considered the positive emotion of personal mastery which may buffer the effects of depressive symptoms²⁹. Our results suggest that overall emotional vitality³⁰ may play a major role in precipitation of fear of falling syndrome.

Performance on standing balance and average lower limb muscle strength were not associated with fear of falling. In contrast, chair stand performance was strongly associated with fear of falling. Biomechanically, sit to stand is a challenging task that necessitates precise control of body center of mass over a base of support that is reducing in size. Particularly, during the transition phase when the base of support is being reduced, the body center of mass movement is decelerated in the horizontal direction and accelerated in the vertical direction,

simultaneously. Therefore, in addition to overall lower limb strength it may also be considered as a measure of dynamic postural control. Our results are supported by those of Delbaere et al.³¹ who demonstrated significantly poor dynamic postural control (rhythmic weight shifting) in community dwelling older adults with high fear of falling; but did not find differences in their static balance task. A possible overall interpretation of our findings is that the perceived personal mastery that is associated with fear of falling, can be reflected in a test of dynamic balance such as the performance on the sit to stand task. We plan to investigate whether performance on challenging physical performance tasks is independently associated with the sense of personal mastery.

Prevalence and correlates of fear-induced activity restriction

Our results indicate that 65% of those who reported FF also reported some activity restriction. A comparable prevalence has been reported by previous studies^{11,13}. In our study, fear-induced activity restriction increased with increasing age and was more prevalent in women than in men in each age group. However, when adjusted for total fear of falling, the gender effect disappeared suggesting that the initial gender differences were due to higher fear of falling in females rather than gender *per se* (Figure 2).

Few studies have looked into the characteristics associated with activity restriction as a consequence of fear of falling in community dwelling older adults^{5,7}. To our knowledge, this is the first study that comprehensively examined the associations of psychological, physical and sensory function parameters with fear-induced activity curtailment. Our results demonstrated that in fearful participants free of depressive symptoms, the higher activity restriction was associated with a combination of poor psychological, physical and sensory function. These findings indicate that the decision to restrict activities may stem from a combination of actual deficits and poor personal mastery. A similar role of personal mastery in absence of depression has been shown in other adverse health outcomes such as progression of disability and mortality³⁰.

Relevance of findings

The available evidence from intervention studies suggests that fear of falling is modifiable²³. The association of fear of falling in our study with personal mastery provides support for the cognitive restructuring therapy approach advocated by Gagnon et al.³². Such an approach may mitigate poor personal mastery and may provide a suitable intervention strategy for alleviating fear of falling as well as for encouraging continued activity in those with fear of falling.

Poor chair stand performance was the only physical characteristic associated with fear of falling, suggesting that overall lower limb strength and deficits in dynamic postural control could be contributing factors. Therefore, interventions incorporating exercise programs that not only improve muscle strength but also sufficiently challenge postural control mechanisms may be warranted. Further, including exercises to develop and improve a sense of balance (such as Tai Chi) may help to alleviate activity restriction in those who have fear of falling. Our findings suggest that exercise programs or behavioral therapy alone may not evoke sufficient response. Modest and transient effects of an intervention study²³ that contrasted an exercise program (strengthening and simple exercises such as walking and stepping in place) to educational program (coping strategies and risk evaluation) support this conclusion. A systematic evaluation of a well-balanced combination program is warranted in this respect.

The major limitation of this study is that discussion is based on a cross-sectional design. A longitudinal study is warranted to substantiate causal relationships. It is possible that the physical and some psychological parameters can have reciprocal relationships with fear of

falling as well as fear-induced activity restriction. For example, poor performance on chair standing task indicating poor dynamic postural control may contribute to fear of falling or fear of falling may in turn contribute to a cautious strategy that results in reducing the speed of this challenging task. Nonetheless, if breaking this vicious cycle is crucial, intervention programs to improve physical and psychological health could be a good starting point.

Acknowledgements

The InCHIANTI study was supported as a “targeted project” (ICS 110.1\RS97.71) by the Italian Ministry of Health and in part, by National Institute on Aging Contracts N01-AG-916413, N01-AG-821336, N01-AG-5-0002, and NIA Grant R01 AG027012 and the Intramural Research Program, National Institute on Aging, NIH.

Funding: The InCHIANTI study was supported as a “targeted project” (ICS 110.1\RS97.71) by the Italian Ministry of Health and in part, by National Institute on Aging Contracts N01-AG-916413, N01-AG-821336, N01-AG-5-0002, and NIA Grant R01 AG027012 and the Intramural Research Program, National Institute on Aging, NIH.

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APPENDIX I

The participant was asked to maintain an erect standing position for 10 seconds in a series of positions characterized by progressive reduction of the base of support in the frontal plane. The series of foot positions was as follows: ASIS: Feet were placed under the respective anterior superior iliac spine; Free Base: If participant was unable to maintain ASIS position for more than one second, s/he was asked to choose her/his comfortable feet position; SBS: Feet together; SemiTandem: Heel of one foot touching the base of the big toe of the other foot; Tandem: Heel of one foot touching the tip of the big toe of the other foot; One Leg: Standing on one leg only.

The standing balance performance was scored as following:

0 = ASIS < 1sec, Free base < 2sec

- 2 = ASIS 2–9 sec, Free Base 2–9 sec
- 3 = ASIS 2–9 sec, Free Base 10 sec sway
- 5 = ASIS 10 sec with sway
- 6 = ASIS 10 sec still 9 = SBS 2–9, ASIS 2–9, Free Base 2–9 sec
- 12 = SBS 2–9 sec, ASIS 10 sec with sway
- 13 = SBS 2–9 sec, ASIS 10 sec still
- 14 = SBS 10 sec sway, SemiTandem <1 sec
- 15 = SBS 10 sec still, SemiTandem <1 sec
- 16 = SemiTandem 2–9 sec
- 17 = SemiTandem 10 sec sway, Tandem <1 sec
- 18 = SemiTandem 10 sec still, Tandem <1 sec
- 19 = Tandem 2–9 sec
- 20 = Tandem 10 sec sway, One Leg <1 sec
- 21 = Tandem 10 sec still, One Leg <1 sec
- 22 = One Leg 2–9 sec
- 23 = One Leg 10 sec with sway
- 24 = One Leg 10 sec still

Figure 1.

A) The graph shows total fear of falling according to age and gender for the total sample of $n = 848$. The fear of falling increased with increasing age ($F_{(3,840)} = 13.942$, $p < 0.001$) and was higher in women ($F_{(1,840)} = 28.560$, $p < 0.001$). There was no age $\times$ gender interaction ($F_{(3,840)} = 1.456$, $p = 0.225$). Grey markers represent men and black markers represent women.

B) The graph shows fear-induced activity restriction, according to age and gender in those who reported some fear of falling ($n = 440$). Activity restriction increased with increasing age and was higher in women. However, when adjusted for total fear of falling, age groups ($F_{(3,839)} = 6.080$, $p < 0.001$) but not genders ($F_{(1,839)} = 0.004$, $p = 0.949$) were significantly different. Total FF was a significant covariate ($F_{(1,839)} = 752.512$, $p < 0.001$). Grey markers represent men and black markers represent women.

Participant characteristics (Means $\pm$ SD) for the total sample and in four fear of falling (FF) groups (according to SAFE scores): no fear (0), mild fear (1–4), moderate fear (5–8) and severe fear (9–11). *p* values indicate significance after adjusting for age and gender.

	Whole Population	Fear of Fall (FF) groups			<i>P</i>
		No Fear	Mild Fear	Moderate Fear	
N	848	408	381	46	13
males/females (%)	45/55	60/40	32/68	26/74	8/92
Age	75.9(6.4)	74.5 (5.4)	76.9 (6.9)	78.9 (6.6)	83.4 (6.3)
BMI (kg/m²)	26.47 (3.62)	26.17 (3.47)	26.70 (3.67)	27.02 (3.93)	27.70 (4.86)
MMSE	25.6(3.2)	26.2 (2.9)	25.2 (3.4)	24.6(3.6)	23.0 (3.2)
CESD	15.6(8.7)	13.2 (7.2)	17.1 (9.0)	23.1 (9.9)	25.2 (10.6)
PSMS	19.8 (5.3)	21.7 (4.6)	18.4 (5.1)	15.7 (5.2)	14.4 (6.4)
Standing balance	20.6(3.6)	21.3 (3.1)	20.1 (3.8)	18.5 (5.1)	16.5 (4.7)
chair stand	2.7(1.3)	3.1 (1.2)	2.5 (1.4)	1.9 (1.5)	1.1 (1.1)
Hip Abductors	0.28(0.07)	0.30 (0.07)	0.26 (0.06)	0.24 (0.06)	0.22 (0.04)
Hip Flexors	0.31 (0.07)	0.34 (0.07)	0.30 (0.06)	0.27 (0.07)	0.25 (0.06)
Knee Extensors	0.23 (0.05)	0.25 (0.05)	0.22 (0.05)	0.20 (0.05)	0.18 (0.06)
Ankle Dorsiflexors	0.29 (0.07)	0.31 (0.07)	0.28 (0.06)	0.26 (0.08)	0.24 (0.05)
Grip Strength	0.46 (0.13)	0.51 (0.13)	0.42 (0.11)	0.40 (0.12)	0.37 (0.09)
Visual Acuity	7.6 (2.2)	7.9 (2.1)	7.4 (2.2)	6.9 (2.3)	6.1 (1.7)
Contrast Sensitivity	1.68 (0.06)	1.69 (0.04)	1.67 (0.07)	1.68 (0.05)	1.64 (0.06)
Vibration Sensitivity	2.1 (0.7)	2.1 (0.7)	2.1 (0.7)	2.4 (0.6)	2.5 (0.5)
Disability in ADL	0.2 (0.8)	0.1 (0.7)	0.2 (0.7)	0.2 (0.7)	0.7 (1.4)
Disability in IADL	0.7 (1.8)	0.3 (1.3)	1.0 (2.0)	1.6 (2.1)	3.3 (2.7)
Walk speed (m/s)	1.22(0.25)	1.31 (0.23)	1.17 (0.23)	0.98 (0.28)	0.94 (0.30)
Fall in previous year(No/Yes) (%)	77/33	82/18	74/26	56/44	26/74
Total Activities	8.6 (2.6)	9.2 (2.1)	8.1 (2.7)	7.2 (2.5)	5.3 (3.4)

* Age and gender significant covariates,

[†] Age significant covariate,

[‡] gender significant covariate

Abbreviations: BMI: Body mass index, MMSE: Mini mental state examination, CESD: The Center for Epidemiological Studies Depression scale, PSMS: Pearlin and Schooler Mastery Scale

Results of the multiple linear regression analysis demonstrating the association of the psychological, physical and sensory function parameters with the total fear of falling. The model was adjusted for age, BMI, sex, average social support and fall history.

Table 2

	$\beta \pm$ Std Error	t	p
(Constant)	-0.081 $\pm$ 0.386	-0.210	.834
Cognition	0.135 $\pm$ 0.173	0.784	.433
Depression	0.073 $\pm$ 0.041	1.767	.078
Personal mastery	-0.011 $\pm$ 0.002	-5.596	.000
Standing balance	0.030 $\pm$ 0.070	0.429	.668
Chair stand	-0.027 $\pm$ 0.008	-3.344	.001
Lower limb strength	-0.314 $\pm$ 0.210	-1.498	.135
Grip strength	-0.077 $\pm$ 0.108	-0.717	.474
Visual acuity	-0.078 $\pm$ 0.066	-1.180	.238
Contrast sensitivity	0.082 $\pm$ 0.603	0.136	.892
Vibration sensitivity	0.089 $\pm$ 0.055	1.628	.104
Age	0.005 $\pm$ 0.002	2.789	.005
BMI (kg/m ²)	0.002 $\pm$ 0.003	0.577	.564
Sex	0.104 $\pm$ 0.023	4.585	.000
Avg Social Support	0.006 $\pm$ 0.011	0.547	.585
fall yes/no	0.032 $\pm$ 0.021	1.534	.125

Table 3

Results of the multiple linear regression analysis demonstrating the association of the psychological, physical and sensory function parameters with the fear-induced activity restriction. Only those participants with some fear of falling (Total FF > 0, n = 440) were included in these models. The models were adjusted for age, BMI, sex, average social support, fall history and fear of falling. Adjusting for fear of falling (model 1) changed the direction of association with depression suggesting an interaction between depression and fear of falling. When depression $\times$ fear of falling term was also added (Model 2), the results showed a significant interaction.

	Model 1			Model 2		
	$\beta \pm$ Std Error	t	p	$\beta \pm$ Std Error	T	p
(Constant)	1.058 $\pm$ 0.376	2.816	.005	0.933 $\pm$ 0.356	2.621	.009
Cognition	-0.381 $\pm$ 0.171	-2.228	.026	-0.302 $\pm$ 0.165	-1.828	.068
Depression	-0.110 $\pm$ 0.047	-2.315	.021	-0.273 $\pm$ 0.054	-5.081	.000
Personal mastery	-0.010 $\pm$ 0.002	-4.931	.000	-0.010 $\pm$ 0.002	-5.126	.000
Standing balance	-0.243 $\pm$ 0.068	-3.584	.000	-0.261 $\pm$ 0.066	-3.931	.000
Chair stand	0.019 $\pm$ 0.008	2.290	.022	0.017 $\pm$ 0.008	2.100	.036
Lower limb strength	-0.631 $\pm$ 0.212	-2.971	.003	-0.667 $\pm$ 0.208	-3.208	.001
Grip strength	-0.034 $\pm$ 0.114	-0.299	.765	-0.019 $\pm$ 0.111	-0.174	.862
Visual acuity	0.063 $\pm$ 0.067	0.938	.349	0.080 $\pm$ 0.066	1.214	.225
Contrast sensitivity	0.266 $\pm$ 0.549	0.485	.628	0.255 $\pm$ 0.541	0.472	.637
Vibration sensitivity	-0.080 $\pm$ 0.061	-1.307	.192	-0.103 $\pm$ 0.060	-1.712	.088
Depression $\times$ Fear of falling				0.437 $\pm$ 0.093	4.707	.000
Age	0.002 $\pm$ 0.002	1.462	.144	0.003 $\pm$ 0.002	1.768	.078
BMI (kg/m ²)	-0.002 $\pm$ 0.003	-0.867	.386	-0.003 $\pm$ 0.003	-1.154	.249
Sex	-0.002 $\pm$ 0.024	-0.081	.936	-0.006 $\pm$ 0.024	-0.241	.810
Avg Social Support	-0.006 $\pm$ 0.012	-0.485	.628	-0.004 $\pm$ 0.012	-0.364	.716
fall yes/no	-0.013 $\pm$ 0.021	-0.603	.547	-0.013 $\pm$ 0.021	-0.648	.517
Fear of falling	0.715 $\pm$ 0.049	14.501	.000	0.514 $\pm$ 0.063	8.212	.000

Table 4

Results of the multiple linear regression analysis demonstrating the association of the psychological, physical and sensory function parameters with the fear-induced activity restriction. Only those participants with some fear of falling (Total FF > 0, n = 440) were included in these models. Following a significant depression $\times$ fear of falling interaction (Table 3, model 2) the participants were stratified in 'no depression' (CESD $\leq$ 20, n = 286) and 'with depressive symptoms' (CESD > 20, n = 154). The models were adjusted for age, BMI, sex, average social support, fall history and fear of falling.

	Model 1 (no depression)			Model 2 (with depressive symptoms)		
	$\beta \pm$ Std Error	t	p	$\beta \pm$ Std Error	t	p
(Constant)	-0.018 $\pm$ 0.459	-0.039	.969	1.822 $\pm$ 0.627	2.904	.004
Cognition	-0.145 $\pm$ 0.197	-0.735	.463	-0.668 $\pm$ 0.298	-2.240	.027
Personal mastery	-0.013 $\pm$ 0.002	-5.212	.000	-0.005 $\pm$ 0.004	-1.399	.164
Standing balance	-0.213 $\pm$ 0.080	-2.645	.009	-0.296 $\pm$ 0.121	-2.458	.015
Chair stand	0.014 $\pm$ 0.010	1.388	.166	0.017 $\pm$ 0.013	1.295	.197
Lower limb strength	-0.676 $\pm$ 0.252	-2.685	.008	-0.567 $\pm$ 0.381	-1.488	.139
Grip strength	0.015 $\pm$ 0.125	0.123	.902	-0.039 $\pm$ 0.233	-0.167	.867
Visual acuity	0.060 $\pm$ 0.074	0.812	.418	0.104 $\pm$ 0.139	0.749	.455
Contrast sensitivity	-2.379 $\pm$ 0.925	-2.570	.011	-0.756 $\pm$ 0.758	-0.997	.320
Vibration sensitivity	-0.067 $\pm$ 0.069	-0.969	.333	-0.208 $\pm$ 0.126	-1.656	.100
Age	0.005 $\pm$ 0.002	2.770	.006	-0.002 $\pm$ 0.003	-0.584	.560
BMI (kg/m ²)	-0.003 $\pm$ 0.003	-0.893	.373	-0.004 $\pm$ 0.005	-0.828	.409
Sex	0.021 $\pm$ 0.027	0.790	.430	-0.062 $\pm$ 0.049	-1.253	.212
Avg Social Support	0.008 $\pm$ 0.014	0.547	.585	-0.038 $\pm$ 0.022	-1.694	.093
fall yes/no	0.008 $\pm$ 0.026	0.315	.753	-0.040 $\pm$ 0.035	-1.155	.250
Fear of falling	0.473 $\pm$ 0.061	7.725	.000	1.003 $\pm$ 0.080	12.483	.000