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A multiple correspondence analysis of the fear of falling, sociodemographic, physical and mental health factors in older adults

Garden Tabacchi¹✉, Giovanni Angelo Navarra¹, Antonino Scardina¹, Ewan Thomas¹, Antonella D'Amico¹, Javier Gene-Morales², Juan C. Colado², Antonio Palma¹ & Marianna Bellafiore¹

Fear of falling (FoF) is a disabling condition due to different factors. The present study assessed potential FoF predictors, among sociodemographic, physical, and mental health domains, and explored their structural patterns. This cross-sectional study is part of the Physical Activity Promotion & Domestic Accidents Prevention (PAP & DAP) project, and was targeted to a sample of 229 independent older people (M 14.0%, F 86.0%) aged over 60 (mean 70.5 ± 5.96), both normal and overweight (median BMI 25.8 kg/m², Interquartile Range 5.24). Standardized tools were used to assess the variables: the Short Falls Efficacy Scale International for the FoF; an information questionnaire for the socio-demographic variables, the presence of diseases, and previous falls; the International Physical Activity Questionnaire for the PA level; the Senior Fitness Test for physical fitness data; the Short Form 12 questionnaire for variables in the mental domain; and the Psychological Well-Being Scale 24 for the psychological well-being. Correlation/regression analyses were used to explore relationships between FoF and the considered variables. A Multiple Correspondence Analysis (MCA) was conducted to show graphical patterns projected into space dimensions. A percentage of 59.0 of the sample showed moderate/high concern of falling. The multiple regression model showed the following variables being significant predictors ($p < 0.05$) of the FoF: BMI (coeff 0.44, SE 0.104), musculoskeletal disease (1.55, 0.681), upper body strength (0.33, 0.117), mobility and balance (0.76, 0.320), perceived physical health (-0.21, 0.047), and self-acceptance (-0.52, 0.190). MCA evidenced two dimensions: the first one explained 41.8% of the variance and was described mostly by FoF (square residuals 0.721), gender (0.670), leg strength (0.617), perceived mental health (0.591), musculoskeletal diseases (0.572), and PA level (0.556); the second dimension (12.3% of the variance), was characterized mainly by perceived physical health (0.350), life objectives (0.346), education (0.301), upper body strength (0.278), and living in family/alone (0.260). The pattern elicited by MCA was characterized by older subjects with moderate/high FoF having low education or no occupation, being overweight and inactive, suffering from different diseases, having low physical fitness, and declaring low perceived physical and mental health. These results suggest that interventions aimed at reducing FoF should be addressed to this specific profile of older people.

Keywords Fear of falling, Older, Sociodemographic, Physical health, Mental health

A fall has been defined by the America Geriatrics Society as “an unexpected event in which the participant comes to rest on the ground, floor, or lower level without known loss of consciousness” (www.profane.eu.org; www.americangeriatrics.org). In the over-65 population, falls are the leading cause of injuries requiring emergency treatment and cause more hospital admissions and deaths than any other type of accident; globally, falls are a

¹Sport and Exercise Sciences Research Unit, Department of Psychology, Educational Science and Human Movement, University of Palermo, Via Pascoli 6, Palermo, Italy. ²Prevention and Health in Exercise and Sport (PHES), University of Valencia, Valencia, Spain. ✉email: garden.tabacchi@unipa.it

serious public health problem and are the second leading cause of unintentional death and the seventh leading cause of death in people aged 65 years and over; every year, approximately 37.3 million falls occur that are serious enough to require medical attention, 648 of which are fatal (World Health Organization. *Falls [Internet]* [cited 2021 Sep 17]. Available from: <https://www.who.int/news-room/fact-sheets/detail/falls>).

The major consequences of falls result in minor or moderate injuries, but about 5–10% of the elderly suffer a hip fracture and wrist injuries requiring hospital care¹. Other significant consequences are psychological discomfort and worrying about falling again. Tinetti et al. defined the FoF as “an enduring preoccupation with falling that leads the individual to avoid activities that he or she is still capable of performing”².

The factors contributing to the FoF can be diverse and numerous: impaired balance, poor physical and mental health, cognitive impairment, lowering of visual acuity, previous history of falls, and reduced mobility^{3,4}. Some determinants of FoF include loss of muscle strength, presence of high levels of pain, low life satisfaction, vision problems, reduced proprioception, heart disease, obesity, diabetes, depression, and use of walking devices^{5,6}. It has been estimated that the prevalence of FoF in the elderly approaches 90% among those who fall, compared to 65% among those who do not fall. Furthermore, several authors have indicated that FoF could predict the occurrence of falls among the elderly in the future⁷.

FoF can lead to loss of balance, loss of self-confidence and deprivation of activity, potentially reducing fitness, mobility, and increasing social isolation, time spent at home, anxiety and depression; this leads to a reduction in quality of life^{8–10}, to a decrease in social interactions, and has a direct impact on self-esteem, thus making the FoF a disabling condition^{11–13}. Furthermore, some studies support the relationships between the experience of previous falls and the FoF^{14–16}. Precisely because of all the physical and psychological consequences the FoF entails, it is important to investigate factors related, aiming to improve the quality of life of the elderly.

Different strategies can be used to examine the complex relationships among multidomain aspects of individuals related to aging, which are often complex to explore. One way is the multivariate analysis, that was used in the present study for the continuous quantitative variables in order to investigate factors that could influence the FoF. However, since this analysis alone does not allow exploring the individual response classes of the categorical variables and does not provide a graphical view for identifying the structural relationships among the variable categories, the Multiple Correspondence Analysis (MCA) was also used as alternative strategy to take into account the categorical nature of the variables¹⁷. This technique has been widely used in social sciences and in studies on older populations^{18,19}, but a gap in the literature exists concerning its use for a detailed exploration of the variables related to the FoF in Italian populations.

Therefore, the aim of the present study was to explore structural patterns of sociodemographic, physical health, and mental health domains in relation to the FoF in a sample of physically independent older people, and additionally, we intended to assess potential predictors of the FoF among the considered factors.

Methods

Sample characteristics

This study was carried out from November 2022 to January 2023, as part of an evaluation intervention of the Physical Activity Promotion & Domestic Accidents Prevention (PAP & DAP) project²⁰, a collaboration between the University of Palermo and the Azienda Sanitaria Provinciale (ASP) of Palermo, Italy. The study involved 229 elderly (32 men and 197 women) aged over 60 (117 from 60 to 70 years and 112 over 70), completely independent, without heavy physical and/or mental disabilities and cognitive disorders. Participants were recruited from September 2022 through ASP contact persons in various districts of Palermo and its province using posters with voluntary adherence.

All participants gave their written informed consent for the participation to the study, which was approved by the Ethical Board of the University of Palermo (N. 111/2022) and conformed to criteria for the use of persons in research as defined in the Declaration of Helsinki. All older adults participated voluntarily and could withdraw from the study at any time.

Data collection and outcomes

Fear of falling

FoF was used as the dependent variable, while the independent variables were grouped into three macro-categories: sociodemographic, physical, and mental health.

FoF was determined through the Short Falls Efficacy Scale International (Short FES-I), a scale that investigates the worry of falling while performing some basic and/or social activities of daily life²¹. It allows to quantify the intensity of the FoF and the activities that cause fear. Each question can be answered by selecting one of four options ranging from “does not worry me” to “worries me a lot”. The total score of the Short FES-I is obtained by simply adding up the scores of all the nine items, resulting in these ranges: 7–8 (low concern about falling), 9–13 (moderate concern), 14–28 (high concern)²². For our study we considered the variable categorized into “low concern” and “moderate/high concern” (derived by summing up the high and moderate levels).

All the variables possibly associated to the FoF were collected through standardized tools, and were treated both as quantitative and qualitative; in fact, quantitative variables were dichotomized for the sake of the study into binary variables. All these variables were grouped into three macro domains, with the “sociodemographic” domain including gender, age, living area, civil status, living situation, education, and current occupation; the “physical health” domain encompassing weight status, PA status, disease number, musculoskeletal and neuropsychiatric disease, previous falls, and all the physical tests performances; the “mental health” domain incorporated the perceived physical and mental health, and all the six dimensions of the psychological well-being.

Socio-demographic domain

An information questionnaire composed by several sections was administered to all participants. The sociodemographic variables considered were the following: gender (male/female), age (55–70/ > 70 years), civil status (married/unmarried), living situation (alone/with family), education (primary, secondary low/secondary high, degree), current occupation (occupied/retired, home worker), living area (city center/suburb).

Physical health domain

Factors related to the “physical health” of the sample included different aspects.

Weight and height were self-reported by the participants; weight status (normal weight/overweight, obese) was estimated by the Body Mass Index (BMI) cut-offs for adults, in underweight (< 23.0 kg/m²), normal weight (23.0–24.9 kg/m²), overweight (25.0–29.9 kg/m²), and obese (≥ 30.0 kg/m²).

Physical Activity (PA) status (active/inactive) was estimated through the International Physical Activity Questionnaire (IPAQ), which consists of seven items used to estimate the amount of physical activity performed over the past 7 days by the subjects²³. By means of questions, participants report how many days and minutes of PA of different intensities and walking they perform and how long they remain seated, in order to calculate a score corresponding to metabolic equivalence of task in minutes per week (MET min/week). The MET expresses the amount of energy expended to perform PA and 1 MET is equivalent to what is consumed when at rest. For each type of PA, a different MET is obtained by multiplying: minutes spent in PA, days and a MET value arbitrarily assigned to each PA²⁴. The questionnaire outcome, therefore, is obtained through the sum of the METs consumed for each type of PA (vigorous, moderate, or walking). The patient can be classified as inactive if the total MET count is less than 700, sufficiently active if the score ranges between 700 and 2519 METs, and active or very active if the total is ≥ 2520 METs; in the present study we used the binary variable active/inactive, in which active participants had a total MET score above 700²⁵.

The presence of diseases was assessed through the information questionnaire, and the final considered variables were number (1/> 1 diseases) and type (musculoskeletal/neuro-psychiatric diseases). Eventual previous falls (no/yes) were also evaluated by using the same questionnaire.

All the physical fitness (PF) data were collected using the Senior Fitness Test (SFT)²⁶. This is a battery of tests designed by Rikli and Jones in 2001 for a population over 60 years of age, consisting of the following exercises: 1) Chair Stand Test, to test leg strength and endurance; 2) Arm Curl in 30 s, to test upper body strength; 3) 6-Min Walk Test, to test aerobic capacity and endurance; 4) 2 in Step Test, to test aerobic capacity and endurance; 5) Chair Sit and Reach Test, to measure the flexibility of the lower back and hamstring muscles; 6) Back Stretch Test, to assess the flexibility of the shoulder joint and the left and right shoulder arch; 7) Timed Up and Go Test (TUG), to assess mobility, balance, walking ability, and fall risk; to be noted that the TUG measures the time (in seconds) a person takes to complete a round starting from the standing from a chair with no arms, walking 3 meters and returning to sit down; thus, the higher the time the lower the performance. Aerobic capacity was assessed with the 2-min step test and not the 6-min walking test as the former was more accessible and feasible in an elderly population than the latter²⁷. Each test in the battery has its own reference score classified by age and gender. The variables related to the PF were classified into “above average” and “below average” (<https://www.medicina.univr.it/documenti/OccorrenzaIns/matdid/matdid182478.pdf>) and were named as leg strength, lower body flexibility, upper body strength, lower body flexibility, mobility and balance, and aerobic capacity. In addition, the mobility and balance ability (that measures the time an adult needs to get up from a chair, walk 3 meters, turn around, come back to the chair and sit down) was used to evaluate individuals as “frail”, when the time to perform the test was longer than 12 s^{28,29}.

Mental health domain

A series of variables aimed at evaluating “mental and psychological health” were collected through standardized instruments.

The perceived physical health (pPH) and perceived mental health (pMH) were evaluated through the Short Form 12 (SF-12) and dichotomized into “above average” and “below average” according to predefined values in relation to the age of the subjects³⁰. The SF-12 is a 12-item questionnaire derived from the 36 items of the original SF-36 questionnaire³¹. The SF-12 produces two measures relating to two different aspects of health: perceived physical component and perceived mental component and consists of four scales: physical functioning, role and physical health, role and emotional state, and mental health. Through the 12 items, health status can be described by two summary indices: the physical component summary (PCS), which concerns physical health, and the mental component summary (MCS), which measures mental health. The results of the two indices PCS and MCS were evaluated through the algorithms of a Microsoft Excel software spreadsheet³².

The Psychological Well-Being Scale (PWS)³³ was used to collect information on six dimensions of the psychological well-being: positive relations, autonomy, control, personal growth, life objectives, and self-acceptance. It is a self-reported questionnaire composed of 18 items. The items are rated on a 5-point Likert scale (from 1 = never true for me to 5 = always true for me). For each of the six dimensions there are three items, and each item is given a score from 1 to 5. The score for all dimensions is distributed as follows: low (score until 7), moderate (8–13), and high (14–15). The classification into low (L) and medium/high (M/H) was used for the analysis. In the present study we used the Italian version adapted by Ruini et al.³⁴.

Statistical analysis

Statistics were performed by using the software STATA/MP 12.1 (Stata- CorpLP, College Station, TX, USA).

Normality analysis was conducted through the Shapiro-Francia test³⁵.

Means/Standard Deviations (SDs) and Medians/Interquartile Ranges (IQRs) were estimated for quantitative normally distributed and not normally distributed data, respectively, while frequencies in number and percentages were estimated for categorical data.

In order to show graphically relationships and patterns between categorized variables projected into space-dimensions, reducing at the same time the dimensionality of the large number of factors, a Multiple Correspondence Analysis (MCA) was conducted. MCA is an exploratory multivariate factor analysis, widely used in population-based surveys addressing healthy lifestyle, and it has been used also in studies targeting medical, socio-demographic or psychological conditions in aging populations^{36,37}. All variables were dichotomized before being included in the MCA. As some authors suggest, a two-dimensional plot was chosen to allow for better data interpretation³⁸. The default method of MCA in STATA was used, which is a correspondence analysis of the Burt matrix for the data, followed by simple scale adjustments of the principal inertias (in STATA “Burt/adjusted inertias” method)³⁹.

A plot was obtained to graphically see data clustering. Distances of categories from the origin of the axes (horizontal for Dimension 1 and vertical for Dimension 2) helped to identify variables that were the most correlated with each dimension; a category that is closer to the origin fits more with the independence hypothesis and, then, corresponds to an average pattern, while a category lying farther from the origin reveals distinctive characteristics.

The discriminant values were estimated both for overall and the single two dimensions. “Principal inertia” percent was taken as a geometric measure of the dispersion of the profiles, with higher values corresponding to higher dispersion of the categories from the origin. The “mass” of the category represents the proportion in the marginal distribution (with the masses of all categories of a variable adding up to 1). “Quality” values indicate categories that were the most represented, and are expressed as a number between 0 (very bad) and 1 (perfect). The percentage of inertia is the % of inertia contained in the category, with total inertia summing up to 100%. The values relative to the squared residuals between the profile and the categories are indicated as “sqcorr”, and their sum adds up to the quality of the approximation for the category. “Contribution” values indicate the relationship between category and dimension, and its values add up to 1 over all categories of a variable³⁹. Moreover, on each dimension, categories that are very close to each other are shared by similar subjects, while categories opposite on the dimension belong to distinct sets of individuals; categories around zero will not be part of the dimension constituents.

To explore relationships between quantitative variables, correlations and regression analyses were performed. A linear correlation analysis between the FoF (dependent variable) and the considered independent variables was conducted, using Pearson or Spearman correlation coefficients, depending on the data distribution. The variables significantly correlated with the FoF were then included in a multiple linear regression model in order to predict factors influencing the FoF, and regression coefficients (coef), Standard Errors (SE), and *p*-values were obtained, together with standardized coefficients (beta). All estimates were considered statistically significant at a *p*-value < 0.05.

Results

Sample description

Results on the quantitative and categorical variables are described in Tables 1 and 2, respectively.

More than a half of the sample (59.0%) showed a moderate/high concern of falling, with a median score of 9.0 and IQR of 4.00. Nearly equal distributions are showed for the two subcategories of age, civil status, and education, while higher percentages of participants were females (86.0%), reported living in suburban areas (74.2%), with the family (66.0%), and were retired (79.0%).

A high percentage of the sample was overweight or obese (57.7%), with a median BMI above the cut-off for overweight status (25.8 kg/m²), even though the major part was active (73.9%) with a median MET of 1560, and most of the fitness performances were above the average of the population (mobility and balance 90.4%, upper body strength 82.2%, aerobic capacity 69.6%, leg strength 56.3%, and upper body flexibility 55.5%). Additionally, considering the performance in mobility and balance (TUG Test), only 12.2% of the individuals were classified as “frail” (data not shown in the table).

Most people declared having more than one disease (72.4%), with more than a half of the sample (58.9%) having musculoskeletal diseases, and 20.6% reporting neuropsychiatric diseases. Almost half of the sample declared a previous fall (46.1%), in particular, 24.6% out of them reported a fall in the previous 12 months (of which 12.3% in the previous month), 49.1% between 1 and 5 years ago, and 26.3% more than 5 years ago (data not shown in the table).

Regarding the mental health domain, most participants had a pPH above the average (62.4%), while the pMH was below the average for most of them (66.1%); the medians of the scores were, respectively, 45.5 (IQR 12.49) and 47.7 (IQR 140.45). The perceived psychological well-being was generally low (scores lower than 7) for most people along the six dimensions of control (96.5%), positive relations (94.2%), life objectives (90.1%), autonomy (86%), personal growth (85.4%), and self-acceptance (57.9%), with mean values ranging from 8.4 (in positive relations) to 11.9 (in self-acceptance).

Multiple correspondence analysis results

Dimensions 1 and 2 explained the highest percentage of variability, for a total of 54.1%; the first dimension explained the 41.8% of the variance, and the second accounted for 12.3%.

The best overall represented categories (showing the highest quality values) were the FoF (0.794), gender (0.715), civil status (0.715), living alone/not-alone (0.711), education (0.716), musculoskeletal diseases (0.719), and previous falls (0.706); the poorest representations occurred for age (0.097), living area (0.038), and self-acceptance (0.095) (Supplementary Table S1).

	N	Mean ± SD
Age (years)	229	70.5 ± 5.96
Functional fitness abilities		
Leg strength (n. of chair stands)	180	10.0 ± 2.49
Upper body strength (n. of arm curls in 30s)	176	14.0 ± 3.98
Upper body flexibility (dx) (distance in cm)	177	-13.0 ± 14.29
Aerobic capacity (distance in m)	182	119.0 ± 42.45
Psychological well-being dimensions (score)		
Positive relations	171	8.4 ± 1.72
Autonomy	171	10.9 ± 2.16
Control	171	9.7 ± 1.95
Personal growth	171	11.5 ± 1.85
Life objectives	171	8.6 ± 2.40
Self acceptance	171	11.9 ± 2.16
	N	Median (IQR)
Fear of falling (score)	229	9.0 (4.00)
BMI (Kg/m ²)	214	25.8 (5.24)
MET total (sum of min/week)	176	1560.0 (3070.00)
Functional fitness abilities		
Lower body flexibility (dx) (distance in cm)	182	-8.5 (19.50)
Lower body flexibility (sx) (distance in cm)	182	-9.0 (20.00)
Upper body flexibility (sx) (distance in cm)	179	-17.0 (15.50)
Mobility and balance (time in sec)	182	8.1 (2.28)
Perceived physical health (score)	186	45.5 (12.49)
Perceived mental health (score)	186	47.7 (140.45)

Table 1. Characteristics of the participants, showed as means and standard deviations (SDs) for normally distributed variables, and as medians and interquartile ranges (IQRs) for non-normally distributed variables. BMI Body Mass Index, MET Metabolic Equivalence of Task.

The categories that show the best contribution values (“contrib” values) to the inertia of Dimension 1 (≥ 0.04) are low FoF (0.061), male gender (0.075), being unmarried (0.040), being inactive (0.051), mental health perception above average (0.051), not having musculoskeletal diseases (0.050), below average mobility and balance (0.049), below average aerobic capacity (0.046). The MCA coordinate plot (Fig. 1) shows graphically these modalities best explaining Dimension 1, that are farthest from the origin on the horizontal axis.

The categories being more correlated (“sqcorr” values = 0.300 or more) to Dimension 1 are hierarchically FoF, gender, leg strength, pMH, musculoskeletal diseases, PA status, aerobic capacity, previous falls, mobility/balance, current occupation, civil status, living alone/not-alone, education, lower body flexibility, disease number and neuropsychiatric diseases (Supplementary Table S1). When these variables are graphically observed (Fig. 2) a kind of gradient can be identified, with people moderately or highly worrying of falls, females, socially isolated (living alone, unmarried, retired), low educated, physically frail (inactive; with low fitness levels of mobility/balance, aerobic capacity, leg strength and lower body flexibility; having experienced previous falls; having more than 1 disease; with musculoskeletal and neuropsychiatric diseases) and with low pMH, on the left along the horizontal axis of dimension 1, and the opposite conditions on the right side of the axis.

The best contributors to inertia of Dimension 2 are civil status in the two categories (0.049, 0.063), living alone/not-alone (0.066, 0.046), education in the two categories (0.070, 0.055) and perceived PH in both the modalities (0.044, 0.071); not having musculoskeletal diseases (0.044), M/H autonomy (0.035) and M/H life objectives (0.070) (Supplementary Table S1). In the MCA coordinate plot (Fig. 1) these modalities that best explain Dimension 2 are farthest from the origin on the vertical axis.

The categories more correlated to Dimension 2 (“sqcorr” values = 0.300 or more) are hierarchically pPH, life objectives, education, upper body strength and living in family/alone (Supplementary Table S1). Looking at the graph of dimension 2, a gradient along the vertical axis is observed with people lower educated, living in family, with upper body strength below average, low pPH and low life objectives in the inferior part of the axis, and the opposite categories laying above (Fig. 3).

Looking at the distances between the modalities of the different categories (Fig. 1), a clustering can be identified including all subjects with similar characteristics being closer to each other: those with low FoF are close to subjects occupied, graduated, normal weight, being active, suffering from just one disease, having all higher physical fitness performances, declaring high perceived physical and mental health, having life objectives and high personal growth. This cluster could be identified as a profile of subjects with low FoF that are “highly

Fear of falling (concern)	N								
Low	94								
Moderate/high	135								
Total	229								
Sociodemographic domain	N	%	Physical health domain	N	%	Mental health domain	N	%	
Gender	229		Weight status	213		Perceived physical health	186		
Female	197	86.0	Normal weight	90	42.3	Above average	116	62.4	
Male	32	14.0	Overweight/obese	123	57.7	Below average	70	37.6	
Age	229		PA status	176		Perceived mental health	186		
55–70	117	51.1	Active	130	73.9	Above average	63	33.9	
>70	112	48.9	Inactive	46	26.1	Below average	123	66.1	
Living area	198		Disease number	127		Positive relations	171		
City center	51	25.8	1	35	27.6	Moderate/high	10	5.8	
Suburban	147	74.2	> 1	92	72.4	Low	161	94.2	
Civil status	141		Musculoskeletal disease	141		Autonomy	171		
Married	78	55.3	No	58	41.1	Moderate/high	24	14.0	
Unmarried	63	44.7	Yes	83	58.9	Low	147	86.0	
Living in family/alone	141		Neuropsychiatric disease	141		Control	171		
In family	93	66.0	No	112	79.4	Moderate/high	6	3.5	
Alone	48	34.0	Yes	29	20.6	Low	165	96.5	
Education	124		Previous falls	141		Personal growth	171		
Primary/secondary low	62	50.0	No	76	53.9	Moderate/high	25	14.6	
Secondary high/degree	62	50.0	Yes	65	46.1	Low	146	85.4	
Current occupation	143		Lower body flexibility	113		Life objectives	171		
Occupied	30	21.0	Above average	53	46.9	Moderate/high	17	9.9	
Retired	113	79.0	Below average	60	53.1	Low	154	90.1	
			Upper body flexibility	110		Self acceptance	171		
			Above average	61	55.5	Moderate/high	72	42.1	
			Below average	49	44.5	Low	99	57.9	
			Leg strength	112					
			Above average	63	56.3				
			Below average	49	43.8				
			Upper body strength	107					
			Above average	88	82.2				
			Below average	19	17.8				
			Mobility and balance	114					
			Above average	103	90.4				
			Below average	11	9.6				
			Aerobic capacity	115					
			Above average	80	69.9				
			Below average	35	30.4				

Table 2. Frequencies showed as N. and % of the dichotomized variables considered in the study. PA Physical Activity.

educated, occupied, physically healthy, physically and mentally active'. On the contrary, all individuals with the opposite characteristics form a cluster showing worry of falling.

Correlation and regression analyses results

The linear correlation analysis revealed that 18 variables were significantly correlated to the FoF (Table 3): age, with older people having higher concern ($r=0.23$, $p<0.001$); current occupation, with people retired having a higher FoF ($\rho=0.25$, $p<0.01$); education, with those having a lower education being more concerned ($\rho=0.20$, $p<0.001$); BMI, with overweight/obese people having more worry of falling ($\rho=0.24$, $p<0.001$); total MET, with more active older individuals having lower concern of falling ($\rho=-0.23$, $p<0.01$); presence of musculoskeletal and neuropsychiatric diseases, directly correlated to the FoF ($\rho=0.23$, $p<0.01$, and 0.25 , $p<0.01$, respectively); previous falls, also directly related to the FoF ($\rho=0.21$, $p<0.05$); all the fitness performances, excluding the upper body flexibility, with higher scores correlated to lower FoF (r and ρ ranging from -0.21 to -0.35); perceived physical and mental health, with higher scores corresponding to lower FoF ($\rho=-0.55$ and -0.24 , $p<0.001$, respectively); and three of the six well-being dimensions, with people that

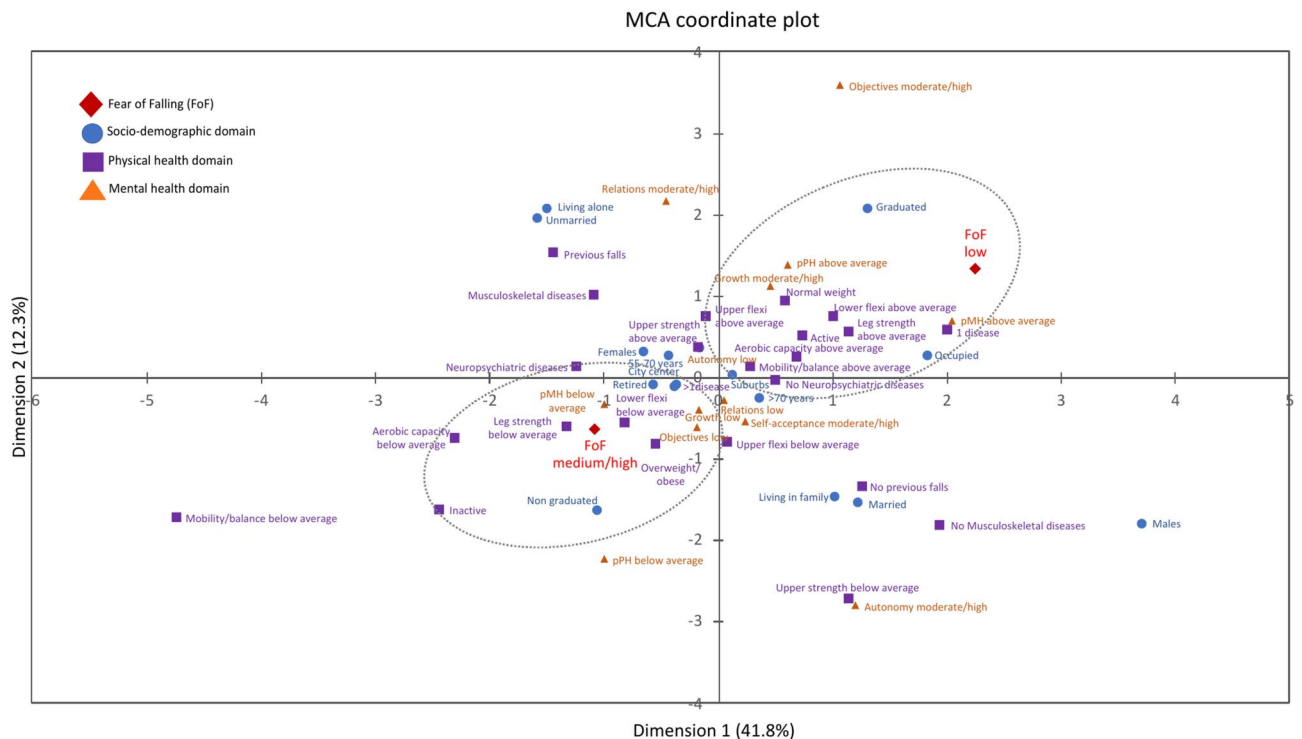


Fig. 1. Multiple Correspondence Analysis of the Fear of Falling (FoF) and the variables of the three considered domains (socio-demographic, physical health, and mental health domains). The distances between the modalities of the different categories indicate that subjects with similar characteristics are closer to each other. The modalities best explaining Dimension 1, which accounted for the 41.8% of the variance, are farthest from the origin on the horizontal axis, and are here clustered by the outlined ellipses. pPH = perceived physical health; pMH = perceived mental health.

declare higher autonomy, higher personal growth and higher self-acceptance, having lower FoF ($r = -0.18$, $p < 0.05$; $r = -0.17$, $p < 0.05$; $r = -0.22$, $p < 0.01$; respectively).

When a multiple regression model including the significantly correlated variables was analyzed, the following variables remained significant predictors of the FoF: BMI ($p < 0.01$), with a coef of 0.44, and beta of 0.47; musculoskeletal disease ($p < 0.05$), showing the highest coef (1.55), and beta 0.26; upper body strength ($p < 0.05$, coef 0.33, beta 0.38); mobility and balance (coef 0.76, beta 0.36); pPH ($p < 0.001$), coef -0.21 , beta -0.06 ; and self-acceptance ($p < 0.05$, coef -0.5 , beta -0.37) (Table 4).

Discussion

The present cross-sectional study provides an overview of sociodemographic, physical and mental characteristics in relation to the FoF, in a sample of physically independent older adults.

A concerning FoF in the examined sample has been evidenced in more than half participants. These results are in line with other papers stating that more than half of the older population suffers from FoF^{9,40,41}.

Overall characteristics of the sample

Sociodemographic domain

When exploring the sociodemographic aspects, most of the individuals were recruited from suburban areas, were retired and lived with other family components; equal distributions were observed for the younger and the older adults. These data are in line with the most recent data for Italian population (ISTAT 2023, available at: <https://www.istat.it/it/archivio/295586>). With regard to education levels, half people had at least a university diploma, this value being quite higher than the Italian population average of 11%, and so was the occupation rate (30%), that resulted higher than the national average of 8% (ISTAT 2023, available at: <https://www.istat.it/it/archivio/295586>). This result in contrast to the national average could be due to the interest in participating in the study by older people with a higher cultural level, considering that participation in our study was voluntary and not based on systematic sampling.

Around 34% of older people in our sample lived alone, this being confirmed by the 2023 ISTAT data stating that one third of the Italian population lives alone (ISTAT 2023, available at: <https://www.istat.it/it/archivio/295586>).

Physical health domain

With regard to the physical domain of the sample, the study showed a high overweight and obese prevalence, that reflects official data from the national surveillance system PASSI D'Argento (<https://www.epicentro.iss.it>

Categories along the axis 1 (Dimension 1)

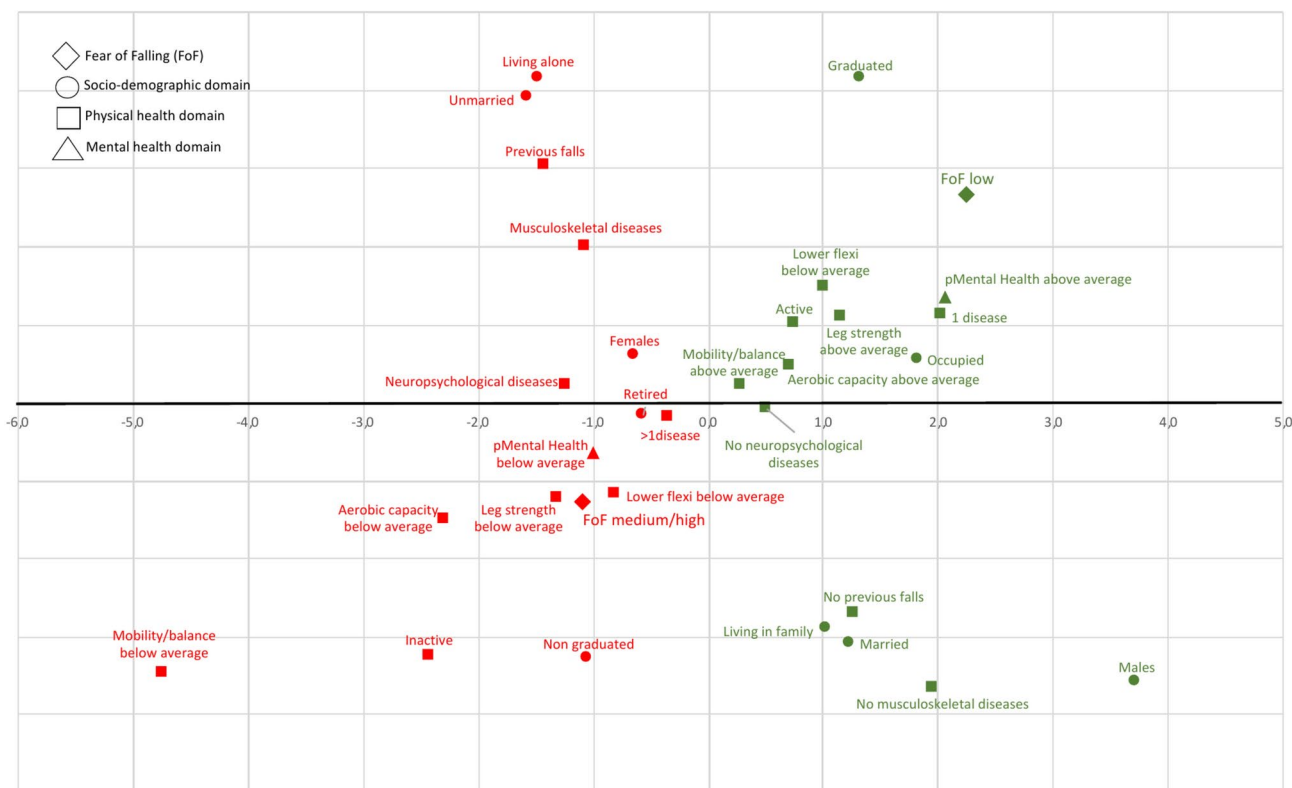


Fig. 2. Plot of the categories along the axis 1, explaining Dimension 1. Along the left of the axis, the most represented categories with people moderately or highly worrying of falls are showed; on the right side of the axis, the opposite categories in people with low FoF.

[t/passi-argento/dati/obesita](#)), with 57.7% of our sample versus 58.1% of the Italian population and 63.4% of the Sicilians. A considerable presence of multimorbidity was observed, including in particular musculoskeletal diseases. Despite these conditions, a large portion of this population was sufficiently or highly active and had a good physical fitness level. This was also confirmed by the low percentage of frail people in the sample. Moreover, when investigating the psychological perceptions of the participants, it resulted that more than a half had a good perception of their own physical health. These results are in line with a paper by Suryadinata et al.⁴², showing that there were no significant differences in physical activity levels between obese and non-obese people over 60, whereas there were significant differences among the younger populations. Overweight and obese people also overestimated the total amount of exercise by means of self-reported questionnaires⁴³, which could explain why our sample was sufficiently or highly active. Chen et al.⁴⁴ showed that the underweight and obese elderly had worse overall health than those who met the physical activity guidelines with a normal weight, and those who did not meet any of the physical activity guidelines were more likely to have worse physical and mental health, regardless of weight status. Thus, the advice is to engage in physical activity in order to increase levels of physical and mental health in the elderly.

Among the people that experienced previous falls, which amount at around the half of the sample, a quarter of them declared a recent (in the last 12 months) previous fall, with the 12.3% declaring a fall in the previous month; these data are slightly higher than the national average of 7.6% or the regional average of 9.4% (PASSI D'Argento 2021/2022, <https://www.epicentro.iss.it/passi-argento/dati/cadute>).

Mental health domain

Contrarily to the physical status, the mental health domain, both the pMH and the psychological well-being dimensions, were generally low in the considered sample of older people. The median PCS score of 45.5 (IQR 12.49) was in line with other data from the European Study of the Epidemiology of Mental Disorders reporting a median of 43.7 and a 25–75% quantile range of 31.8–50.3 for Italy; instead, for the MCS score the data reported in the present study were lower than those reported in that study (median 47.7, IQR 140.45 vs. 55.0, 48.9–58.8)⁴⁵. However, similar results for the mental health component were found out when compared to one Italian study reporting mean and SD of 46.2 ± 11.4 ⁴⁶. Concerning the psychological well-being dimensions, results obtained in our sample showed that scores in all dimensions fall in medium high (> 8) range, with the highest values for Self-acceptance and Personal growth dimensions and the lower ones for Positive relations and Life objectives (Table 1). As claimed by Fusi et al.⁴⁷, the developmental trajectories of the various subcomponents of PWB

Categories along the axis 2 (Dimension 2)

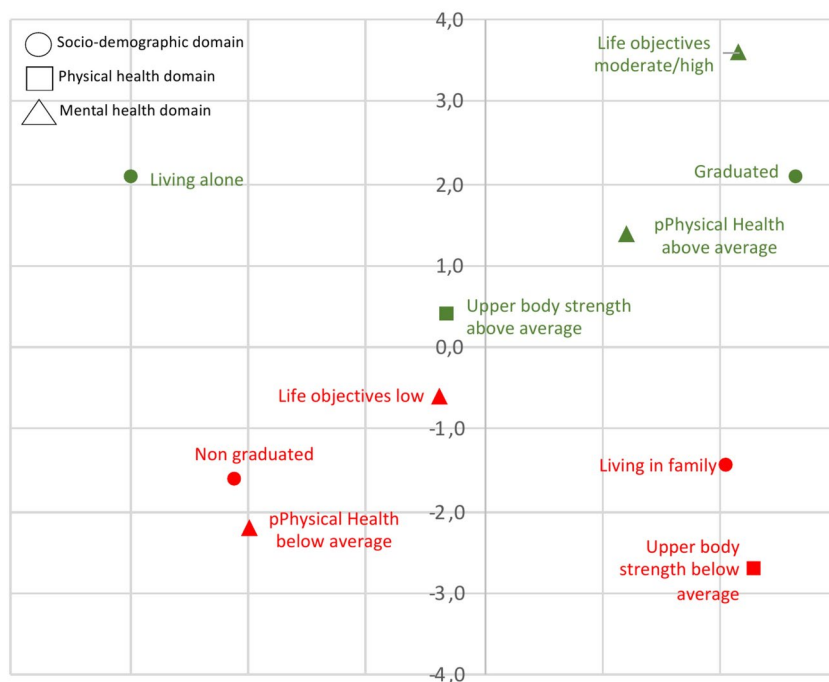


Fig. 3. Plot of the categories along the axis 2, explaining Dimension 2.

across the lifespan, are not completely clear, with some results by Ryff and Keyes³³ supporting a decline with age in some dimensions, and other studies evidencing a U-shaped trajectory also called “paradox of well-being”⁴⁸, with elderly people showing scores higher than young people⁴⁹; our results showed a good level of well-being, suggesting that our subjects might fall in the upward phase of the U-curve.

Relationships between variables

In this study, results for quantitative variables from the correlation analyses indicate that the highest correlations (r or $\rho > 0.3$) of FoF were found with physical health-related factors, such as (in order of strength of correlation) the pPH, aerobic capacity, leg strength, and mobility and balance, with all these fitness components inversely correlated to FoF. Among these factors, those predicting FoF after multiple regression analyses were the pPH and the mobility and balance, with this last ability highly influencing FoF ($R = 0.76$).

Other correlation coefficients were found to be lower (r or $\rho < 0.3$) but significant, with higher FoF in people being older, retired, with low education level, with higher weight status, inactive, with diseases and previous falls, lower upper body strength, lower body flexibility, lower pMH, and three well-being aspects (lower autonomy, personal growth, and self-acceptance).

Out of these variables, the ones that remained correlated with FoF in the adjusted regression analyses, and then resulted being predictors of a higher FoF, were the higher BMI, the presence of musculoskeletal disease, the poorer upper body strength score and the lower self-acceptance score as a component of the well-being score. This could have practical implications for planning of interventions and developing correct strategies targeted to elderly and aiming at reducing FoF; such kind of interventions, indeed, could be more efficacious if focused on older adults who are overweight, suffering of musculoskeletal diseases or diseases that involve a reduction of strength in their upper body, and on those who have a low self-acceptance.

The lack of correlations between FoF and MCS is consistent with the studies of Ozcan et al.⁵⁰ and Uriah et al.⁵¹. The first study showed how in the correlation analyses between FoF and SF-12, as the FoF increased, the quality of life decreased except for mental health; even the second exhibited that the PCS-12 was related to the FoF, whereas MCS wasn't.

The self-acceptance dimension of the well-being scale was the only mental well-being component independently associated with the FoF. Individuals with high self-acceptance are those who trust their own opinions and are independent from others, who are satisfied with most aspects of their personality and about how things have gone in their life, and that reported low FoF. This result is in line with our expectations and is an all-new finding considering that, to our knowledge, no other studies investigated the relationship between FoF and PWB using the Ryff's scale.

Our results highlight that the physical aspect has a preeminent role in influencing the FoF; with regards to the BMI effect, overweight/obese people are generally more worried about falling, and this is in line with some studies assessing anthropometrics as a possible influencing factor^{52,53}. Both the measured (musculoskeletal disease, upper body strength, and mobility and balance) and perceived physical health aspects were predictors

	Fear of falling (score)	
	Coeff.	r/rho
Age (years)	0.23***	r
Gender	0.10	rho
Living area	-0.01	rho
Living alone/family	0.01	rho
Current occupation	0.25**	rho
Education	0.20*	rho
BMI (kg/m ²)	0.24***	rho
MET total	-0.23**	rho
Disease number	0.12	rho
Musculoskeletal diseases	0.23**	rho
Neuropsychiatric diseases	0.25**	rho
Previous falls	0.21*	rho
Leg strength	-0.34***	r
Upper body strength	-0.26***	r
Lower body flexibility (dx)	-0.21**	rho
Upper body flexibility (dx)	-0.06	r
Mobility and balance	0.33***	rho
Aerobic capacity	-0.35***	r
Perceived physical health (score)	-0.55***	rho
Perceived mental health (score)	-0.24***	rho
Positive relations	-0.01	r
Autonomy	-0.18*	r
Control	-0.14	r
Personal growth	-0.17*	r
Life objectives	0.06	r
Self acceptance	-0.22**	r

Table 3. Pearson (r) and Spearman (rho) correlation coefficients between the fear of falling and the considered variables. Estimates were considered statistically significant at a p -value < 0.05 (* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$).

of FoF. In particular, mobility and balance were strong predictors of the FoF, as outlined in our study, and this is in line with the literature; e.g., the study from Badrasawi et al.⁵³ confirms that mobility and balance assessed through the Timed Up and Go Test was a mere predictor of the FoF; Schroeder et al.⁵⁴ demonstrated that gait and balance impairments were risk factors for FoF and falls; another study confirmed the risk of newly developed FoF related to lower ability of standing-balance and gait⁵⁵. Moreover, another study reported that functional impairment measured by the Short Physical Performance Battery was a predictor of the FoF⁵⁶; other studies outlined that impaired physical performance or physical frailty explained the increase in the FoF^{52,57,58}, and Washington and colleagues⁵⁹ reported that older adults with lower mobility performance/functioning scores were more likely to have FoF.

The upper body strength was one of the two physical fitness components, together with mobility/balance, that were predictors of the FoF. One recent study in the literature emphasizes the relationship between the upper extremity strength and the FoF, with strength reduced in those having FoF, so that it is underlined that muscle strength could be considered one of the significant indicators of the FoF⁶⁰. Another study highlights that muscle strength is significantly correlated with agility, which, in turn, predicts the FoF⁶¹.

The relationship found between FoF and presence of musculoskeletal disease has been also reported in other studies stating that, e.g., osteoarthritis, which is the most common progressive musculoskeletal disease and cause of disability in the elderly, is associated with increased prevalence of FoF and/or lower falls efficacy^{62,63}; minor physical function, buckling and sensations of instability were associated with FoF in people with knee osteoarthritis^{64,65}; in addition, ankle proprioceptive acuity was associated with FoF-related activity avoidance⁶⁶.

In agreement with other studies, pPH was revealed as an important predictor of the FoF. In the study from Korenhof et al.⁶⁷ significantly lower physical component scores were highlighted in people reporting moderate/high FoF; this association was found also in other two studies that confirmed an inverse association between the PCS score and the FoF^{10,68}.

In the present study, having experienced previous falls is not a predictor of FoF, although in the simple correlation a significance was found out. This is in contrast with the historical view that previous falls could generate FoF^{14,62,69-72}; however, it can be explained considering that there could be different factors which contribute to the onset of fear⁷³. Beyond a direct painful experience, fear could start even in the absence of

	Fear of falling (score)			
	Coeff.	SE	<i>p</i> -value	Beta coeff.
Age (years)	-0.04	0.639	0.545	-0.07
Current occupation	-3.08	1.277	0.026	-0.40
Education	0.12	0.101	0.248	0.15
BMI (kg/m ²)	0.44**	0.104	0.001	0.47
MET total	-0.00	0.000	0.085	-0.27
Musculoskeletal disease	1.55*	0.681	0.034	0.26
Neuropsychiatric disease	0.74	0.760	0.343	0.11
Previous falls	-1.02	0.805	0.220	-0.17
Leg strength	-0.08	0.158	0.611	-0.06
Upper body strength	0.33*	0.117	0.011	0.38
Lower body flexibility (dx)	0.03	0.035	0.402	0.11
Mobility and balance	0.76*	0.320	0.028	0.36
Aerobic capacity	-0.01	0.008	0.241	-0.16
Perceived physical health (score)	-0.21***	0.047	0.000	-0.06
Perceived mental health (score)	0.04	0.047	0.412	0.13
Autonomy (score)	-0.31	0.186	0.111	-0.22
Personal growth (score)	0.04	0.185	0.836	0.02
Self acceptance (score)	-0.52*	0.190	0.013	-0.37

Table 4. Coefficients and Standard Errors (SEs), *p*-values, and standardized beta coefficients of the multiple regression model between the fear of falling and the considered variables. Estimates were considered statistically significant at a *p*-value < 0.05 (* *p* < 0.05, ** *p* < 0.01, *** *p* < 0.001).

a fall via social observation, transmission, or verbal information^{74–76}, so that observing a fall, or having a friend with previous experience of fall, or receiving information about the risks of falling, may be sufficient for the development of FoF. This suggests that anxiety and worrying can occur even in the absence of a negative experience and explains how people with previous experience of falls do not develop FoF⁶⁹, as showed in our study (Coeff -1.02, SE 0.805, *p*-value 0.220). We then hypothesize that the main mental components that could generate an apprehension status leading to the FoF in our sample are the low perception of their physical health (as demonstrated by the regression analyses confirming the pPH is a predictor of FoF) and their low self-acceptance, rather than from the perception of the mental health or from other psychological factors.

Nonetheless, concerning the pattern elicited by the MCA of the present study, previous fall experience represented one important condition associated with the first Dimension which was delineated by a cluster of people with moderate or high FoF, of female gender, socially isolated, lower educated, physically frail and with low pMH. This analysis was used as a relevant statistical method for exploring the categorical data under examination. This method does not require assumptions regarding distributions, allows to reduce several variables identifying underlying structures, and provides a clear graphical output of the distances between variables. In the present study, two dimensions were identified, since they explained the highest percentage of variability. FoF, civil status, living alone/not alone, education, musculoskeletal diseases and previous falls were the categories that were the most represented overall. When examining the categories in the two dimensions, Dimension 1 provided the highest contribution and a clear pattern of features such as “FoF, gender, social life, education, physical health, and pMH”. In fact, a kind of gradient can be observed along the horizontal axis of Dimension 1, with people characterized by “FoF, female gender, socially isolated, lower educated, physically frail, low pMH” on the left side of the horizontal axis, and people with “low FoF, males, higher educated, physically healthy, high pMH” on the right side. This is explained also in many studies where higher FoF was evidenced in women^{57,68,77,78}; those with low education level or living alone⁷⁹; those with low income, widower/widow, housekeeper or retired, with a history of falling in the last year, or frail⁸⁰, or being physically inactive^{12,78}; and, finally, those with low physical performance or various morbidities⁵⁷.

Moreover, both the number and type of disease contributed to Dimension 1; in the literature, different studies outlined an increase of FoF in older people with more health conditions through mechanisms involving balance, gait, fall risk, psychological and cognitive function^{63,69,81–83}.

Another pattern was explained by Dimension 2, where few components were correlated and showed a gradient along the vertical axis: people “lower educated, living with the family, with upper body strength above average, low perceived PH and low life objectives” in the inferior part of the axis, and the opposite categories laying above. Education contributes to both dimensions, thus suggesting that it is a basic requirement helping older people to participate more in everyday life and to face the challenges of modern society through a physically and mentally active lifestyle. This is in line with some studies in the literature showing the influence of a lower education on the FoF increase both in contexts similar and different from Italy, such as the Netherlands⁸⁴, Germany⁸⁵, USA⁸⁶, Japan⁸⁷ or China⁸⁸. Considering the only component of life objectives, it reflects the ability to have goals and a sense of direction for life; probably this Dimension explains a pattern of undereducated individuals that feel

physically unhealthy and don't feel purposeful anymore, with the mental domain being preponderant on this dimension compared to Dimension 1.

In the model that we described, the role of psychological well-being was minor, as evidenced both in the MCA and in the correlation and regression analyses. Different studies in the literature have assessed an association of FoF with aspects related to the psychological well-being; e.g., FoF can be predicted by depressive symptoms^{57,89–92} or by mental Health-related quality-of-life (HRQoL) scores⁶⁷. In these associations, other variables can mediate interactions, such as activity avoidance⁹³, which could lead to lower social participation and then to lower HRQoL⁶⁷. These psychological factors should be addressed in the elderly to help them cope with challenges in their daily life^{68,94}.

When observing the distances between variables in the MCA graph, a profile of subjects with low FoF that are “highly educated, occupied, physically active, and mentally and physically healthy” has been identified, and an opposite cluster with contrasting characteristics could be observed close to individuals with moderate/high FoF.

Anyway, as it can be evidenced, the genesis of the FoF is explained by a complexity of factors that have a direct or indirect influence⁶⁹. Many studies analyzed the correlations of sociodemographic, physical, psychological or cognitive factors with FoF as separate factors, but actually factor analyses can be more adequate to identify patterns explaining how these factors co-exist and interact. All these considerations suggest that any kind of intervention to decrease the risk of falling could be targeted preferentially to that profile of people showing a higher FoF and being less educated, retired, physically and mentally frail. Some evidence exists that physical activity together with cognitive interventions could be effective in reducing the FoF in elderly populations^{12,95} above all when it is multifactorial and personalized, based on the physical or cognitive need of the people. This effect is mediated by the improvement of physical characteristics such as balance, gait, and mobility, and mental aspects such as self-efficacy, autonomy, or perceived health.

Limitations

Even though we have assessed the components of psychological well-being through the PWBS, a limit of our study is that a more deeply evaluation of aspects such as depression, anxiety or neuroticism, and even cognitive functions such as working or episodic memory, and executive function and attention, could have been assessed, since they could be important predictors of the FoF⁸⁷. Similarly, it could be interesting to consider also the mood and temperament of the older people, which was studied only in a few observational studies⁶⁹. We believe that in further studies all these aspects will be considered as part of the pattern.

Conclusion and implications

In conclusion, this study provided a profile of older people, consisting of individuals with moderate/high FoF, being low educated, non-occupied, physically unhealthy and inactive, and with a low level of mental and psychological health. This pattern suggests that interventions aimed at reducing the FoF should be addressed to this group of people, and could focus on specific aspects such as mobility and balance, upper body strength and the maintenance of an optimal body weight, among the physical factors, and on the increase of self-PPH and self-acceptance as psychological factors. These last psychological aspects can be experienced and perceived differently from individual to individual, thus we should bear in mind to conduct interventions on a personalized level. The importance of the awareness of the main factors that can lead to the FoF in the elderly could suggest how it can be useful to integrate an initial assessment of the mental and psychological status of the individual, focusing on his perception of the physical health and the dimension of his self-acceptance. This approach could help researchers or healthcare workers to correctly plan strategies and tailor interventions through also a right evaluation of the real risk of falling rather than the perceived one. It can encourage policy implementation to improve and foster environments for elderly. These actions should be carried out parallelly to monitoring interventions over time on older populations through novel analysis techniques, to identify groups that could develop FoF. The aim is mainly to increase daily physical activity and improve the physical performance, and this will be reflected on the reduction of the physical and cognitive decline, of isolation, and on the increase of safety, autonomy and independence and overall quality of life, finally reducing the risk of hospitalization.

Data availability

The datasets generated during and/or analysed during the current study are available from the corresponding author on reasonable request.

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References

1. Vaishya, R. & Vaish, A. Falls in older adults are serious. *Indian J. Orthop.* **54**, 69–74 (2020).
2. Tinetti, M. E. & Powell, L. A fear of falling and low self-efficacy: A cause of dependence in elderly persons. *J. Gerontol.* **48**, 35–38 (1993).
3. Legters, K. Fear of falling. *Phys. Ther.* **82**, 264–272 (2002).
4. Yardley, L. Fear of falling: Links between imbalance and anxiety. *Rev. Clin. Gerontol.* **13**, 195–201 (2003).
5. Lach, H. W. & Parsons, J. L. Impact of fear of falling in long term care: An integrative review. *J. Am. Med. Dir. Assoc.* **14**, 573–577 (2013).
6. Zijlstra, G. A. R. et al. Interventions to reduce fear of falling in community-living older people: A systematic review. *J. Am. Geriatr. Soc.* **55**, 603–615 (2007).
7. Gazibara, T. et al. Falls, risk factors and fear of falling among persons older than 65 years of age. *Psychogeriatrics* **17**, 215–223 (2017).

8. Mentis, M., Zervakis, E., Mavroei, E. & Konstantopoulou, G. The Impact of Fear of Falling (FOF) on the quality of life of the elderly: A cross-sectional clinical study in a Regional Health Center. *J. Psychol. Neurosci.* <https://doi.org/10.47485/2693-2490.1066> (2023).
9. Schoene, D. et al. A systematic review on the influence of fear of falling on quality of life in older people: Is there a role for falls?. *Clin. Interv. Aging* **14**, 701–719 (2019).
10. Bjerk, M., Brovold, T., Skelton, D. A. & Bergland, A. Associations between health-related quality of life, physical function and fear of falling in older fallers receiving home care. *BMC Geriatr.* **18**, 253 (2018).
11. Boyd, R. & Stevens, J. A. Falls and fear of falling: Burden, beliefs and behaviours. *Age Ageing* **38**, 423–428 (2009).
12. Kumar, A. et al. Exercise for reducing fear of falling in older people living in the community: Cochrane systematic review and meta-analysis. *Age Ageing* **45**, 345–352 (2016).
13. Whipple, M. O., Hamel, A. V. & Talley, K. M. C. Fear of falling among community-dwelling older adults: A scoping review to identify effective evidence-based interventions. *Geriatr. Nur. (Lond.)* **39**, 170–177 (2018).
14. Chen, W.-C., Li, Y.-T., Tung, T.-H., Chen, C. & Tsai, C.-Y. The relationship between falling and fear of falling among community-dwelling elderly. *Medicine* **100**(26), e26492. <https://doi.org/10.1097/MD.00000000000026492> (2021).
15. Toyoda, H., Hayashi, C. & Okano, T. Associations between physical function, falls, and the fear of falling among older adults participating in a community-based physical exercise program: A longitudinal multilevel modeling study. *Arch. Gerontol. Geriatr.* **102**, 104752 (2022).
16. Jin, J. Prevention of falls in older adults. *JAMA* **319**, 1734 (2018).
17. Sourial, N. et al. Correspondence analysis is a useful tool to uncover the relationships among categorical variables. *J. Clin. Epidemiol.* **63**, 638–646 (2010).
18. Costa, P. S., Santos, N. C., Cunha, P., Cotter, J. & Sousa, N. The use of multiple correspondence analysis to explore associations between categories of qualitative variables in healthy ageing. *J. Aging Res.* **2013**, 1–12 (2013).
19. Torres, M. J., Pédrone, G., Rigou, A., Carcaillon-Bentata, L. & Beltzer, N. Identifying profiles of people aged 65 and over who fall at home and associated falling-induced injuries: The French ChuPADom study. *Injury* **53**, 2511–2518 (2022).
20. Navarra, G. A. et al. Functional fitness, lifestyle and demographic factors as predictors of perceived physical and mental health in older adults: A structural equation model. *PLoS ONE* **18**, e0290258 (2023).
21. Kempen, G. I. J. M. et al. The short FES-I: A shortened version of the falls efficacy scale-international to assess fear of falling. *Age Ageing* **37**, 45–50 (2007).
22. Delbaere, K. et al. The Falls Efficacy Scale International (FES-I). A comprehensive longitudinal validation study. *Age Ageing* **39**(2), 210–216. <https://doi.org/10.1093/ageing/afp225> (2010).
23. Craig, C. L. et al. International physical activity questionnaire: 12-Country reliability and validity. *Med. Sci. Sports Exerc.* **35**, 1381–1395 (2003).
24. Wolin, K. Y., Heil, D. P., Askew, S., Matthews, C. E. & Bennett, G. G. Validation of the international physical activity questionnaire-short among blacks. *J. Phys. Act. Health* **5**, 746–760 (2008).
25. Abate Daga, F., Agostino, S., Peretti, S. & Beratto, L. COVID-19 nationwide lockdown and physical activity profiles among North-western Italian population using the International Physical Activity Questionnaire (IPAQ). *Sport Sci. Health* **17**, 459–464 (2021).
26. Rikli, R. E. & Jones, C. J. Development and validation of criterion-referenced clinically relevant fitness standards for maintaining physical independence in later years. *The Gerontologist* **53**, 255–267 (2013).
27. Langhammer, B. & Stanghelle, J. K. The senior fitness test. *J. Physiother.* **61**, 163 (2015).
28. Machón, M. et al. Dietary patterns and their relationship with frailty in functionally independent older adults. *Nutrients* **10**, 406 (2018).
29. Herman, T., Giladi, N. & Hausdorff, J. M. Properties of the ‘timed up and go’ test: More than meets the eye. *Gerontology* **57**, 203–210 (2011).
30. Apolone, G., Mosconi, P. & Quattrocioni, L. *Questionario Sullo Stato Di Salute SF-12. Versione Italiana.* (Guerini e Associati, 2005).
31. Jakobsson, U. Using the 12-item Short Form health survey (SF-12) to measure quality of life among older people. *Aging Clin. Exp. Res.* **19**, 457–464 (2007).
32. Ottoboni, G., Cherici, A., Marzocchi, M. & Chattat, R. Algoritmi di calcolo per gli indici PCS e MCS del questionario SF-12. (2017) <https://doi.org/10.6092/UNIBO/AMSACTA/5751>.
33. Ryff, C. D. & Keyes, C. L. M. The structure of psychological well-being revisited. *J. Pers. Soc. Psychol.* **69**, 719–727 (1995).
34. Ruini, C., Ottolini, F., Rafanelli, C., Ryff, C. & Fava, G. A. La validazione italiana delle psychological well-being scales (PWB). *Riv. Psichiatria.* <https://doi.org/10.1708/173.1864> (2003).
35. Mbah, A. K. & Paothong, A. Shapiro-Francia test compared to other normality test using expected *p*-value. *J. Stat. Comput. Simul.* **85**, 3002–3016 (2015).
36. Dartigues, J.-F. et al. Co-occurrence of geriatric syndromes and diseases in the general population: Assessment of the dimensions of aging. *J. Nutr. Health Aging* **26**, 37–45 (2022).
37. Jones, I. R., Papacosta, O., Whincup, P. H., Goya Wannamethee, S. & Morris, R. W. Class and lifestyle ‘lock-in’ among middle-aged and older men: A multiple correspondence analysis of the British Regional Heart Study. *Sociol. Health Illn.* **33**, 399–419 (2011).
38. Gifi, A. *Nonlinear Multivariate Analysis* (Wiley, 1991).
39. Greenacre, M. *Correspondence Analysis in Practice* (Chapman and Hall/CRC, 2017). <https://doi.org/10.1201/9781315369983>.
40. Romli, M. H., Mackenzie, L., Lovarini, M., Clemson, L. & Tan, M. P. Home hazards with fear of falling: Findings from the baseline study of the Malaysian elders longitudinal research (MELoR). *Front. Public Health* **8**, 612599 (2021).
41. Zijlstra, G. A. R. et al. Prevalence and correlates of fear of falling, and associated avoidance of activity in the general population of community-living older people. *Age Ageing* **36**, 304–309 (2007).
42. Suryadinata, R. V., Wirjatmadi, B., Adriani, M. & Lorensia, A. Effect of age and weight on physical activity. *J. Public Health Res.* <https://doi.org/10.4081/jphr.2020.1840> (2020).
43. Hainer, V., Toplak, H. & Stich, V. Fat or fit: What is more important?. *Diabetes Care* **32**, S392–S397 (2009).
44. Chen, S., Ling, J. & Cheng, Y. Physical activity and body mass index were interactively related to health-related quality of life among older adults. *Arch. Gerontol. Geriatr.* **104**, 104833 (2023).
45. König, H.-H. et al. Health status of the advanced elderly in six European countries: Results from a representative survey using EQ-5D and SF-12. *Health Qual. Life Outcomes* **8**, 143 (2010).
46. Gasperini, B. et al. The earlier the better: Health-related quality of life is inversely related to age of smoking cessation in older former Italian smokers. *Aging Clin. Exp. Res.* **29**, 655–663 (2017).
47. Fusi, G. et al. Aging and psychological well-being: The Possible role of inhibition skills. *Healthcare* **10**, 1477 (2022).
48. Stone, A. A., Schwartz, J. E., Broderick, J. E. & Deaton, A. A snapshot of the age distribution of psychological well-being in the United States. *Proc. Natl. Acad. Sci.* **107**, 9985–9990 (2010).
49. Kunzmann, U., Little, T. D. & Smith, J. Is age-related stability of subjective well-being a paradox? Cross-sectional and longitudinal evidence from the Berlin Aging Study. *Psychol. Aging* **15**, 511–526 (2000).
50. Ozcan, A., Donat, H., Gelecek, N., Ozdirenc, M. & Karadibak, D. The relationship between risk factors for falling and the quality of life in older adults. *BMC Public Health* **5**, 90 (2005).
51. Uriah, S. S., Oguzor, U. C., Atata, C. T., Nwanze, N. M. & Dienye, P. O. Fear of falling and its relationship with quality of life in the elderly attending a family medicine clinic in South-South Nigeria. *West Afr. J. Med.* **40**, S23–S24 (2023).

52. Freiburger, E. et al. Transient versus stable nature of fear of falling over 24 months in community-older persons with falls– data of the EU SCOPE project on Kidney function. *BMC Geriatr.* **22**, 698 (2022).
53. Badrasawi, M. et al. Predictors of fear of falling among community-dwelling older adults: Cross-sectional study from Palestine. *PLoS ONE* **17**, e0276967 (2022).
54. Schroeder, O., Schroeder, J., Fitschen-Oestern, S., Besch, L. & Seekamp, A. Effectiveness of autonomous home hazard reduction on fear of falling in community-dwelling older women. *J. Am. Geriatr. Soc.* **70**, 1754–1763 (2022).
55. Oshima, K., Asai, T., Fukumoto, Y., Yonezawa, Y. & Nishijima, A. Development and persistence of fear of falling relate to a different mobility functions in community-dwelling older adults: One-year longitudinal predictive validity study. *Aging Clin. Exp. Res.* **33**, 2453–2460 (2021).
56. Curcio, C.-L. et al. A regression tree for identifying risk factors for fear of falling: The international mobility in aging study (IMIAS). *J. Gerontol. Ser. A* **75**, 181–188 (2020).
57. Dos Santos, E. P. R. et al. Investigating factors associated with fear of falling in community-dwelling older adults through structural equation modeling analysis: A cross-sectional study. *J. Clin. Med.* **12**, 545 (2023).
58. Makino, K. et al. Prospective associations of physical frailty with future falls and fear of falling: A 48-month cohort study. *Phys. Ther.* **101**, pzb059 (2021).
59. Washington, S. E., Snyder, M., Hu, Y.-L. & Stark, S. L. Evaluation of race as a predictor of fear of falling in Black older adults. *Clin. Gerontol.* **46**, 47–52 (2023).
60. Yardimci, B., Akdeniz, M. & Demir, T. The correlation between fear of falling and upper extremity muscle strength. *Saudi Med. J.* **42**, 411–418 (2021).
61. Rodrigues, F., Monteiro, A. M., Forte, P. & Morouço, P. Effects of muscle strength, agility, and fear of falling on risk of falling in older adults. *Int. J. Environ. Res. Public Health* **20**, 4945 (2023).
62. Liu, J. Y. Fear of falling in robust community-dwelling older people: Results of a cross-sectional study. *J. Clin. Nurs.* **24**, 393–405 (2015).
63. Moreira, B. D. S. et al. Factors associated with fear of falling in community-dwelling older adults with and without diabetes mellitus: Findings from the Frailty in Brazilian Older People Study (FIBRA-BR). *Exp. Gerontol.* **89**, 103–111 (2017).
64. Nguyen, U.-S.D.T. et al. The impact of knee instability with and without buckling on balance confidence, fear of falling and physical function: The Multicenter osteoarthritis study. *Osteoarthritis Cartilage* **22**, 527–534 (2014).
65. Tsonga, T. et al. Risk factors for fear of falling in elderly patients with severe knee osteoarthritis before and one year after total knee arthroplasty. *J. Orthop. Surg.* **24**, 302–306 (2016).
66. Deshpande, N. et al. Ankle proprioceptive acuity is associated with objective as well as self-report measures of balance, mobility, and physical function. *AGE* **38**, 53 (2016).
67. Korenhof, S. et al. The association of fear of falling and physical and mental Health-Related Quality of Life (HRQoL) among community-dwelling older persons; A cross-sectional study of Urban Health Centres Europe (UHCE). *BMC Geriatr.* **23**, 291 (2023).
68. Suzuki, M., Ohyama, N., Yamada, K. & Kanamori, M. The relationship between fear of falling, activities of daily living and quality of life among elderly individuals. *Nurs. Health Sci.* **4**, 155–161 (2002).
69. Peeters, G., Bennett, M., Donoghue, O. A., Kennelly, S. & Kenny, R. A. Understanding the aetiology of fear of falling from the perspective of a fear-avoidance model – A narrative review. *Clin. Psychol. Rev.* **79**, 101862 (2020).
70. Lavedán, A. et al. Fear of falling in community-dwelling older adults: A cause of falls, a consequence, or both?. *PLoS ONE* **13**, e0194967 (2018).
71. Ayoubi, F., Launay, C. P., Annweiler, C. & Beauchet, O. Fear of falling and gait variability in older adults: A systematic review and meta-analysis. *J. Am. Med. Dir. Assoc.* **16**, 14–19 (2015).
72. De Souza, N. S. et al. The influence of fear of falling on orthostatic postural control: A systematic review. *Neurol. Int.* <https://doi.org/10.4081/ni.2015.6057> (2015).
73. Mineka, S. & Zinbarg, R. A contemporary learning theory perspective on the etiology of anxiety disorders: It's not what you thought it was. *Am. Psychol.* **61**, 10–26 (2006).
74. Bennett, M. P., Meulders, A., Baeyens, F. & Vlaeyen, J. W. S. Words putting pain in motion: The generalization of pain-related fear within an artificial stimulus category. *Front. Psychol.* <https://doi.org/10.3389/fpsyg.2015.00520> (2015).
75. Cameron, G., Roche, B., Schlund, M. W. & Dymond, S. Learned, instructed and observed pathways to fear and avoidance. *J. Behav. Ther. Exp. Psychiatry* **50**, 106–112 (2016).
76. Dymond, S. & May, R. Quantifying the empirical growth of relational frame theory research: A cautionary note. *Psychol. Rec.* **68**, 255–260 (2018).
77. Scheffer, A. C., Schuurmans, M. J., Van Dijk, N., Van Der Hooft, T. & De Rooij, S. E. Fear of falling: Measurement strategy, prevalence, risk factors and consequences among older persons. *Age Ageing* **37**, 19–24 (2008).
78. Denking, M. D., Lukas, A., Nikolaus, T. & Hauer, K. Factors associated with fear of falling and associated activity restriction in community-dwelling older adults: A systematic review. *Am. J. Geriatr. Psychiatry* **23**, 72–86 (2015).
79. Choi, K. & Ko, Y. Characteristics associated with fear of falling and activity restriction in South Korean older adults. *J. Aging Health* **27**, 1066–1083 (2015).
80. Baneshi, R. et al. Fear of falling and its relationship with frailty in older adults. *Salmand* **18**, 204–217 (2023).
81. Jonasson, S. B., Ullén, S., Iwarsson, S., Lexell, J. & Nilsson, M. H. Concerns about falling in Parkinson's disease: Associations with disabilities and personal and environmental factors. *J. Park. Dis.* **5**, 341–349 (2015).
82. Schmid, A. A. et al. Fear of falling in people with chronic stroke. *Am. J. Occup. Ther.* **69**(3), 6903350020p1–6903350020p5. <https://doi.org/10.5014/ajot.2015.016253> (2015).
83. Chang, H.-T., Chen, H.-C. & Chou, P. Factors associated with fear of falling among community-dwelling older adults in the Shih-Pai study in Taiwan. *PLoS ONE* **11**, e0150612 (2016).
84. Kempen, G. I., Van Haastregt, J. C., McKee, K. J., Delbaere, K. & Zijlstra, G. R. Socio-demographic, health-related and psychosocial correlates of fear of falling and avoidance of activity in community-living older persons who avoid activity due to fear of falling. *BMC Public Health* **9**, 170 (2009).
85. Hajek, A., Bock, J. & König, H. Psychological correlates of fear of falling: Findings from the German aging survey. *Geriatr. Gerontol. Int.* **18**, 396–406 (2018).
86. Dierking, L., Markides, K., Al Snih, S. & Kristen Peek, M. Fear of falling in older Mexican Americans: A longitudinal study of incidence and predictive factors. *J. Am. Geriatr. Soc.* **64**, 2560–2565 (2016).
87. Uemura, K. et al. Effects of mild cognitive impairment on the development of fear of falling in older adults: A prospective cohort study. *J. Am. Med. Dir. Assoc.* **16**(1104), 1104.e9–1104.e13 (2015).
88. Zhang, Y. et al. Age differences in factors affecting fear of falling among community-dwelling older adults: A cross-sectional study. *Geriatr. Nurs. N. Y. N* **49**, 74–80 (2023).
89. Gambaro, E. et al. The complex associations between late life depression, fear of falling and risk of falls. A systematic review and meta-analysis. *Ageing Res. Rev.* **73**, 101532 (2022).
90. Choi, N. G., Gell, N. M., DiNitto, D. M., Marti, C. N. & Kunik, M. E. Depression and activity-limiting fall worry among older adults: Longitudinal reciprocal relationships. *Int. Psychogeriatr.* **32**, 495–504 (2020).
91. Iaboni, A. & Flint, A. J. The complex interplay of depression and falls in older adults: A clinical review. *Am. J. Geriatr. Psychiatry* **21**, 484–492 (2013).

92. Turunen, K. M. et al. Associations of neuroticism with falls in older adults: Do psychological factors mediate the association?. *Aging Ment. Health* **26**, 77–85 (2022).
93. Gottschalk, S. et al. Mediating factors on the association between fear of falling and health-related quality of life in community-dwelling German older people: A cross-sectional study. *BMC Geriatr.* **20**, 401 (2020).
94. Rivasi, G., Kenny, R. A., Ungar, A. & Romero-Ortuno, R. Predictors of incident fear of falling in community-dwelling older adults. *J. Am. Med. Dir. Assoc.* **21**, 615–620 (2020).
95. Sherrington, C. et al. Exercise for preventing falls in older people living in the community. *Cochrane Database Syst. Rev.* <https://doi.org/10.1002/14651858.CD012424.pub2> (2019).

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Author contributions

G.T. analysed the data and drafted the manuscript, G.A.N. collected the data and drafted the manuscript, A.S. collected the data, E.T. contributed to the methodology setting, A.D.A. interpreted the results and worked on the manuscript, J.G.M. revised the manuscript, J.C.C. revised the manuscript, A.P. contributed to the study design, M.B. conceived the study and revised the manuscript. All authors reviewed the manuscript.

Declarations

Competing interests

The authors declare no competing interests.

Additional information

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Correspondence and requests for materials should be addressed to G.T.

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