Associations of Neuroticism with Falls in Older Adults: Do Psychological Factors Mediate the Association?

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Abstract

Objectives: Neuroticism predicts falls in older people. In addition, concern about falling and depressive symptoms are associated with fall risk. This study examined whether concern about falling and depressive symptoms mediate the association between neuroticism and falls.

Method: Cross-sectional data on 314 community-dwelling people aged 70-85 years were utilized. Neuroticism was assessed with a short modified form of the Eysenck Personality Inventory. Indoor and outdoor falls during the past year were self-reported. Concern about falling was assessed with the Falls Efficacy Scale-International and depressive symptoms with the Geriatric Depression Scale-15. Path modeling was used to examine the associations between variables.

Results: Mediating pathways linking neuroticism and falls were found: neuroticism was positively associated with concern about falling, which was subsequently linked to indoor falls (indirect effect β=0.34, P=0.002) and recurrent outdoor falls (β=0.19, P=0.045). Moreover, a pathway from neuroticism to indoor falls through depressive symptoms was also found (β=0.21, P=0.054). In other words, higher neuroticism was associated with higher concern about falling and depressive symptoms, both of which were linked to falls. The associations were independent of age, sex, use of psychotropic, chronic diseases, persistent pain, physical performance, physical activity, and executive functioning that are known risk factors for falls.

Discussion: The results indicate that concern about falling and depressive symptoms mediate the association between neuroticism and falling. Longitudinal studies are needed to confirm the causality of the findings and to examine the potential to reduce falls by targeting concern about falling and depressive symptoms among older adults higher in neuroticism.

KEYWORDS: Aged, Cross-sectional Studies, Accidental Falls, Risk Factors, Fear, Personality.

Introduction

More than one-third of community-dwelling older adults fall each year, and approximately ten percent of these falls result in serious injury such as a fracture. Falling continues to present a challenge despite extensive knowledge of the intrinsic physiological risk factors, such as impaired balance and vision, poor muscle strength, medication and extrinsic risk factors such as environmental hazards. Some of the known risk factors contributing to falling are modifiable (Deandrea et al., 2010). However, psychological factors such as personality traits, depressive symptomalogy and concern about falling have received less attention. A better understanding of these psychological factors could be informative about the mechanisms underlying falls and thus help in the development of more effective fall-prevention interventions for older people at increased risk for falling.

Personality traits, defined as individuals' characteristic ways of behaving, thinking and feeling, are relatively stable across both contexts and time (Caspi, 1998; McCrae & Costa, 2008). The personality traits included in the well-established Five-Factor Model (Digman, 1990) are neuroticism, extraversion, openness, conscientiousness, and agreebleness. The present article focuses on neuroticism, as this trait is recognized as an important contributory factor to falls in older adults (Canada et al., 2019). Neuroticism can be scored on a continuum, ranging from emotional stability (low neuroticism) to emotional instability (high neuroticism). It consists of multiple facets such as anxiety and feeling worried, tense and fearful (McRae & Costa, 2008) that may contribute to the variance in fall-related psychological concerns. Neuroticism has been linked to several health outcomes that contribute to the higher risk of falling in old age, including frailty (Stephan et al., 2017), muscle weakness (Tolea et al., 2012), physical inactivity (Sutin et al., 2016), cognitive impairment (Terracciano et al., 2017), depressive symptoms (Hakulinen et al., 2015) and anxiety (Kotov et al., 2007).

A recent study by Canada and colleagues (2019) found that higher neuroticism increased fall risk among older adults over an 11-year follow-up. Their longitudinal study with a large sample (N = 4 759) of older adults aged from 65 to 99 years confirmed previous cross-sectional findings among older adults living independently in a retirement community (Kloseck et al., 2007). The latter study also showed that higher neuroticism was associated with lower confidence in avoiding a fall when performing daily tasks (Kloseck et al., 2007). Similarly, a link between neuroticism and higher concern about falling has been found among community-dwelling women over 70 (Mann et al., 2006). Concern about falling is an important psychological factor in older people, as about one in three without a falls history and about two in three with a falls history have expressed concern about falling (Kumar et al., 2016). Moreover, concern about falling has been shown to increase fall risk, even in older adults with no physiological risk factors for falls (Delbaere et al., 2010[a]). Similarly, depressive symptoms have been linked with an increased risk of falling, independently of the presence of a higher physiological fall risk and poorer executive functioning (Kvelde et al., 2015).

Despite the evidence on the associations between neuroticism and falls (Canada et al., 2019), neuroticism and concern about falling (Mann et al., 2006), neuroticism and depressive symptoms (Hakulinen et al., 2015), concern about falling and falls (Delbaere et al., 2010[a]) and depressive symptoms and falls (Kvelde et al. 2015), the associations between neuroticism, concern about falling, depressive symptoms and actual falls have not previously been investigated simultaneously. This study explored the associations between neuroticism, concern about falling, depressive symptoms and indoor and outdoor falls. Based on the existing evidence, we hypothesized, first, that neuroticism is associated with falls and, second, that the relationship between neuroticism and falls is mediated by increased concern about falling and depressive symptoms. In other words, we assumed that higher neuroticism

is associated with higher concern about falling and depressive symptoms, which in turn are linked to actual falls. Given the multivariate nature of falls and differences between indoor and outdoor fall risk profiles (Kelsey et al., 2010), we investigated indoor and outdoor falls separately, taking into account several related factors.

Method

Participants

This cross-sectional study used baseline data gathered for a randomized controlled trial (the PASSWORD study, Sipilä et al., 2018). Community-dwelling 70- to 85-year-old men and women were randomly selected from the population register. The study recruitment strategy and inclusion and exclusion criteria have been published earlier (Sipilä et al., 2018). Briefly, inclusion criteria were sedentary or at most moderately active (walking < 150 min/wk., no regular resistance training), able to walk 500 m without assistance and a score of ≥24 points in a Mini Mental State Examination. Exclusion criteria included a severe chronic condition, medication that could affect study participation, contraindications for physical exercise, excessive use of alcohol, difficulties in communication due to severe hearing or vision problems, and another family member already participating in the study. The flow chart of the study is shown in Figure 1. Finally, 314 participants formed the study population. The PASSWORD study was approved by the Ethical Committee of Central Finland Health Care District (14/12/2016, ref.:11/2016). All participants signed an informed consent before the baseline measurements.

122 Measurements

123 *Falls*

124 Information on indoor and outdoor falls during the previous year was collected
125 retrospectively by a structured questionnaire. The questions (two questions answered
126 separately) were: "How many times have you fallen indoors/outdoors during the previous
127 year?" The response options were 1= none, 2= once, 3= two to four times, 4= five to seven
128 times, and 5= eight times or more. For the analyses, participants who reported no falls during
129 the previous year were coded as "non-fallers"; those who reported ≥1 falls indoors were
130 coded as "indoor fallers"; and those who reported one fall outdoors, but no indoor falls, were
131 coded as "single outdoor fallers" (Pajala et al.,2008). In addition, those who had ≥2 outdoor
132 falls, but no indoor falls, were coded as "recurrent outdoor fallers" (Kelsey et al., 2012). We
133 used the dichotomized variables for indoor falls, single outdoor and recurrent outdoor falls
134 (0=no, 1= yes).

135

136 *Personality traits*

137 The trait of neuroticism in the short form of the Eysenck Personality Inventory modified by
138 Floderus (1974) was used. In the inventory, neuroticism is measured by 10 items (e.g., "Do
139 you often feel listless and tired without any special reason?"). Participants were asked to
140 answer 'yes' (= 1) or 'no' (= 0) to each item. The total score, ranging from 0 to 10, with
141 higher scores indicating a higher degree of neuroticism, was used in the analysis. Because a
142 missing value may result in excessively low sum scores, missing values were imputed by
143 calculating the probability of a positive response (2.9 % of participants had one missing
144 value). The short version of the Eysenck Personality Inventory is a widely used self-
145 completion tool that has been validated in many populations (Floderus-Myrhed et al., 1980;
146 Rose et al., 1988). Cronbach's alpha for the neuroticism subscale was 0.72.

147 *Concern about falling*

148 The Falls Efficacy Scale-International (FES-I, Yardley et al., 2005) was used to assess level
149 of concern about falling when carrying out a wide range of activities, such as walking on
150 slippery, uneven or sloping surfaces, cleaning the house, shopping, or going to a social event.
151 The questionnaire contains 16 items, each rated on a four-point scale (1=not at all concerned
152 to 4= very concerned). Total scores, ranging from 16 to 64, were computed, a higher score
153 indicating more concern about falling. The psychometric properties of the FES-I have been
154 reported to be excellent (Yardley et al., 2005). In our population, Cronbach's alpha was 0.90.
155 Widely used cut-points differentiating between low (16–19), moderate (20–27) and high (28–
156 64) concern about falling have been presented by Delbaere and colleagues (2010[b]).

157 *Depressive symptoms*

158 Depressive symptoms were interviewed using the 15-item Geriatric Depression Scale (GDS-
159 15, Yesavage & Sheikh, 1986) during the nurse examination. Summary scores, ranging from
160 0 to 11 (theoretical range 0-15), were computed; a score of zero to four is considered to be
161 within the normal range and a score of five or more to indicate depressive symptoms
162 (Almeida & Almeida, 1999). In this study, the GDS-15 was used as a continuous variable and
163 Cronbach's alpha was 0.60.

164 Covariates

165 *Executive function*

166 Executive functioning was assessed with the Trail Making Tests parts A and B (Reitan,
167 1958). Part A is a psychomotor speed task requiring the participant to connect as quickly as
168 possible and in ascending order a series of randomly dispersed circles containing numbers.
169 Part B requires the participant to shift attention by connecting as quickly as possible and in
170 alternating sequential order a series of randomly dispersed circles containing numbers and

letters. The time taken to complete each task is recorded and the difference in the time taken to accomplish Parts B and A calculated. Smaller time differences indicate better performance.

Physical performance and level of physical activity

Physical performance was measured using the Short Physical Performance Battery (SPPB, Guralnik et al., 1994). The SPPB includes habitual walking speed over four meters, five-time chair rise, and standing balance tests. Summary scores range from 0 to 12, with higher scores indicating better performance. Self-reported level of physical activity over the previous month was assessed with a validated single question comprising 7 categories (Hirvensalo et al., 1998): 0=I do not move more than is necessary in my daily routines/chores, 1=I go for casual walks and engage in light outdoor recreation 1-2 times a week; 2=I go for casual walks and engage in light outdoor recreation several times a week; 3=I engage, 1-2 times a week, in brisk physical activity (e.g. yard work, walking, and cycling) to the point of perspiring and some degree of breathlessness; 4=Several times a week (3-5), I engage in brisk physical activity (e.g. yard work, walking, and cycling) to the point of perspiring and some degree of breathlessness; 5=I do keep-fit exercise several times a week in a way that causes rather strong shortness of breath and sweating during the activity; 6 = I participate in competitive sports and maintain my fitness through regular training. Categories 5 and 6 were combined with category 4 (only one participant reported a level 5 and no participant a level 6 activity). For the background analysis, the variable was recoded into three categories: low (categories 0 and 1), medium (categories 2 and 3) and high (category 4).

To assess health status, information on chronic diseases, presence of persistent pain and medication was collected by self-reports and from the national integrated patient information system by the study physician. *Number of chronic diseases* was calculated as the sum of conditions from the following list: high blood pressure, heart disease, stroke, lung disease,

diabetes, arthritis, arthrosis, chronic back disease, osteoporosis, and cancer. *Use of psychotropic drugs* (no/yes) including opiates, benzodiazepines, anticholinergic agents, dopaminergic agents, and antidepressants was documented according to the Anatomical Therapeutic Chemical (ATC) classification. *Persistent musculoskeletal pain* in the lower body was assessed by the question "During the past six months, have you suffered from pain in the low back, hip, knee, ankle or foot daily or almost daily for at least one month?". Participants who reported pain in one or more of these body regions were considered to have persistent pain. In addition, *age*, *sex (1=male, 2= female)* and *education* in years were treated as sociodemographic factors.

Statistics

Descriptive statistics were computed according to fall status (non-faller, single outdoor faller/recurrent outdoor faller, indoor faller). Differences in continuous variable means between the fall groups were examined using one-way ANOVA. Concern about falling and neuroticism were non-normally distributed due to skewed data. Transformations [100/original variable for concern about falling and ln (1+original variable) for neuroticism] were used to normalize the distribution. Pairwise group differences were tested with post-hoc Tukey's multiple comparisons tests. A chi-square test was used for categorical variables according to fall status. Associations between variables were calculated by Spearman's rank correlation coefficients.

It has been shown that neuroticism is associated with falls (Canada et al., 2019) and concern about falling (Mann et al., 2006) and that a bidirectional relation exists between concern about falling and falls (Delbaere et al., 2010a). It was therefore hypothesized that concern about falling would mediate the relationship between neuroticism and falls. Similarly, neuroticism was assumed to predict depressive symptoms (Hakulinen et al., 2015), which in

219 turn are associated with increased fall risk (Kvelde et al. 2015). These factors were included
220 in the conceptual framework that was tested in this study (Figure 2). Previously identified
221 major confounders affecting the association between neuroticism and falls, neuroticism and
222 concern about falling/depressive symptoms and concern about falling/depressive symptoms
223 and falls were age, sex, use of psychotropic, chronic diseases, persistent pain, physical
224 performance, physical activity, and executive functioning. These factors were thus controlled
225 for in the analyses.

226 Path analysis was conducted to examine the pathways between neuroticism and indoor and
227 outdoor falls. We started from the conceptual framework adjusted for the confounders. We
228 used the maximum likelihood approach with Monte Carlo integration (5 000 nodes) which is
229 able to handle complex path models, including the present dichotomous fall outcome
230 variables, and missing values, assuming that missing data were generated by the missing-at-
231 random mechanism. The exploratory mediator model was used to investigate the pathways
232 between neuroticism and indoor and recurrent outdoor falling with concern about falling and
233 depressive symptoms as possible mediators.

234 In addition, differences in the mediation model parameters between males and females were
235 assessed by a likelihood ratio test based on gender-group modeling. Thus, we compared the
236 mediation parameters by gender (gender-specific model) to the mediation parameters in a
237 model where these parameters were constrained equal across the gender groups (pooled
238 gender model). The latter is a nested model of the former, and a non-significant result
239 indicates that the parameter estimates from the two models are statistically similar. Hence,
240 the pooled-gender model is taken to be a sufficient and more parsimonious description of the
241 associations (see, e.g., Jöreskog et al., 1993). The significance level was set at 0.05 (if the
242 95% confidence interval for a path coefficient did not contain the value zero, the parameter
243 was considered statistically significantly different from zero). We did not correct p-values for

multiple testing. Analyses were performed with Mplus Version 5.21 (Muthen & Muthen 1998-2009, Los Angeles, CA).

246 Results

247 Descriptive statistics are presented in Table 1. Mean participant age was 74.5 years (SD 3.8),
248 body mass index 28 kg^2 (5) and 60% were women. Thirty-seven participants (12%) had fallen
249 indoors, and the majority of them (n=33, 89%) had also had at least one outdoor fall. In all,
250 160 participants reported outdoor falls: 103 participants (33%) reported one fall, and 57
251 (18%) recurrent falls outdoors in the previous year. Table 1 presents the data on the 87
252 participants reporting one outdoor fall but no indoor falls, the 40 participants reporting ≥ 2
253 (recurrent) outdoor falls but no indoor falls, and the 37 participants reporting ≥1 indoor falls.
254 Those who had fallen either indoors or recurrently outdoors during the previous year had
255 reported higher concern about falling, and indoor fallers had also reported more depressive
256 symptoms than non-fallers and single-outdoor fallers. Recurrent outdoor fallers were also
257 more likely to have persistent musculoskeletal pain than non-fallers and single-outdoor
258 fallers. Compared to those reporting only one fall outdoors, indoor fallers had more
259 depressive symptoms and poorer physical performance. In addition, indoor fallers were more
260 concerned about falling, scored higher on neuroticism, and were more likely to be inactive
261 than those who reported one outdoor fall. However, except for their higher frequency in the
262 low physical activity group, indoor fallers did not differ from recurrent outdoor fallers (Table
263 1). In total, 156 participants (50%) were moderately concerned about falling (FES-I score 20
264 to 27) and 45 (14%) were highly concerned about falling (FES-I score more than 28).

265 The inter-correlations are presented in Table 2. Neuroticism correlated significantly with
266 indoor, single outdoor and recurrent outdoor falls. Neuroticism also correlated with concern
267 about falling and depressive symptoms. In turn, concern about falling correlated with indoor,
268 and recurrent outdoor falls, and depressive symptoms with indoor falls.

Figure 3 presents path coefficients for the final model estimating concern about falling and depressive symptoms as mediators of the relationship between neuroticism and indoor falls. In the adjusted model, neuroticism was positively associated with concern about falling. In turn, concern about falling was positively associated with falling indoors. The indirect effect of neuroticism on indoor falls via concern about falling was significant (β = 0.34, 95% CI 0.124, 0.561; P = 0.002). In addition, neuroticism was associated with indoor falls through depressive symptoms (β = 0.21, 95% CI -0.004, 0.423; P = 0.054). Thus, the total effect of neuroticism on indoor falls through the two indirect paths was β = 0.55, 95% CI 0.274, 0.831, P < 0.001. This model explained 17% (R^2=0.169) of the variance in indoor falls. Likelihood ratio tests indicated no statistically significant differences in the path coefficients across the gender groups ($\chi^2_{df=11}$ = 15.25, P = 0.172).

Neuroticism, concern about falling and depressive symptoms were not associated with having only one outdoor fall. Therefore, the mediation analysis for having one outdoor fall was not performed. However, we tested the hypothesis that the association between neuroticism and recurrent outdoor falls is mediated by concern about falling and depressive symptoms. Neuroticism was significantly associated with concern about falling, which in turn was related to recurrent outdoor falls (Figure 4). The mediation analysis revealed a statistically significant indirect pathway between neuroticism and recurrent outdoor falls through concern about falling (β = 0.19, 95% CI 0.004, 0.371, P = 0.045). Depressive symptoms were not associated with recurrent outdoor falls. This model accounted for 10% (R^2=0.096) of the variance in recurrent outdoor falls. We found no statistically significant differences in the mediation parameters in the gender-group analysis (recurrent outdoor falls $\chi^2_{df=10}$ = 13.22, P = 0.212).

Discussion

The main aim of the present study was to examine whether concern about falling and/or depressive symptoms function as mediators between neuroticism and falling. The correlations showed that neuroticism was associated with both indoor and recurrent outdoor falls. The mediation analysis revealed that a higher score on neuroticism was positively associated with higher concern about falling, which, in turn, was associated with indoor falls and recurrent outdoor falls. In addition, neuroticism was associated with higher depressive symptoms, which in turn were linked to indoor falls only. Thus, our findings suggest that concern about falling mediates the association between neuroticism and recurrent outdoor falls and that concern about falling and depressive symptoms mediate the relationship between neuroticism and indoor falls. The associations between neuroticism and falls remained significant when adjusted for traditional risk factors for falls, such as poor physical performance, low level of physical activity, poor executive functioning, persistent pain, chronic diseases, and the use of psychotropic medications. These results emphasize that, to prevent falls among older people, interventions are needed that also take account of psychological factors.

Our findings extend those of a previous study reporting a link between neuroticism and higher fall risk (Canada et al., 2019) by examining indoor and outdoor fall outcomes separately and the mediator role of higher concern about falling and depressive symptoms in the association between neuroticism and falls. Indoor and outdoor falls differ in older adults: relatively healthy and physically active older adults more often fall outdoors than indoors, whereas indoor falls are associated with activity restriction, health problems and poorer physical performance (Kelsey et al., 2010; Mänty et al., 2009). In line with the literature, the present participants reporting indoor falls tended to be more inactive, to be more concerned about falling, and to have more depressive symptoms than those reporting outdoor falls. Among these relatively healthy, community-living older adults, those who had fallen indoors

318 also seemed to be prone to recurrent outdoor falls, supporting earlier findings that recurrent
319 falls are indicative of an underlying high-risk state (Deandre et al., 2010). Non-recurrent
320 outdoor falls, in turn, seem to be more coincidental and may be related to contextual factors
321 such as environmental hazards (Nyman et al., 2013).

322 This study supports earlier findings showing that higher concern about falling (Delbaere et
323 al., 2010[a]) and higher depressive symptomatology (Kvelde et al. 2015) are associated with
324 increased fall risk, even in older adults without obvious physical risk factors. Among older
325 adults who score higher on neuroticism, increased concern about falling and decreased
326 confidence on their ability to undertake activities of daily living without falling may relate to
327 a persistent and dysfunctional disruption of attention and more cautious behavior (Delbaere et
328 al., 2010[a]). Concern about falling may, for example, impact negatively on gait. It can lead to
329 so called "cautious" gait, which in turn results in decreased walking stability and increased
330 risk of falling (Delbaere et al., 2009). A recent study by Tuerk and colleagues (2016) showed
331 that increased concern about falling was associated with decreased gray matter volume in the
332 brain areas important for motor control and hence gait safety. Interestingly, their results
333 suggested that this relationship was explained by generalized anxiety and neuroticism rather
334 than physical risk factors for falls. In addition, persons overly concerned about falling or
335 having depressive feelings may restrict their activities of daily living (Zijlstra et al., 2007),
336 resulting in increased physical inactivity, loss of muscle strength and impaired physical
337 condition, all of which are known common risk factors for falls (Deandrea et al., 2010).
338 Moreover, there is evidence that physical inactivity (Sutin et al., 2016), poor muscle strength
339 (Tolea et al., 2012) and deteriorated physical condition (Stephan et al., 2017) are linked with
340 neuroticism. However, we controlled for these common risk factors for falls and found that
341 increased fall risk was a result not only of physical deterioration but also of the psychological
342 challenges experienced by persons scoring high on emotional instability.

Individuals scoring high on neuroticism may have more depressive symptomatology, general worries and anxiety (Kotov et al., 2007), factors that have also typically been associated with fall-related psychological concerns (Payette et al., 2015) and lower self-efficacy (O'Shea et al., 2016). In the present study, having depressive symptoms was strongly associated with neuroticism and also directly with indoor falls despite the exclusion of individuals with clinical depression. In addition, Yasunaga and Yaguchi (2014) found that poor self-efficacy mediated the association between neuroticism and a lower level of physical activity among relatively healthy older adults. Concern about falling among older adults who are emotionally unstable may result from the interplay between multiple factors such as lower self-efficacy, anxiety or worrying, depressive mood, and persistent pain. For example, persistent pain that interferes with activities of daily living considerably reduces self-efficacy and increases older adults' concern about falling (Stubbs et al., 2014). Prolonged lower body pain has also been associated with impaired balance (Lihavainen et al., 2009) and risk for falls (Leveille et al., 2009) in older people. Among the present relatively healthy older adults, persistent musculoskeletal pain was related in particular to recurrent outdoor falls. Sex did not moderate the relationship between neuroticism and falls tested in our mediation models, although women reported higher rates of concern about falling than men, as also found previously (Delbaere et al., 2010). Thus, several factors may lead to concern about falling and hence to less effective coping strategies (Loft et al., 2018). The latter in turn increase vulnerability to falls in older adults with relatively high scores on the personality trait of neuroticism.

Whereas balance and muscle strength training have proven to be effective in reducing falls (Sherrington et al., 2019), the effects of training on reducing concern about falling are less clear (Kumar et al., 2016). In addition to exercise, successful interventions may need behavioral components aimed at reducing psychological concerns and depressive mood and enhancing self-efficacy (Ziljstra et al., 2009). Moreover, enhancing self-efficacy may

368 improve coping with persistent pain (Turner et al., 2005). Consequently, multicomponent
369 interventions that better take individuals' characteristics into account may be the most
370 effective way of preventing falls in older adults.

371 This study has its limitations. First, the cross-sectional design does not allow any conclusions
372 to be drawn on causality. On the other hand, it has been argued that the association between
373 fall-related psychological concerns and falls is bidirectional (Friedman et al., 2002). In
374 addition, the personality trait of neuroticism is relatively stable throughout adulthood (Kokko
375 et al., 2015) and old age (Steunenberg et al., 2005). Future research could build upon present
376 findings by examining these associations over time. In addition, our measure of neuroticism
377 (10 items) did not allow examination of the facets of this trait. The use of a broader measure
378 of neuroticism would be needed to understand whether specific facets of the trait may be
379 driving these results. A further, major, limitation is that falls were measured retrospectively,
380 and hence may be affected by recall bias. Moreover, the participants with a physician
381 diagnosis of major depression were excluded from the study. Thus, the data may under- or
382 overestimate falls (Sanders et al., 2009) and under-estimate the effect of depressive
383 symptoms. Future studies should use prospective monitoring with daily falls calendars and
384 separate the injurious falls from falls with less severe consequences. There is evidence that
385 higher levels of anxiety, for example, predict fall-related fractures (Catalano et al. 2018).
386 Thus, the possibility of an enhanced risk of fall-related fractures among older people with
387 higher level of neuroticism, should be considered in future works.

388 A strength is the use of detailed and valid assessments of several well-known risk factors for
389 falls. A large sample of community-dwelling older adults with sedentary or at most moderate
390 levels of physical activity but free from severe chronic conditions participated, allowing us to
391 generalize the results to the healthy older adults. Levels of concern about falling (Tuerk et al.,
392 2016) and fall levels (Lord et al., 1993; Schoene et al., 2014), were representative of those

among community-dwelling older adults. In addition, the mean scores for neuroticism were comparable to those previously found in large population-based studies of adults (Navrady et al., 2019).

In conclusion, this study provides new evidence on the mechanism through which a higher score on neuroticism, also known as emotional instability, may contribute to increased fall risk. Fall-related psychological concerns such as concern about falling could become an important target for more personalized interventions aimed at reducing the incidence of falls in community-dwelling older adults.

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Table 1. Participant characteristics and the fall status, n=314.

Variables	Non-fallers [1] (n=150)	Outdoors fallers		Indoor fallers [4] (n=37)	1vs 2 P-value	1 vs 3 P-value	1 vs 4 P-value	2 vs 3 P-value	2 vs 4 P-value	3 vs 4 P-value
		Single [2] (n=87)	Recurrent [3] (n=40)							
Age, years [mean (SD)]	74.7 (3.6)	73.9 (3.7)	75.0 (4.4)	74.3 (4.1)	.410	.957	.970	.399	.917	.874
Sex [n (%) female]	95 (63)	50 (58)	24 (60)	19 (51)	.372	.699	.181	.788	.530	.455
Level of education [n (%) highest]	33 (22)	21 (24)	6 (15)	6 (16)	.705	.330	.438	.242	.328	.883
Executive function, TMTΔ seconds [mean (SD)]	93.0 (61.1)	76.7 (32.2)	90.2 (47.1)	95.9 (54.9)	.101	.991	.990	.532	.248	.532
Number of chronic diseases, [mean (SD)]	1.5 (1.1)	1.5 (1.2)	1.6 (1.2)	1.7 (1.2)	.983	.632	.939	.961	.938	.928

Depressive symptoms, GDS-15 score [mean (SD)]	1.4 (1.4)	1.6 (1.6)	1.8 (1.7)	2.5 (2.5)	.798	.512	.002	.919	.032	.919
Use of psychotropic [n (%) yes]	21 (14)	11 (13)	7 (18)	6 (16)	.768	.579	.731	.466	.597	881
Physical performance, SPPB score [mean (SD)]	10.1 (1.6)	10.5 (1.4)	10.2 (1.2)	9.6 (2.0)	.314	.991	.286	.786	.024	.345
Level of physical activity [n (%) yes] Low Medium High	 60 (40) 76 (51) 14 (9)	 32 (37) 42 (48) 13 (15)	 13 (33) 20 (50) 7 (17)	 21 (57) 10 (27) 6 (16)	.624	.386	.065	.639	.040	.032
Presence of persistent pain [n (%) yes]	43 (29)	32 (37)	23 (58)	14 (38)	.175	.001	.278	.033	.947	.084
Concern about falling, FES-I score [mean (SD)]	21.6 (4.6)	21.5 (4.1)	24.3 (4.9)	26.5 (8.4)	.970	.010	< .001	.016	< .001	.358

Neuroticism, score [mean (SD)]	2.9 (2.2)	2.7 (2.0)	3.7 (2.1)	4.5 (2.7)	.960	.166	.011	.105	.007	.808

Notes: P-values were calculated for continuous variables using one-way ANOVA post hoc comparisons, Tukey's test. Between-group differences in categorical variables were tested using Chi-square test.

Table 2. Inter-correlations of the study variables

Variable	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
1. Single outdoor falls	1	-.29**	-.23**	-.11	-.09	-.01	.02	.12*	-.03	-.02	.12*	.05	.00	-.03	-.10
2. Recurrent outdoor falls		1	.26**	.21**	-.26**	.10	.17**	-.02	.04	.02	.05	.04	-.07	-.05	.03
3. Indoor falls			1	.19**	-.18**	.12*	.02	-.09	.02	.03	.04	-.09	-.04	-.06	-.02
4. Neuroticism				1	.37**	.48**	.11*	-.09	.27*	.11	-.00	-.02	-.05	.07	.11
5. Concern about falling					1	-.27**	-.24**	.32**	-.09	-.15**	-.04	.04	.02	-.26**	-.08
6. Depressive symptoms						1	.13*	-.22**	.23**	.17**	.00	-.15**	.03	.04	.07
7. Persistent pain							1	-.20**	.11	.27**	.05	-.11*	-.09	.08	.06
8. Physical performance								1	-.04	-.20**	-.22**	.19**	.14*	-.28**	-.17**
9. Use of psychotropic									1	-.00	.04	-.03	-.02	.06	.03
10. Chronic diseases										1	.15**	-.14*	-.15**	-.04	.20**
11. Executive function											1	-.05	-.37**	-.13*	.32**

12. Level of physical activity												1	.04	.-03	-.06
13. Level of education													1	.14*	-.02
14. Sex														1	.04
15. Age															1

Notes: *p<.05, **p<.01.

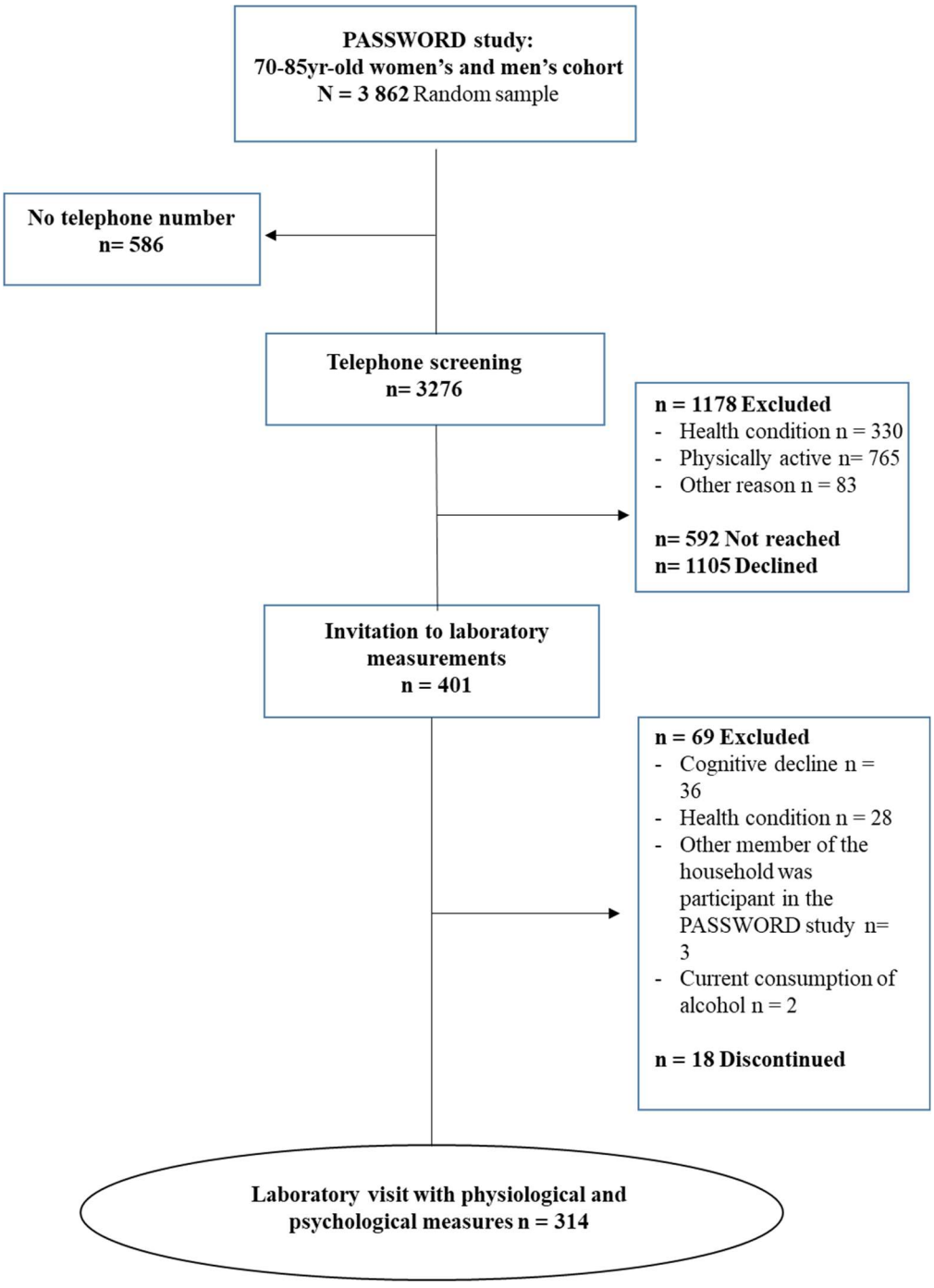

Figure 1. Flow chart of the study

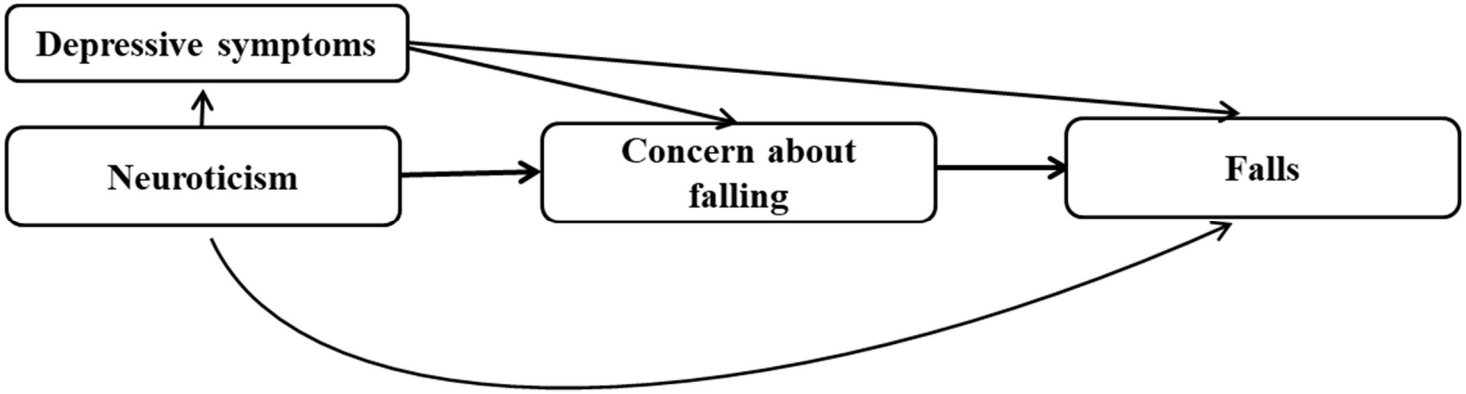

Figure 2. Conceptual framework tested.

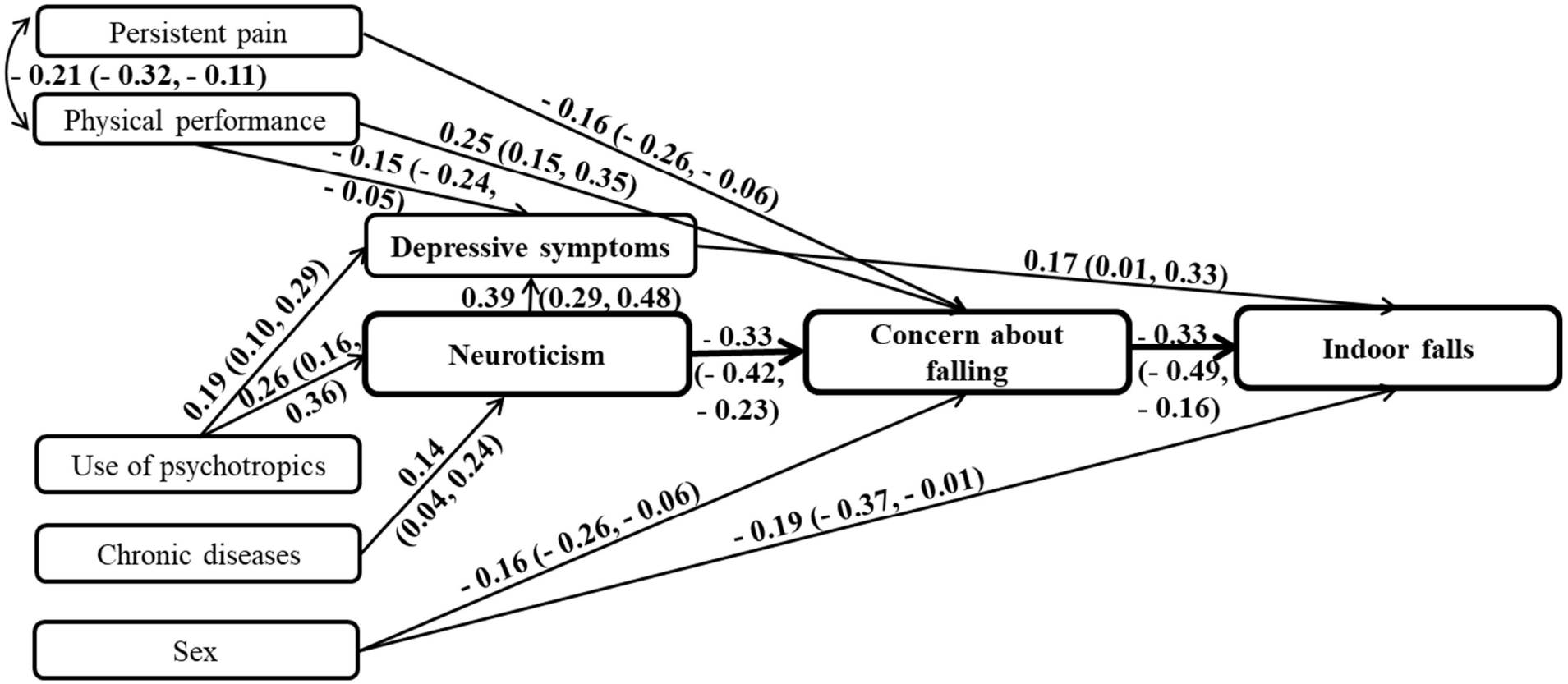

Figure 3. Standardized path coefficients (95% confidence intervals) of the mediator model for neuroticism, concern about falling and indoor falls among community-dwelling older people (n=314). Note: the model is controlled for age, sex, use of psychotropic, chronic diseases, persistent pain, physical performance, physical activity, and executive functioning; non-significant control variables were removed from the final mediation model.

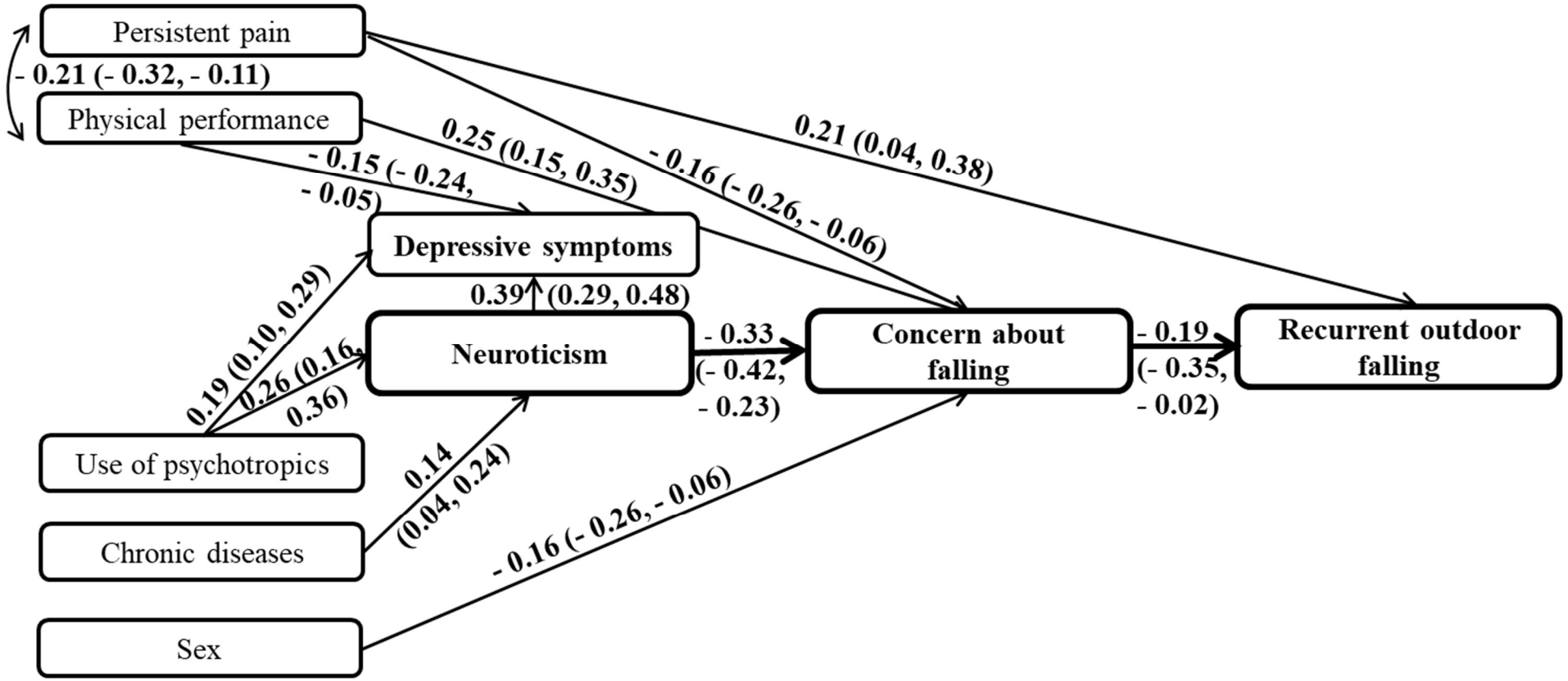

Figure 4. Standardized path coefficients (95% confidence intervals) of the mediator model for neuroticism, concern about falling and recurrent outdoor falls among community-dwelling older people (n=314). Note: the model is controlled for age, sex, use of psychotropic, chronic diseases, persistent pain, physical performance, physical activity, and executive functioning; only significant associations of these variables are presented.