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Prevalence of falls in noninstitutionalized people aged 65–80 and associations with sex and functional tests: A multicenter observational study

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Abstract

Falls have a considerable impact on the functional prognosis of older adults. The main focus of this multicenter, retrospective, observational study was to examine the prevalence of falls in Spanish people aged 65–80 years still living at home. The secondary aims included examining the overall sociodemographic and clinical variables associated with a history of falls and then stratifying these findings by sex. We also aimed to determine the differences between sexes with regard to the history and consequences of falls and to evaluate associations between fall history and functional performance tests. The 747 older adults had all participated in the otago exercise program, which is a progressive home program of strength, balance, and endurance exercises. They were recruited by nurses in 21 primary care centers in 10 Spanish provinces between September 2017 to December 2018. The participants' mean age was 72.2 (SD: 4.3) years, and 67% were women. We recorded sociodemographic and clinical variables, functional performance test results, and any falls and/or injuries in the last 12 months. We found that 32% had fallen, 36% of those had fallen more than once, and 48% had sustained injuries when they fell. The bivariate analysis showed that women had more than twice the odds of falling than

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men and that living alone and being obese or overweight increased the odds of a fall, although living alone was not associated with falls in the multivariable analysis. Our results could guide the development of risk-specific fall prevention programs to prevent disabilities in older people.

KEYWORDS

accidental falls, older adults, otago exercise program, physical functional performance, sex differences

1 | INTRODUCTION

There were more than 100 million people over the age of 65 living in the European Union in 2018, who accounted for just under a fifth of the total population (Eurostat, 2019). Increases in life expectancy, together with decreased birth rates, have resulted in an aging population, especially in Spain (Ministry of Health Social Services and Equality, 2014). In addition, medium-term projections show a progressive increase in disability and dependency as the population ages, which has been associated with falls in older adults (Ministry of Health Social Services and Equality, 2014).

Falls are commonly defined by the World Health Organization (2007) as “*inadvertently coming to rest on the ground, floor, or other lower level, excluding intentional change in position to rest in furniture, wall, or other objects.*” It is estimated that 28%–35% of people over 65 fall at least once a year (World Health Organization, 2007), with higher figures in those aged 80 plus (Rubenstein et al., 2021). Injuries caused by falls have been classified by the conceptual framework for the international classification for patient safety (World Health Organization & WHO Patient Safety, 2009) as transient or permanent, and minor or major, depending on whether it increases the length of hospital stays and compromises how older adults perform basic daily activities. However, while most falls do not result in serious injuries, approximately 5% of older adults who still live at home fall and sustain a fracture or require hospitalization (Rubenstein et al., 2021). These falls have been associated with increasing rates of disability and mortality (National Institute for Health and Care Excellence, 2013; Veronese et al., 2014).

Falls are more frequent in women, and the risk of falling has been related to many factors, such as older age, a history of previous falls, fear of falling and gait, and balance impairment (Dokuzlar et al., 2020; Kim et al., 2017; Liang et al., 2014; Tinetti & Kumar, 2010; Veronese et al., 2014). In many cases, falls are caused by a loss of dynamic balance while walking or by a person's inability to maintain their body's center of gravity when they are standing still (Veronese et al., 2014). It is also well-known that alterations in gait, balance, and muscle weakness in the lower extremities are linked to loss of functionality in older adults (M. Tinetti et al., 1988).

Although falls are not an inevitable outcome of aging, they are a major concern for most older adults and for the healthcare system (National Institute for Health and Care Excellence, 2013). The

functional status of older adults is seen as an indicator of health status and a predictor of disability in Spain and the country's primary care professionals use objective tests to measure performance (Guralnik et al., 2000).

The clinical application of these performance tests is based on identifying people who risk functional impairment and those who have a higher risk of falling (Veronese et al., 2014). Several studies have demonstrated that older adults who have recurrent falls achieve lower scores in tests that are commonly used to assess functional status (Karlsson et al., 2012; Shimada et al., 2011; Veronese et al., 2014) and that poorer functional status increases the risk of falls (Veronese et al., 2014). However, there is limited evidence about the associations between the most frequently used, and validated, performance tests, the history of falls, and any differences in these associations between men and women (Kim et al., 2017).

The main aim of this study was to examine the prevalence of falls in older Spanish adults, aged 65–80 years, who were still living in their own homes. There were four secondary objectives. The first was to examine sociodemographic and clinical variables associated with a history of falls in the last 12 months and the second was to identify any differences in those variables between the sexes. The third was to determine whether there were any differences in the history and consequences of falls by men and women in the last 12 months. The fourth was to evaluate any associations between a history of falls in the last 12 months and the results of functional performance tests.

2 | METHODS

2.1 | Design

This was a multicenter, retrospective, observational study. It followed the recommendations of the strengthening the reporting of observational studies statement, which aims to improve the quality of publication of observational studies (Elm et al., 2007). Baseline data from a trial that used the otago exercise program (OEP) (Albornos-Muñoz et al., 2018) were used for this study. The OEP is a progressive home-based exercise program, where trained health professionals help people engage in strength, balance, and endurance exercises.

2.2 | Sample

Convenience sampling was used to select 21 primary care centers in 10 provinces around Spain. Population estimates (National Institute of Statistics, 2020) showed that there were approximately 6,375,000 people aged 65–80 years of age in Spain in 2019. A value of population proportion of $p = 0.35$ was used for planning purposes, as a 35% incidence of falls was expected in this population (National Institute for Health and Care Excellence, 2013). We calculated that we needed to study a random sample of 714 individuals, with 95% confidence intervals (CI) and a precision of $\pm 3.5\%$.

2.3 | Selection criteria

The cohort comprised people aged 65–80 who were registered with the nominated study centers, who walked independently with or without the use of technical aids, such as a cane or walker, lived in their own home, and agreed to participate in the OEP. The inclusion and exclusion criteria for the OEP study protocol have previously been described in detail (Albornos-Muñoz et al., 2018). We excluded people with specific health issues that would have made it difficult for them to complete the program. People were also excluded if they were already participating in another clinical trial, research study, or exercise program that involved similar balance and strength activities to the OEP exercises.

2.4 | Recruitment

The participants were consecutively recruited between the 10th and 19th of each month from September 2017 to December 2018. Suitable subjects were suggested by four nurses from each primary care center until the total sample size for their province was reached. The monthly recruitment periods were agreed by all of the centers at the beginning of the study but were paused during vaccination campaigns.

2.5 | Study measures

The study variables were based on the available scientific literature and the *Consensus document on the prevention of frailty and falls in the older adults*, published by the Spanish Ministry of Health, Social Services and Equality (2014). The sociodemographic and clinical variables investigated were: the study center that the participants were registered with and their age, sex, education level, marital status, and body mass index (BMI) (Ministry of Health Consumption and Social Welfare, 2021). BMI was divided into underweight/normal if it was below 25 kg/m^2 and overweight/obese if it was that level or above. We also considered separating the obese category ($\text{BMI} > 30 \text{ kg/m}^2$) in the analyses.

Four functional performance tests were performed. The Tinetti test comprised two tests: gait and balance when standing up from a

sitting position and sitting down again. Scores below 25 indicated a fall risk (M. E. Tinetti et al., 1995). The timed up and go test (TUG) evaluated the risk of falls by timing how long it took a person to get up from a chair with armrests, without using their upper limbs, walk 10 feet, turn around, and sit back down. The test was conducted twice and the lowest score was recorded. A score of 10 s or more indicated frailty and risk of falling (Bellanco & Benítez, 2014; Ministry of Health Social Services and Equality, 2014; Navarro et al., 2001; Podsiadllo & Richardson, 1991). The short physical performance battery (SPPB) test assessed mobility limitations. It comprised three tests: balance in parallel, semi-tandem, and tandem positions for 10 s, 4 m walking speed and standing up from and sitting down to a chair five times. Each test scored 0–12 points, ranging from the poorest to the best physical condition, respectively. A total score of less than 10 for all three tests indicated a state of fragility and a risk of falling (Guralnik et al., 2000; Kiel, 2014; Kwon et al., 2009; Ministry of Health Social Services and Equality, 2014).

We also evaluated the results of the 4 m walking speed test and determined its association with a history and risk of falls. This test is simple and feasible to use in primary care settings (Ministry of Health Social Services and Equality, 2014) and the scientific evidence suggest that a lower walking speed could increase the risk of falls (Huijben et al., 2018; Liang et al., 2014). The 4 m walking speed test indicated how long it took for a person to cover that distance walking at a normal, comfortable speed. The test was carried out twice and the lowest score was recorded. A walking speed of less than 0.8 m per second indicated a risk of falling (Burton et al., 2017).

2.6 | Outcome measures

There were two outcome measures. The first was the number of falls during the previous 12 months. These were reported by the older adults and validated by their medical records if the fall required medical attention. The second was the consequences of any falls and these were categorized as minor and major transitory injuries and minor and major permanent injuries, according to the World Health Organization categories WHO Patient Safety, (2009).

2.7 | Data collection and quality

Older adults were evaluated by the study nurses during the health center assessment visits. The data collection procedures were specifically developed for the study. The local principal researchers provided the study nurses with training on how to collect the data and use the assessment instruments. This ensured that we collected high quality, consistent data. All variables were self-reported by the patients, and their medical records were checked if they said they had fallen. The nurses received a data collection notebook for each subject, which included all fields to be collected. They also used the same stopwatch model and 1.5 m tape measure when time or distances were recorded.

The participants' gait and balance were evaluated using validated questionnaires selected based on the literature and detailed in the study measures section. The study was managed by a central coordinating team, who were experienced principal investigators in each province, and standardized procedures were used for data collection and quality assurance.

2.8 | Ethical considerations

The study was carried out according to the Declaration of Helsinki and was approved by the Institute of Health Carlos III and the research ethics committees of the participating centers (code 2016-067-1). The subjects provided written, informed consent after they were told about the aims of study and were advised that they had the right to withdraw from the study at any time, without affecting their further care. All study data were handled in accordance with the Spanish Organic Law on the Protection of Personal Data (3/2018) and secured in accordance with Spanish Law (41/2002). Confidentiality was assured by using a numerical code for each participant instead of their name.

2.9 | Data analysis

All data were uploaded to a Research Electronic Data Capture (REDCAP) database and analyzed using the R statistical package (R Core Team, 2021). Means and standard deviation (SD) were used for the summaries of quantitative variables and absolute frequencies and percentages for the categorical variables. The Student's *t*-test for continuous variables was used for the bivariate analysis of the sociodemographic and clinical variables and the history of falls, the sociodemographic and clinical variables for men and women by fall status, and the physical performance variables for men and women by fall status. The χ^2 test was used for the categorical variables, and Fisher's exact test was used if the frequency was lower than five. To explore the joint effects of covariates and a physical test, we modeled a multivariable mixed-effects logistic regression model to assess the relationship of functional performance with falling once adjusted by age, sex, level of education, marital status, type of cohabitation, BMI classification, and the random effect of the province. In accordance with the literature consulted, and to avoid introducing collinearity, only the Tinetti test was included in the model since all four tests assess functional performance. The model is presented in terms of odds ratio (OR) and their 95% CI. All statistical analysis was performed applying a significance level of 0.05.

3 | RESULTS

We approached 2367 older adults, 827 agreed to participate in the OEP and 747 were able to attend the assessment a few days later and were included in the analysis (Figure 1). Participation varied from

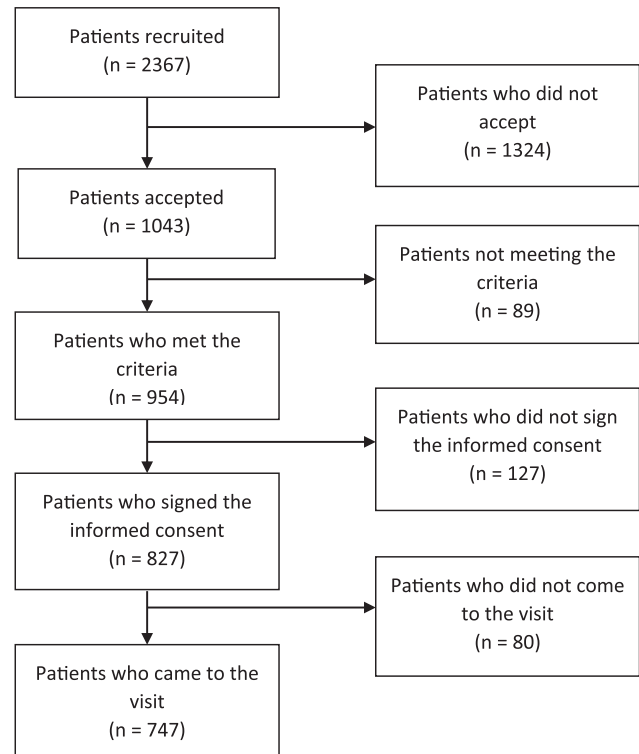


FIGURE 1 Flowchart of patient inclusion and exclusion in the study

5.5% to 12.4% in the 10 provinces, but the differences across provinces were not statistically significant.

3.1 | Sample characteristics

Table 1 shows the demographic and clinical characteristics of the 747 older adults (67.3% women) who agreed to take part in the study. They had a mean age of 72.2 (SD: 4.3) years. We also found that 45.1% had completed their primary education, 61.6% were married, and 74.0% were living with their spouse or another person. When it came to their BMI, 16.6% had an insufficient or normal weight and 83.4% were overweight or obese.

In the analysis of the sociodemographic and clinical data, the participants' sex was associated with their level of education (no formal education, primary, secondary, or university) ($p < 0.001$), marital status (single, married, widower, or other type) ($p < 0.001$), type of cohabitation (lived alone or didn't live alone) ($p < 0.001$), and BMI ($p = 0.036$). There were no statistically significant associations with the remaining sociodemographic and clinical variables.

3.2 | Prevalence and description of falls

The annual prevalence of falls was 32.8% ($n = 167$ falls), and 36.6% of those had fallen more than once. Of the 245 older adults who had fallen, 63.4% had fallen once, 21.2% twice, 4.5% three times, 2.9% four times,

TABLE 1 Demographic and clinical characteristics between two groups divided by fall history ($n = 747$)

Community dwelling participants	All participants ($n = 747$)		Fallers ($n = 245$)		Nonfallers ($n = 502$)		OR	95% CI	p Value
	n	%	n	%	n	%			
Province									
Lanzarote (Las Palmas)	93	12.4	31	12.7	62	12.4	Ref.	Ref.	0.098
Baleares	74	9.9	31	12.7	43	8.6	1.44	[0.76–2.72]	
Barcelona	80	10.7	18	7.3	62	12.4	0.58	[0.29–1.15]	
Córdoba	78	10.4	26	10.6	52	10.4	1.00	[0.52–1.90]	
Bizkaia	85	11.4	21	8.6	64	12.7	0.66	[0.34–1.27]	
Lleida	83	11.1	29	11.8	54	10.8	1.07	[0.57–2.01]	
Madrid	79	10.6	34	13.9	45	9.0	1.51	[0.81–2.82]	
Murcia	41	5.5	10	4.1	31	6.2	0.65	[0.27–1.47]	
Asturias	64	8.6	23	9.4	41	8.2	1.12	[0.57–2.19]	
Araba	70	9.4	22	9.0	48	9.6	0.92	[0.47–1.78]	
Sex									
Male	244	32.7	54	22.1	190	37.8	Ref.	Ref.	<0.001*
Female	503	67.3	191	77.9	312	62.2	2.15	[1.52–3.08]	
Level of education									
No formal education	73	9.8	23	9.4	50	10.0	Ref.	Ref.	0.698
Incomplete primary	158	21.2	59	24.1	99	19.7	1.29	[0.72–2.36]	
Complete primary	337	45.1	109	44.5	228	45.4	1.04	[0.61–1.81]	
Secondary education	122	16.3	36	14.7	86	17.1	0.91	[0.49–1.72]	
University studies	57	7.6	18	7.3	39	7.8	1.00	[0.47–2.13]	
Marital status									
Single	43	5.8	11	4.5	32	6.4	Ref.	Ref.	0.011*
Married	460	61.6	138	56.3	322	64.1	1.24	[0.62–2.65]	
Widower	195	26.1	71	29.9	124	24.7	1.65	[0.80–3.63]	
Other type of relationship	49	6.5	25	10.2	24	4.8	2.98	[1.24–7.49]	
Type of cohabitation									
Doesn't live alone	553	74.0	171	69.8	382	76.1	Ref.	Ref.	0.146
Lives alone	194	26.0	74	30.2	120	23.9	1.38	[0.98–1.94]	
Age (years)									
	Mean	SD	Mean	SD	Mean	SD	1.02	[0.98–1.06]	0.326
	72.2	4.2	72.4	4.3	72.1	4.2			
BMI: mean (kg/m^2)									
Insufficient/normal weight	124	16.6	28	11.4	96	19.1	Ref.	Ref.	0.011*
Overweight/obesity	623	83.4	217	88.6	406	80.9	1.82	[1.17–2.92]	

Note: Bivariate associations (sociodemographic/clinical variables for older adults by fall status [fallers vs. nonfallers]): Student's t -test for continuous variables and the χ^2 test for categorical variables. Insufficient weight ($\text{BMI} < 18.5 \text{ kg}/\text{m}^2$), normal weight ($18.5 > \text{BMI} < 25 \text{ kg}/\text{m}^2$), overweight ($25 > \text{BMI} < 30 \text{ kg}/\text{m}^2$), and obese ($\text{BMI} > 30 \text{ kg}/\text{m}^2$).

Abbreviation: BMI, body mass index; CI, confidence interval; OR, odds ratio; Ref, reference.

* $p < 0.05$.

and 2.0% had fallen five times. Just under half of the cohort, 119 (48.6%), had suffered some kind of fall-related injury. Of these falls, 74.9% resulted in a minor transitory injury, 19.8% in a major transitory injury, 3.6% in a minor permanent injury, and 1.8% in a major permanent injury.

Of the 54 men who had fallen, 79.6% had fallen once, 13% twice, and the other 7.4% had fallen three or more times. More than half (53.7%) of the men who had fallen sustained an injury. Of the 191 women who had fallen, 66.5% had fallen once, 23.6% twice, and the

other 9.9% had fallen three or more times. Just under half (47.1%) of the women who had fallen sustained an injury.

3.3 | Demographic and clinical characteristics associated with falls

The bivariate analyses revealed few significant differences between older adults who had fallen in the last 12 months and those who had not. The three exceptions were the participants' sex ($p < 0.001$), marital status ($p = 0.011$), and BMI ($p = 0.011$).

The prevalence of having one or more falls in the 12 months before the assessment visit was 22.1% for men and 38.0% for women. Women had more than twice the odds of falling than men (OR: 2.15, 95% CI: 1.52–3.08). Single people had a lower percentage of falls than people who were married or in a stable partnership. People who were in a relationship, but not married, had almost three times the odds of falling than single people (OR: 2.98, 95% CI: 1.24–7.49), which was statistically significant ($p = 0.014$). Overweight or obese people had nearly twice the odds of falling than people who were normal weight or underweight (OR: 1.82, 95% CI: 1.17–2.92) and this difference was statistically significant ($p = 0.007$) (Table 1).

History of falls in the last 12 months was associated significantly with BMI in women ($p = 0.016$). Women who were overweight or obese had almost twice the odds of having fallen in the last 12 months than women who were underweight or normal weight (OR: 1.88, 95% CI: 1.15–3.14, $p = 0.011$). A history of falls in the last 12 months only had a statistically significant association with age in men ($p = 0.046$). There was a difference between the mean ages of the men with a history of falls (73.2 years) and those who had not fallen (71.9 years) (Table 2).

3.4 | Functional performance tests associated with falls

The results of the functional performance tests for older adults who did or did not fall are shown in Table 3. According to the Tinetti test, 4.95% of the older adults had a fall risk, but the percentages increased when we used the TUG (40.4%), SPPB (36.3%), and 4 m walking speed (26.4%) tests. According to the functional performance tests, the odds of falls were higher in older adults who had suffered at least one fall in the last 12 months. The performance test results were related significantly to falls for the TUG ($p = 0.003$) and SPPB ($p = 0.035$) tests. Older adults with an impaired TUG show 1.6 times the odds of falling than those without it (95% CI: 1.18–2.19) and 1.4 times the odds of falling if we analyze the SPPB test (95% CI: 1.02–1.92). However, Tinetti ($p = 0.176$) or 4 m walking speed tests ($p = 0.100$) were not related significantly to falls (Table 3).

Table 4 shows the analysis by sex for fallers and nonfallers concerning the functional performance test. The percentage of women at risk of falling was higher for all four performance tests compared to men, and there were not statistically significant

differences in the prediction of risk of falling of fallers and nonfallers by sex for all performance test.

3.5 | Multivariable analysis

Following the recommendations of the literature consulted, Table 5 shows the logistic regression model with the Tinetti score, sex, and BMI classification, adjusting for the random effect of provinces. It should be noted that the results for the SPPB, TUG, and 4 m walking speed tests were similar in multivariable analysis.

The Tinetti score showed a protective effect with lower odds of falling associated to higher Tinetti score, with an OR of 0.94 (95% CI: 0.9–0.98, p value: 0.004). Women showed higher odds of falling than men, with an OR of 2.06 (95% CI: 1.43–3.07, $p < 0.001$). In comparison with patients with BMI lower than 25, patients with a BMI of overweight or obese showed higher odds of falling (OR of 1.90, with 95% CI: 1.15–3.14 and p Value 0.012; and OR of 2.00, with 95% CI: 1.23–3.26 and p value 0.006, respectively). The rest of the covariates did not show a significant association with falling.

4 | DISCUSSION

This study showed that just under a third (32.8%) of the people aged 65–80 in our cohort had experienced at least one fall in the 12 months before they took part in the study. Falls were much more common in women (38.0%) than men (22.1%). Pellicer-García et al. (2015) reported a broad prevalence range in their systematic review of papers that explored falls in noninstitutionalized older adults in Spain. Porta et al. (2020) studied 261 Spanish people over the age of 65 and found that 33% of women and 28% of men reported falls. Another Spanish study of noninstitutionalized older adults aged 65 or over, by Pellicer-García et al. (2020), reported that the prevalence of falls was almost 75%. These studies confirmed the wide-ranging prevalence that is found in Spain and underline the need for further research into why these data vary so much. The prevalence of falls in our study was higher than in several other international studies of community-dwelling adults. These include Ehrlich et al. (2019), who studied 11,558 participants aged 65 years or more in the United States. The prevalence of falls in the last 12 months ranged from 20.6% to 27.6% (Ehrlich et al., 2019). A systematic review and meta-analysis of 37 studies with 58,597 participants concluded that 27% of Brazilian people aged 60 plus had fallen in the last 12 months (Elias Filho et al., 2019).

Our results indicated that women had double the likelihood of falling in the last 12 months than men. Several other studies have focused on how a participant's sex influenced the likelihood of falls (Gale et al., 2018; Yeung et al., 2019). According to the United Kingdom National Health Service (2018), women faced greater fall risks than men, due to osteoporosis, which was associated with hormonal changes that occur during menopause. In Spain, hospital discharges for femoral neck fractures were analyzed, and these indicated that women had a greater risk of falls than men and

TABLE 2 Sex-stratified analysis of sociodemographic and clinical characteristics

Community dwelling participants	Men Total (n = 244)				Women Total (n = 503)				OR (95% CI)	p Value ^a	Fallers (n = 191)		Nonfallers (n = 312)		p Value ^b
	n	%	n	%	n	%	n	%			n	%	n	%	
Level of education															
No formal education	18	7.4	3	5.6	15	7.9	Ref.	55	10.9	20	10.5	35	11.2	Ref.	0.742
Incomplete primary	37	15.2	7	13.0	30	15.8	1.14 [0.26-6.23]	121	24.1	52	27.2	69	22.1	1.31 [0.68-2.57]	
Complete primary	102	41.8	23	42.6	79	41.6	1.40 [0.41-6.75]	235	46.7	86	45.0	149	47.8	1.01 [0.55-1.89]	
Secondary education	61	25.0	13	24.1	48	25.3	1.31 [0.35-6.61]	61	12.1	23	12.0	38	12.2	1.06 [0.49-2.27]	
University studies	26	10.7	8	14.8	18	9.5	2.13 [0.50-11.8]	31	6.2	10	5.2	21	6.7	0.84 [0.32-2.13]	
Marital status															
Single	14	5.7	2	3.7	12	6.3	Ref.	29	5.8	9	4.7	20	6.4	Ref.	0.243
Married	193	79.1	41	75.9	152	80.0	1.52 [0.39-11.0]	267	53.1	97	50.8	170	54.5	1.26 [0.56-3.03]	
Widower	22	9.0	4	7.4	18	9.5	1.29 [0.20-11.7]	173	34.4	67	35.1	106	34.0	1.39 [0.61-3.41]	
Other type of relationship	15	6.1	7	13.0	8	4.2	4.76 [0.85-42.5]	34	6.8	18	9.4	16	5.1	2.45 [0.88-7.22]	
Type of cohabitation															
Doesn't live alone	216	88.5	48	88.9	168	88.4	Ref.	337	67.7	123	64.4	214	68.6	Ref.	0.383
Lives alone	28	11.5	6	11.1	22	11.6	0.97 [0.34-2.42]	166	33.0	68	35.6	98	31.4	1.21 [0.82-1.77]	
Age (years)	Mean	SD	Mean	SD	Mean	SD	1.07 [1.00-1.15]	0.046*	Mean	SD	Mean	SD	Mean	SD	0.992
	72.2	4.3	73.2	4.2	71.9	4.3			72.1	4.2	72.1	4.3	72.2	4.2	
BMI: mean (kg/m ²)															
Insufficient/normal weight	30	12.3	3	5.5	27	14.2	Ref.	84	18.7	25	13.1	69	22.1	Ref.	0.016*
Overweight/obesity	214	87.7	51	94.4	163	85.8	2.69 [0.89-12.1]	409	81.3	166	86.9	243	77.9	1.88 [1.15-3.14]	

Note: Insufficient weight (BMI < 18.5 kg/m²), normal weight (18.5 < BMI < 25 kg/m²), overweight (25 < BMI < 30 kg/m²), and obese (BMI > 30 kg/m²).
 Abbreviations: BMI, body mass index; CI, confidence interval; OR, odds ratio; Ref, reference.
^aBivariate associations: sociodemographic/clinical variables for men by fall status [fallers vs. nonfallers]; Student's t-test for continuous variables and the χ^2 test for categorical variables.
^bBivariate associations: sociodemographic/clinical variables for women by fall status [fallers vs. nonfaller]; Student's t-test for continuous variables and the χ^2 test for categorical variables.
 *p < 0.05.

TABLE 3 Physical performance tests between two groups divided by fall history ($n = 747$)

Physical performance tests	All participants ($n = 747$)		Fallers ($n = 245$)		Nonfallers ($n = 502$)		OR (95% CI)	pValue
	n	%	n	%	n	%		
Tinetti								
Normal	710	95.0	229	32.3	481	67.7	Ref.	
Risk of falls	37	4.95	16	43.2	21	56.8	1.60 [0.81–3.13]	0.176
TUG								
Normal	445	59.6	127	28.5	318	71.5	Ref.	
Risk of falls	302	40.4	118	39.1	184	60.9	1.60 [1.18–2.19]	0.003
SPPB								
Normal	476	63.7	143	30.0	333	70.0	Ref.	
Risk of falls	271	36.3	102	37.6	169	62.4	1.41 [1.02–1.92]	0.035
4 m walking speed test								
Normal	550	73.6	171	31.1	379	68.9	Ref.	
Risk of falls	197	26.4	74	37.6	123	62.4	1.33 [0.95–1.87]	0.100

Note: Univariate associations or unadjusted odds ratio (OR) estimated by simple logistic regression models for each physical performance recoded variable. Numerical scores showed a stronger association with falling (Tinetti OR = 0.93, 95% CI = 0.89–0.96; SPPB OR = 0.90, 95% CI = 0.84–0.97; and 4 m walking speed test OR = 0.57, 95% CI = 0.35–0.93).

Abbreviations: CI, confidence interval; Ref, reference; SPPB, short physical performance battery; TUG, timed up and go test.

* $p < 0.05$.

experienced more serious consequences (Ministry of Health Social Services and Equality, 2014). Kirk et al. (2020) reported that osteosarcopenia, which indicates the presence of osteoporosis and sarcopenia, was associated with falls (OR: 2.83–3.63, $p < 0.05$). Osteoporosis and sarcopenia are major contributors to the development of fragility syndrome (Greco et al., 2019), which has been estimated to be higher in women (9.6%) than men (5.2%) (Collard et al., 2012). All these data support our findings.

We found that single older adults were less likely to fall than those who were married or widowed. In addition, being in another type of relationship was significantly associated with a higher probability of falls than being single. Older adults who lived alone were 1.38 more likely to fall than those who lived with others, but this result was not statistically significant. Our findings are different from those of Gale et al. (2018), who found that men and women who were divorced, widowed, or separated had a higher risk of falls in comparison to single men, but not to other related variables, such as living alone. However, the risk was only higher for women, and not men who had never been married. The differences between Gale et al. (2018) and our study were that different categories were used and different results were obtained for single older adults and older adults in other types of relationships. Gale et al. (2018) concluded that older adults who lived alone had significantly more falls, but our study did not find any statistically significant differences. In conclusion, our findings show that marital status was related to falls, but we would need more data about this status. For example, not all married people cohabit in the same way and some live very separate lives or care for an elderly, unwell or disabled partner. This could have an impact on their risk of falls.

Another factor that we studied was obesity. We found that overweight or obese people had a higher risk of falls than those who were underweight or normal weight (OR: 1.82, 95% CI: 1.17–2.92). Neri et al. (2020) carried out a systematic review and meta-analysis of 24 studies on 1,758,694 participants and concluded that obesity increased the overall risk of falls in people aged 60 years and older (relative risk: 1.16, 95% CI: 1.07–1.26, I^2 90%). Four of the studies also assessed the risk of multiple falls (relative risk: 1.18, 95% CI: 1.08–1.29, I^2 0%). However, there was not enough evidence to associate obesity with injuries from falls or fractures. That study also reported that BMI was significantly associated with a history of falls in the last 12 months in women ($p = 0.016$), but not men ($p = 0.140$). In women, falling was significantly associated with being overweight or obese in comparison with being underweight or normal weight (OR: 1.88, 95% CI: 1.15–3.14, $p = 0.011$). The same comparisons were not significant for men ($p = 0.140$). The authors specifically concluded that obesity was associated with a fall in older women. In our study, insufficient and normal weight were combined due to the low number of subjects with insufficient weight.

Our study also determined the associations between fall history, baseline characteristics, and four functional performance tests: the TUG, Tinetti, SPPB, and 4 m walking speed tests. Older adults who had fallen in the past 12 months had a significantly higher risk of falling than those who had not, according to the TUG and SPPB tests. These data appear to be consistent with reports from other authors who showed an association between some tests of functional performance and previous falls (Kim et al., 2017; Veronese et al., 2014). This was in contrast to a study by Thrane et al. (2007), which was included in a systematic review by Beauchet et al. (2011). The authors studied 974

TABLE 4 Analysis in relation to functional performance tests by sex

Physical performance tests	Men				Women				OR (95% CI)	p Value ^a	p Value ^b				
	Total (n = 244)		Fallers (n = 54)		Total (n = 503)		Fallers (n = 191)								
	n	%	n	%	n	%	n	%							
Tinetti															
Normal	239	98.0	53	22.2	186	77.8	171	93.6	176	37.4	295	62.6	Ref.		0.377
Risk of falls	5	2.05	1	20.0	4	80.8	32	6.36	15	46.9	17	53.1	1.48 [0.71–3.06]		
TUG															
Normal	166	68.0	31	18.7	135	81.3	279	55.5	96	64.4	183	65.6	Ref.		0.081
Risk of falls	78	32.0	23	29.5	55	70.5	224	44.5	95	42.4	129	57.6	1.40 [0.98–2.02]		
SPPB															
Normal	177	72.5	34	19.2	143	80.8	299	59.4	109	36.5	190	63.5	Ref.		0.450
Risk of falls	67	27.5	20	29.9	47	70.1	204	40.6	82	40.2	122	59.8	1.17 [0.81–1.69]		
4 m walking speed test															
Normal	199	81.6	41	20.6	158	79.4	351	69.8	130	37.0	221	63.0	Ref.		0.578
Risk of falls	45	18.4	13	28.9	32	71.1	152	30.2	61	40.1	91	59.9	1.14 [0.77–1.68]		

Abbreviations: CI, confidence interval; OR, odd ratios; Ref, reference; SPPB, short physical performance battery; TUG, timed up and go test.

^aBivariate associations: physical performance variables for men by fall status [fallers vs. nonfallers]; Student's t-test for continuous variables and the χ^2 test for categorical variables.

^bBivariate associations: physical performance variables for women by fall status [fallers vs. nonfallers]; Student's t-test for continuous variables and the χ^2 test for categorical variables.

*p < 0.05.

TABLE 5 Logistic regression model with Tinetti, sex, and BMI classification, adjusting for the random effect of provinces

Characteristic	OR	95% CI	p Value
Tinetti			
Tinetti total	0.94	[0.90–0.98]	0.004*
Sex			
Men	Ref.	Ref.	<0.001*
Women	2.06	[1.43–3.07]	
Age	1.01	[0.97–1.05]	0.5
Level of education			
No formal education	Ref.	Ref.	0.3
Incomplete primary	1.35	[0.73–2.52]	0.5
Complete primary	1.24	[0.69–2.24]	0.4
Secondary education	1.33	[0.67–2.64]	0.4
University studies	1.45	[0.64–3.28]	
Marital status			
Married	Ref.	Ref.	0.3
Widower	0.76	[0.47–1.22]	0.14
Single	0.55	[0.25–1.22]	
Type of cohabitation			
Doesn't live alone	Ref.	Ref.	0.2
Lives alone	1.42	[0.88–2.27]	
BMI: mean (kg/m²)			
BMI <25	Ref.	Ref.	
BMI [35,30)	1.90	[1.15–3.14]	0.012*
BMI ≥30	2.00	[1.23–3.26]	0.006*

Note: The estimated standard deviation in the intercept (on the log odds scale) between the 10 centers in this study was of 0.1758 (random effect in the regression). Insufficient weight (BMI <18.5 kg/m²), normal weight (18.5 ≥ BMI < 25 kg/m²), overweight (25 ≥ BMI < 30 kg/m²), and obese (BMI ≥ 30 kg/m²).

Abbreviations: BMI, body mass index; CI, confidence interval; OR, odds ratio; Ref, reference.

*p < 0.05.

Norwegian older adults and reported that the TUG results were associated with a history of falls in men, but not women. The systematic review by Beauchet et al. (2011) concluded that the TUG results were associated with falls, but its ability to predict the risk of falls could be influenced by the confounding factors of age, female sex, and comorbidities. Addressing these factors would have provided better information about the TUG predictive value for future falls in older adults (Beauchet et al., 2011). Although our results suggested that the TUG and SPPB results were associated with a history of falls, this association needs to be further explored to establish its usefulness. Some studies have reported low specificity and sensitivity for the Tinetti test, including Park et al. (2018). Their systematic review showed that the Tinetti test had a sensitivity of 0.68 (95% CI:

0.56–0.79) and a specificity of 0.56 when there was heterogeneity among the studies. The authors concluded that using two functional performance tests, instead of one, could predict the occurrence of falls with greater accuracy (Park, 2018). The factors associated with falls in the multivariable analysis were consistent with other findings in the literature, including those related to women and obesity (Himes & Reynolds, 2012; Pérez-Ros et al., 2019).

To summarize, our study results were similar to previous worldwide studies, in particular those conducted in Europe. Our study provides new knowledge about the associations between functional performance test scores, fall history, risk of falls, and sociodemographic variables, such as sex. The results can be extrapolated in community-dwelling older adults, as we had a larger sample size than other observational studies (Baixinho et al., 2019; Pellicer-García et al., 2013, 2015; Rodríguez-Moliner et al., 2015).

4.1 | Strengths and limitations

The strengths of our study included the multicenter sampling and large sample size, which allowed us to estimate the prevalence of falls and to generalize the results at a national level. Some studies have indicated that sex, age, and step regularity should be considered in predicting fall-risk (Porta et al., 2020; Taniguchi et al., 2016); in particular, older women have been reported to demonstrate lower walking speeds, progression, and step length values (Thaler-Kall et al., 2015), all of which are factors that contribute to increased risk of falls. (Hughes-Oliver et al., 2018). However, the risks and factors associated with falls may vary between countries and cultures. That is why our results must be interpreted in the clinical context in which they were measured. Our results showed a high prevalence of falls and fall risk in our population, suggesting the need to implement effective fall prevention interventions, such as the OEP, which this study was based on.

Some limitations must also be considered when interpreting our findings. The results could have been affected by positive bias, due to the OEP intervention, as this could have reduced the fall risk in some participants. The majority of the participants were women, but this is common in most health promotion studies of older adults. Another possible limitation is the recall bias on the number of falls participants had experienced. The mean age of the sample was relatively young and insufficient information was provided on the participants' health status or chronic diseases, which could have affected our comparisons with other studies. It is also worth considering that the sample size was not calculated for the secondary objectives and this could have led to a possible lack of power for secondary hypotheses on the associations between falls and other factors. Finally, the 4 m walk speed test was integrated into the SPPB test in other studies, which made comparisons with this study difficult. As mentioned above, more studies are needed to find out how this simple test can help us in the field of falls in older adults. Although our study participants were assessed with the modified Tinetti test, some studies used different versions of the Tinetti test, which made comparisons difficult. Finally, the study was retrospective (falls needed to be evaluated in a period of time) and

cross-sectional (for study measures), so a causal relationship between the related variables could not be established. Even so, the establishment of the relationships described in this study should lead to further research with cohort studies that correctly establish this relationship and help healthcare personnel to predict falls in older adults and to establish preventive measures that avoid them or minimize their consequences.

5 | CONCLUSION

Our data showed that approximately one-third of our community-based cohort (32.8%) had fallen in the last 12 months. Of those, 36.6% had fallen more than once and women had more than twice the odds of falling than men. Almost half (48.6%) had sustained injuries as a result of falling, but 94.7% were transitory injuries.

Bivariate analysis revealed that falls were statistically significantly associated with sex ($p < 0.001$), marital status ($p = 0.011$), BMI ($p = 0.011$), and the TUG ($p = 0.003$) and SPPB ($p = 0.035$) performance tests. However, only sex and BMI maintained statistical significance in the multivariable analysis. This seems to corroborate with the high discrepancy we saw when fall risks were assessed using a single assessment test. This was probably due to the numerous factors that can cause falls in older people.

OTAGO PROJECT WORKING GROUP

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AUTHOR CONTRIBUTIONS

Joan Blanco-Blanco: conceived the study design, participated in the data analysis, and revised the manuscript for important intellectual content. **Laura Albornos-Muñoz:** participated in the design of the study, data analysis, and revised the manuscript for important intellectual content. **María Àngels Costa-Menen:** participated in the design of the study and revised the manuscript for important intellectual content. **Ester García-Martínez:** conceived the study design, data analysis, and drafted the manuscript. **Esther Rubinat-Arnaldo:** revised the manuscript for important intellectual content. **Jordi Martínez-Soldevila:** revised the manuscript for important intellectual content. **María Teresa Moreno-Casbas:** revised the manuscript for important intellectual content. **Ana Beatriz Bays-Moneo:** revised the manuscript for important intellectual content. **Montserrat Gea-Sánchez:** revised the manuscript for important intellectual content. **Otago Project Working Group:** participated in the development of the study.

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CONFLICT OF INTEREST

The author declares no conflict of interest.

DATA AVAILABILITY STATEMENT

The data that support the findings of this study are available from the corresponding author upon reasonable request.

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