Using a multifactorial approach to determine fall risk profiles in portuguese older adults

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ABSTRACT

Aim: The aim of this study was to use a multifactorial approach to characterize episodic and recurrent fallers risk profiles in Portuguese older adults.

Materials and Methods: To accomplish the mentioned purpose, 1416 Portuguese older adults above 65 years were tested with three different field measurements: 1) health and falls questionnaire; 2) Physical Activity questionnaire and 3) a set of functional fitness tests. The subjects were divided in three different groups according to fall prevalence: non-fallers, subjects who did not report any falls during the previous year, episodic fallers, those who reported to have fallen only once during the previous year, and recurrent fallers, the ones that fell twice or more times during the previous year. Episodic and Recurrent fallers risk profiles were established using multifactorial logistic regression models in order to avoid confounding effects between the variables.

Results: The results showed that age was not a risk factor for either episodic or recurrent falling. In addition, health parameters were shown to be the factors which made the distinction between recurrent and episodic fallers. This may imply that recurrent falls are more associated with comorbidities and less likely to occur due to external factors. Furthermore, being a woman, having fear of falling and lower functional fitness levels were determinant factors for both episodic and recurrent falls. It is also important to note that, although total physical activity was only related with episodic falling, promoting physical activity and exercise may be the easiest and cheapest way to improve functional fitness and health levels and therefore, its role in fall prevention should not be underestimated.

Conclusions: The results of this study reinforce the importance of using a multifactorial approach, not only focusing on cognitive-behavioral factors, but also on promoting physical activity and healthy lifestyles, when assessing fall risk or planning an intervention aiming at fall prevention within the older population.

Keywords: Elderly; Fall; Risk Profiles; Multifactorial Approach.

INTRODUCTION

Falls are a major health concern faced by the elderly population in the industrialized countries. The rate of community living older adults who fall at least once each year varies between 30% and 40%, depending on the study[1–3]. It is also reported that this rate increases with ageing, reaching approximately 50% in old people over 80 years[1]. Furthermore, the higher incidence of chronic diseases, like osteoporosis and reduced bone density, characteristic of the elderly population, increases the likelihood of an injury, making even a relatively mild fall particularly dangerous[4]. It is stated that 20% to 30% of those who fall suffer injuries that reduce mobility and independence as well as increase the risk of premature death[1]. Moreover, even a non-injurious fall may have important consequences like functional fitness decline, social withdrawal, anxiety and depression, fear of falling, and an increased use of medical services[1,5–7]. Therefore, older adults who have fallen, regardless of whether they have experienced an injurious fall, are at greater risk of becoming institutionalized[8].

Because of the mentioned consequences to the elders and their families' quality of life, as well as the ge-

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nerated increase in health costs, the implementation of fall preventive strategies is a primary public health concern. These preventive strategies will be more efficient if the risk prediction models are developed separately for homogeneous subpopulations[9]. In fact, it has been reported that in what concerns fall prevention there is no one-size-fits-all intervention[10]. Instead, it is recommended that the characteristics of the intervention should be decided by the clinicians and practitioners according with the fall risk level of their patients[10]. As so, and because the risk profile of an episodic faller may be different from the one of a recurrent faller[11], the success of the intervention will depend on our ability to identify and distinguish older people who are at risk of episodic and recurrent falling from those with no fall risk.

Being a multifactorial problem, several risk factors have been reported and related to falls[1–5,9,11–16]. Among others, the most referenced are: age, gender, specific chronic diseases, impaired mobility, balance and gait, muscle weakness, sedentary behaviour, cognitive impairment, fear of falling, visual impairment, medication intake, health perception and history of falling. In a preliminary study[17], we have verified, in a cohort of 647 Portuguese older subjects from Lisbon and Tagus Valley region, that falls might not be an inevitable consequence of ageing and that health, functional fitness and physical activity parameters were the most determinant factors for both episodic and recurrent falls. However, in the mentioned study, we have analyzed the contribution of each risk factor independently, without identifying possible confounding effects between them.

Since data on the Portuguese older population relative to this matter is scarce, it seems urgent to characterize both episodic and recurrent fallers risk profiles in this population. Thus, the purpose of this study was to use a multifactorial approach to determine and characterize both episodic and recurrent fallers risk profiles in Portuguese older adults.

MATERIALS AND METHODS

SAMPLE

Participants were community-dwelling older adults from the Biomechanics of Locomotion in the Elderly Project (PTDC/DES/72946/2006) that were recruited from 18 Portuguese municipalities, from Lisbon & Tagus Valley area and centre national regions (Lisbon, Cascais, Oeiras, Amadora, Odivelas, Sintra, Mafra, Loures, Almada, Setúbal, Nazaré, Rio Maior, Santarém, Cartaxo, Azambuja, Samora Correia, Torres Vedras, Benavente), and different contexts, including exercise classes, day care centres, senior schools and health promotion public community events. Sample recruitment was done using a multistage approach as described elsewhere[17]. A total of 1416 older adults, from a total of 1723, aged 65 years and older were enrolled in this study, between May 2010 and September 2012. Exclusion criteria were to have a neurologic condition (Dementia, Parkinson or stroke), not being able to comprehend Portuguese Language and not being able to walk independently or with a walking aid. Previously to data collection, all participants were informed about the study, accepted to participate and signed the informed consent. The Ethics Committee of Faculty of Human Kinetics, Technical University of Lisbon, approved the study protocol.

MEASURES AND PROCEDURES

In order to assess the risk factors for falling, three different field measurements were used: two questionnaires (one regarding health and falls parameters (HFQ) and other concerning physical activity (PA) levels) and a set of functional fitness (FF) tests. A more detailed description of the study design and the validation of the procedures has been published elsewhere[17].

Briefly, the questionnaires were administered through an interview, conducted by trained examiners. The HFQ included questions regarding sociodemographic characteristics, health, vision and hearing perception status, medical history (medical visits, hospitalizations, surgeries), medication intake (total and number for each disease, with specification of the drug name), fear of falling (FOF), activity avoidance due to FOF, fall prevalence (in the previous year) and falls characteristics (location, circumstances and consequences of, at most, 3 of the reported falls). A fall was defined as “an unexpected event in which the participant comes to rest on the ground, floor or lower level”[18]. PA levels were assessed by Yale Physical Activity Survey (YPAS) questionnaire[19], which reports to a typical week of activity during the month prior to evaluation. The questionnaire provides an index of intensity, duration and frequency of five distinct physical activity dimensions: 1) vigorous activity (vigorous index) - activities lasting more than 10 minutes which cause large increases in breathing rate and heart rate, sweating or fatigue in the legs; 2) walking (walking index) – walking for at least

10 minutes without stopping or making a vigorous effort; 3) movement (movement index) – all activities involving movement carried out while standing, including walking, 4) standing (stand index) - activities in the standing position without movement; and, 5) sitting (sitting index) - activities performed in a seated position. Each of the partial scores, corresponding to each of the physical activity intensities, is multiplied by the specific weighting factor in order to calculate the partial indexes, and then summed to determine the summary index of PA (Total PA).

Finally, FF assessment included a set of strength and balance tests, as well as the measures of body height and mass for body mass index (BMI) computation. Lower limb strength, power and coordination assessment, was done through the 8 foot Up-and-Go (UG) test (involves getting out of a chair, walking 2,44m to and turn around a shaped elevated mark and returning to the chair in the shortest time possible) and the Chair-Stand (CS) test (involves counting the number of times within 30s that an individual can rise to a full stand from a seated position, without pushing off with the arms) from Senior Fitness Test (SFT) battery[20]. Balance was assessed through items 4 – step up and over (FAB4) , 5 – tandem walk (FAB5), 6 – stand on one leg (FAB6) and 7 – stand on foam eyes closed (FAB7), of FAB Scale[21]. FF tests were selected based on their reported ability to discriminate fallers and detect age functional decline[20,22,23], as well as their feasibility on clinical and exercise field (in what concerns space, time and equipment requirements). Examiners were trained to administer all tests, following the authors' instructions[20,21]. At the end of the screening session, participants received feedback, through a written report, concerning their test results.

STATISTICAL ANALYSIS

Subjects were divided in three different groups according to fall prevalence: non-fallers (NF), subjects who did not report any falls during the previous year; episodic fallers (EF), those who reported to have fallen only once during the previous year, and recurrent fallers (RF), the ones that fell twice or more times during the previous year. Statistical analysis was done according to these groups using PASW Statistics 18.0 with the level of significance set at $p<0.05$.

The variables were divided in four groups: demographic parameters (gender, marital status, living alone, living own home and education level); health parameters (general, visual and hearing health perceptions, total medication intake, fear of falling (FOF), activity avoidance due to FOF and surgeries in the previous year); PA parameters (vigorous, walking, movement, standing and sitting indexes and total PA) and FF parameters (BMI and 6 FF tests). The results from FF tests were also recoded into two other different variables: the balance score, obtained through the sum of FAB4, FAB5, FAB6 and FAB7 test results, from the FAB scale[21], and total functional fitness score (TFFS), computed by summing the balance score with the CS and UG test results, from the SFT battery[20]. Considering that the SFT battery tests results involve different measure units from those of the balance tests, in order to obtain the TFFS, we transformed the first two test results (TUG and CS) in an ordinal scale similar to the one used in the balance tests. This was done by calculating the quartiles of the results of the CS and the UG tests, after adapting for gender, following the original national norms established by the authors of the tests[20].

Descriptive statistics was used to determine the central tendency parameters for scale variables (mean, standard deviation and median) and relative frequency of the nominal ones, allowing the sample characterization.

The main outcome was the number of falls, which was stratified in the following comparisons' groups: non-fallers vs. episodic fallers and non-fallers vs. recurrent fallers.

As risk factors must be easily and quickly measurable, continuous or ordinal variables were dichotomized throughout their median value. Apart from UG test, medication number and sitting time, in which a "good level" was considered if subjects scored below the median value, for the other variables, a "good level" was considered if subjects showed results equal or greater than the median/cut-off value. Further, there was a group of variables wherein specific cut-off values were applied. For general, visual and hearing health perceptions, the cut off value was 4 (in a scale from 1 – very bad – to 5 – excellent); FOF was classified as "no" if the participant answer "never", or "yes" if they answered "sometimes", "often" or "always"; and BMI was dichotomized using the proposed cut-off values to define overweight (BMI≥27Kg/m2) in the older population[24]. The need for using different BMI cut off values when studying the elderly, instead of the ones established for adults, has been suggested in recent studies[24–26]. It is reported that older individuals, especially the ones over 60 years, suffer a decrease in height and lean mass, as well as an increase in fat mass, which has an impact on BMI by approximately 1.5 kg/m^2 in men and 2.5 kg/m^2 in women[27]. Furthermore, studies focused on the identification of risk factors of morbidity and mortality, regardless of the disease, also suggest a higher BMI cut-off value (27kg/m^2) for elderly subjects[25,26].

Differences between groups for the independent variables were verified using the Chi-Square test. Variables that were significantly different between groups were then included in the bivariate logistic regression models (Enter method) so that determinants factors for episodic and recurrent falling could be identified, when compared with non-falling.

Afterwards, multivariate logistic regression models (backward- conditional method) were built, using the previously identified determinant factors for falling and recurrent falling, in order to identify any possible confounding effect between them. Interactions were calculated based on conditional parameter estimates of the final logistic regression models. The goodness-of-fit of the models was assessed with the Homer-Lemeshow test, which allows to verify if the differences between the observed and predictive values are small, as well as if there is no systematic contribution of the differences to the error structure of the model[28]. Additionally, the concordance of predictive values with actual outcomes was verified through the determination of the area under the Receiver-Operator Characteristic curve (AUC-ROC). In this curve, sensitivity is plotted against specificity, having the test a perfect discrimination if the AUC-ROC is 100%[29].

RESULTS

SAMPLE AND FALL GROUPS' CHARACTERIZATION

From a total of 1723 subjects, 1416 met all the inclusion criteria (~82.2%), being therefore included in the study analysis. This sample size represents 0,7% of the Portuguese older subjects and is considered to be appropriate to study the problem of falls in Portugal [n=1370, defined from an estimated effect size (ES) equal to 0.5, power 80%, alpha of 0.05 and a prevalence of falls of 40%][30].

From the 1416 participants, 38% fell during the previous year and within these, 61% fell once (EF) and 39% fell twice or more times (RF). Furthermore, within the participants who fell, 43% suffered an injury and 11% of these injuries were fractures.

The characterization of each sample group is summarized on Table I, as well as the differences between groups. With the exception of general health perception, no differences were found between EF and RF and therefore, differences between these fall groups are not shown.

Participants had a mean age of 73.0±5.6 years ($\tilde{x}$=72.0y) and 35% of them had over 75 years. No differences between fall groups were found for age. Furthermore, even when using a higher cut-off value (≥75y and ≥80 y), instead of the median, the results remained the same, with no differences found between NF and both episodic (X^2 75y=2.60, p=0.11; X^2 80y=0.38, p=0.54) and recurrent fallers (X^2 75y=3.01, p=0.08; X^2 80y=0.13, p=0.72). About 75% of the subjects in the total sample were women. In the NF group 70% of the participants were women, which was a significantly lower percentage comparing with the proportion of women found in EF and RF groups. Still regarding the demographic parameters, when compared with NF, a significantly higher percentage of EF were single and lived alone.

Considering health parameters, NF reported the highest percentage of good general, visual and hearing health perceptions, and the lowest percentage of medication intake, fear of falling and activity avoidance due to FOF.

For the total amount of physical activity, NF were found to be more active than both episodic and recurrent fallers. On the other hand, looking at the partial scores, differences were only found between non-fallers and recurrent fallers, having this last group a more sedentary behaviour (RF walked and moved less and spent more time in a seated position than NF). Further, no differences were found between both fall groups and non-fallers for the time spent in vigorous activities, nor the time spent standing.

Finally, almost all FF tests revealed statistical differences between groups (NF vs EF and NF vs RF), showing a consistent decrease in functional fitness for both episodic and recurrent fallers. Additionally, a higher BMI was found for EF and RF, when compared with NF. However, it is important to note that the average BMI of the total sample was 28.5±4.5 Kg/m² ($\tilde{x}$=28.1 Kg/m²), with 63% of the individuals scoring over 27 Kg/m^2.

FALL RISK PROFILES

The results obtained from the bivariate logistic regression models, presented on Table II, are in accordance with the previous mentioned results.

TABLE I. SAMPLE CHARACTERIZATION: DEMOGRAPHIC, HEALTH, PA AND FF PARAMETERS (ABSOLUTE AND VALID FREQUENCY) AND THEIR ASSOCIATIONS AMONG GROUPS (NON-FALLERS (NF), EPISODIC FALLERS (EF) AND RECURRENT FALLERS (RF)

	NF n=889 n(%)	EF n=325 n(%)	RF n=202 n(%)
Demographic parameters			
Age (≥72years)	463 (52.1)	187 (57.5)	116 (57.4)
Gender (Female)	623 (70.1)	266 (81.8)*	174 (86.1)*
Marital status (Single)	527 (59.3)	163 (50.2)*	111 (56.1)
Living alone	230 (25.9)	107 (33.7)*	58 (29.3)
Living own home	783 (88.1)	294 (90.5)	174 (88.8)
Education level (4th grade)	340 (59.6)	108 (56.8)	80 (63.0)
Health parameters			
General health perception (poor)	532 (59.8)	223 (69.0)*	162 (80.2)*
Visual health perception (poor)	308 (34.9)	132 (41.1)*	119 (58.9)*
Hearing health perception (poor)	254 (40.1)	104 (43.5)	70 (50.7)*
Medication (n≥3/day)	511 (59.6)	210 (67.5)*	158 (79.4)*
FoF (yes)	553 (62.2)	229 (70.5)*	170 (84.2)*
Activity avoidance due to FoF (yes)	59 (18.2)	38 (25.9)	37 (33.0)*
Surgery (yes)	104 (11.8)	40 (12.4)	28 (13.9)
PA parameters			
Vigorous (< 10 min/week)	538 (60.5)	214 (65.8)	133 (65.8)
Walking (<150 min/week)	366 (41.2)	148 (45.5)	108 (53.5)*
Movement (< 5h/day)	250 (28.2)	90 (27.7)	79 (39.1)*
Standing (< 5h/day)	407 (45.8)	161 (49.5)	97 (48.0)
Sitting (≥ 6h/day)	664 (74.7)	241 (74.2)	166 (82.2)*
Total PA(<40 scale points)	396 (44.5)	172 (54.1)*	110 (56.7)*
FF parameters			
FAB4 (<4 scale points)	108 (12.1)	52 (16.0)	62 (30.7)*
FAB5 (<3 scale points)	278 (31.3)	124 (38.2)*	92 (45.5)*
FAB6 (<2 scale points)	211 (23.7)	106 (32.6)*	85 (42.1)*
FAB7 (<4 scale points)	496 (55.8)	155 (47.7)	115 (56.9)*
Balance score (<13 scale points)	360 (41.9)	168 (54.0)*	126 (66.3)*
CS (times/30s)¥	340 (38.3)	198 (39.5)	99 (49.5)*
UG (sec)¥¥	458 (51.5)	189 (58.2)*	127 (62.9)*
TFFS (<17 scale points)	375 (43.7)	168 (54.0)*	124 (66.0)*
BMI (≥27.0 kg/m^2)	526 (59.2)	218 (67.1)*	139 (68.8)*

* p<0.05
¥ adjusted for gender: female: <15x/30s; male: <16x/30s
¥¥ adjusted for gender: female: ≥5,67s; male: ≥5,13s
FoF: fear of falling; PA: Physical activity; UG: 8 foot Up-and-Go test; CS: Chair-Stand test; FAB4: step up and over test; FAB5: tandem walk test; FAB6: stand on one leg FAB7: stand on foam eyes closed; TFFS: Total functional fitness score; BMI: Body mass index

The risk of falling episodically doubles for women and the risk of falling recurrently is even higher. Further, living alone and being single are risk factors for episodic falling, showing the importance of social conditions for the determination of the episodic fallers risk profile.

Health and FF parameters showed to be the most determinant factors for episodic and especially recurrent falls. When compared with NF, the risk of falling episodically increased between approximately 30% and 60%, while

TABLE II. BIVARIATE LOGISTIC REGRESSION MODELS FOR EPISODIC AND RECURRENT FALLERS

	Episodic Fallers OR (95% CI)**	Recurrent fallers OR (95% CI)**
Demographic parameters		
Gender (Female)	1.93 (1.40-2.64)*	2.65 (1.74-4.06)*
Marital status (single)	1.51 (1.17-1.96)*	1.16 (0.85-1.80)
Living alone	1.41 (1.07-1.86)*	1.17 (0.84-1.65)
Health parameters		
General health perception (poor)	1.50 (1.14-1.96)*	2.72 (1.88-3.94)*
Visual health perception (poor)	1.30 (1.03-1.69)*	2.68 (1.96-3.66)*
Hearing health perception (poor)	1.15 (0.85-1.56)	1.54 (1.06-2.23)*
Medication (≥3 med/day)	1.41 (1.07-1.85)*	2.61 (1.80-3.78)*
Fear of falling (yes)	1.45 (1.10-1.91)*	3.23 (2.16-4.82)*
Activity avoidance due to FoF (yes)	1.57 (0.98-2.49)	2.22 (1.37-3.60)*
PA parameters		
Walking (<150 min/week)	1.20 (0.93-1.54)	1.64 (1.21-2.23)*
Movement (< 5h/day)	0.98 (0.74-1.30)	1.65 (1.20-2.27)*
Sitting (≥ 6h/day)	1.03 (0.77-1.38)	1.56 (1.06-2.31)*
Total PA(<40 scale points)	1.42 (1.09-1.83)*	1.57 (1.15-2.15)*
FF parameters		
FAB4 (<4 scale points)	1.38 (0.96-1.97)	3.20 (2.23-4.59)*
FAB5 (<3 scale points)	1.36 (1.04-1.77)*	1.84 (1.35-2.51)*
FAB6 (<2 scale points)	1.56 (1.18-2.06)*	2.33 (1.70-3.21)*
FAB7 (<4 scale points)	1.15 (0.89-1.49)	1.67 (1.23-2.27)*
Balance score (<13 scale points)	1.63 (1.26-2.12)*	2.73 (1.97-3.80)*
CS (times/30s)[¥]	1.03 (0.80-1.34)	1.58 (1.56-2.15)*
UG (sec)[¥¥]	1.48 (1.14-1.91)*	1.80 (1.31-2.46)*
TFFS (<17 scale points)	1.42 (1.09-1.85)*	2.29 (1.64-3.16)*
BMI (≥27.0 kg/m²)	1.41 (1.08-1.84)*	1.52 (1.10-2.11)*

*p<0.05
**OR (95% CI)- Odds Ratio (95% Confidence intervals for OR)
¥ adjusted for gender: female: <15x/30s; male: <16x/30s
¥¥ adjusted for gender: female: ≥5,67s; male: ≥5,13s
FoF: fear of falling; PA: Physical activity; UG: 8 foot Up-and-Go test; CS: Chair-Stand test; FAB4: step up and over test; FAB5: tandem walk test; FAB6: stand on one leg FAB7: stand on foam eyes closed; TFFS: Total functional fitness score; BMI: Body mass index

risk of recurrent falling may be up to 3 times higher, for those with poorer health and functional fitness.

Finally, being less active (i.e. having a lower total PA score) may increase the risk of episodic and recurrent falling by approximately 40% and 60%, respectively. Moreover, to spend less time in moderate and light PA (less then 5 hours in movement and standing activities) and to spend more time in a seated position (more than 6 hours per day) are risk factors for RF.

Multivariate logistic regression models are shown on Table III. To avoid collinearity, variables that were contained in global scores (*e.g.* Balance score and TFFS or sitting index and total PA) were not placed in the models at the same time. The best models, i.e. the ones with better discriminative power (measure by the AUC-ROC) were selected to be presented.

According to these models, gender, FOF, total PA and balance score are determinant factors for episodic falls. Likewise, recurrent falls are also determined by gender and FOF, and further by health parameters (general and visual health perceptions and medication intake) and functional fitness level. All factors included in the models presented higher *odds ratios* for RF than for F.

TABLE III. MULTIVARIATE LOGISTIC REGRESSION MODELS FOR EPISODIC AND RECURRENT FALLERS

	Episodic Fallers OR (95% CI)	Recurrent fallers OR (95% CI)¥
Gender (female)	1.52 (1.07-2.16)	1.84 (1.14-2.96)
General health perception (poor)		1.66 (1.08-2.57)
Visual health perception (poor)		1.63 (1.14-2.34)
Medication (n≥3 med/day)		2.06 (1.14-3.14)
Fear of falling (yes)	1.36 (1.00-1.86)	2.50 (1.35-3.14)
Total PA (<40 scale points)	1.36 (1.01-1.77)	
Balance score (<13 scale points)	1.41 (1.06-1.89)	
TFFS (<17 scale points)		1.48 (1.03-2.13)
Models fit indicators		
Hosmer-Lemshow (p)	3.99 (0.86)	9.37 (0.31)
ROC Curve (CI 95%)	62.0 (0.51-0.65)	72.9 (0.69-0.77)

¥ OR (95% CI)- Odds Ratio (95% Confidence intervals for OR)
PA: Physical activity; TFFS: Total functional fitness score

The Homer-Lemeshow goodness-of-the-fit test for logistic regression was not significant for both models (p>0.05), indicating that the models fit the data well. The area under the ROC curve (AUC) of the two models shows moderate discriminative properties, with about 60% of the subjects classified correctly as fallers and 70% of the subjects classified correctly as recurrent fallers.

DISCUSSION

The purpose of this study was to use a multifactorial approach to determine and characterize both episodic and recurrent fallers risk profiles in Portuguese older adults. In order to accomplish that goal we have tested 1416 community-dwelling older adults from 18 Portuguese municipalities, representing about 0.7% of national elderly population. Our results are in agreement with what we have found before in smaller cohort of Portuguese older adults[17] and allowed us to go further on the establishment of fallers (episodic and recurrent) risk profiles in the Portuguese population by adjusting the models for possible confounders.

An important result of our study is that falls seem not to be an inevitability of ageing, as age was not found to be a risk factor for both episodic and recurrent falls, even if the cut-off value used represents the very old individuals (≥75y and ≥80y), instead of the sample median. This fact, together with the importance of functional fitness in determining falls (both episodic and recurrent), indicates that these events may be prevented and allows the definition of effective intervention programs, tailored to different risk profiles.

Among the other demographic parameters, being single and living alone were risk factors for episodic falling, while being a woman was a risk factor for both falling episodically and recurrently. Other studies[1,11,12] have also identified these demographic parameters as risk factors for falling, although they tend to lose importance when inputted in a multivariate model. In our study, gender was the only demographic parameter that remained in the multivariate models, determining both episodic and recurrent falls. Nevertheless, this result may not be explained only by gender *per se*, but also be a consequence of the higher prevalence of disability and chronic conditions present in elderly women[31].

In what concerns health parameters, bivariate models show that almost all of them were associated with both episodic and recurrent falls. The association of different health parameters, not only with falls, but also with functional fitness decline, is not new[1,2,32,33]. However, it is interesting to note that, when adjusting for confounders' effects, with the exception of FOF, all the other health parameters (specifically, general and visual health perceptions and medication intake) were only determinant for the recurrent fallers' profile. This fact may indicate that, comparing with episodic falls, recurrent falls are more associated with comorbidities and are less likely to occur due to external factors. Further, the strong presence of FOF in both models should be highlighted, not only because of the known vicious circle that link this variable with activity avoidance, balance performance and falls[34], but also because this indicates the need of having a cognitive-behavioural approach in fall prevention programs.

Similarly, having a lower level of FF, either measured through the balance or the total score, was a determinant factor for both episodic and recurrent falls. It is important to note that all FF tests were predictors for both episodic and recurrent falls, but the combined scores (Balance and total scores) originated models with better predictive power, reinforcing the need for a multidimensional approach when dealing with falls. These results are in accordance with the literature where, although different FF measures have been used, having poor FF is reported to be a strong predictor for falls, especially for recurrent falls[11–15]. Actually, muscle weakness, problems with gait and balance have been referred as the most important risk factors for falling[4]. In our sample, lower functional fitness levels were associated especially with recurrent falling, even within subjects without FOF, fact that reinforces the relevance of the inclusion of these measures in both fall risk assessment tools and intervention programs.

Finally, the total PA score was associated with both falling and recurrent falling, while walking, movement and sitting scores were associated only with recurrent falling in the bivariate models. Nevertheless, when inputted in the multivariate models, total PA was the only parameter that remained, being only determinant for episodic falls. The relation between PA and falls is still not clear and, even though recent evidence shows that regular PA significantly reduces falls (specially injurious falls) in older people[35], there is still controversy whether higher PA levels associated with lower functional fitness levels could lead to a higher propensity for falling[15,36]. In our study, being more active, especially in what concerns light and moderate PA, was not only negatively correlated with falls frequency, but also positively correlated with FF level ($p \leq 0.001$). Moreover, PA health benefits for older people, namely the effect of slowing the decline in mobility performance, are widely known[37,38], and therefore, its role in fall prevention should not be underestimated.

A limitation of this study was that falls were assessed retrospectively, which can generate an underestimation of these events, as falls are easily forgotten[39,40] unless they have serious physical consequences. Other limitation of this cross-sectional study was the impossibility to establish cause-effect time-based relationships between the independent variables and the outcome. These facts may limit our conclusions regarding the potential of the tested variables to predict episodic and recurrent falls. Nevertheless, the fact that the results of this study are in agreement with the ones from other prospective studies, as well as the representative dimension of our sample, give us confidence about the strength of our results.

CONCLUSION

In this study we have tested 1416 Portuguese older adults above 65 years and used a multifactorial approach to determine and characterize episodic and recurrent fallers' risk profiles in this population. Our results showed that age was not a risk factor for either episodic or recurrent falling. In addition, health parameters were shown to be the factors distinguishing recurrent from episodic fallers. This may imply that, comparing with episodic falls, recurrent falls are more associated with comorbidities and are less likely to occur due to external factors. Furthermore, being a woman, having fear of falling and lower functional fitness levels were determinant factors for both episodic and recurrent falls. These factors appear to be related since women in our sample had a poorer FF level and more FOF, when compared with men. Moreover, although total physical activity was only related with episodic falling, promoting physical activity and exercise may be the easiest and cheapest way to improve functional fitness and health levels and therefore, its role in fall prevention should not be underestimated.

Concluding, the results of this study reinforce the importance of a multifactorial approach, not only focusing on cognitive-behavioral factors, but also on promoting physical activity and healthy lifestyles, when assessing fall risk or planning an intervention aiming at fall prevention within the older population.

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REFERENCES

1. Todd C, Skelton D. What are the main risk factors for falls among older people and what are the most effective interven-

tions to prevent these falls? Copenhagen: WHO Regional Office for Europe; 2004. Available at: http://www.euro.who.int/document/E82552.pdf.
2. Lord SR, Sherrington C, Menz HB, Close JCT. Falls in older people: risk factors and strategies for prevention. 2nd ed. Cambridge ; New York: Cambridge University Press; 2007.
3. World Health Organization. WHO global report on falls prevention in older age. Geneva, Switzerland: World Health Organization; 2008.
4. Rubenstein LZ. Falls in older people: epidemiology, risk factors and strategies for prevention. Age Ageing. 2006;35(Supplement 2):ii37–ii41. doi:10.1093/ageing/afl084.
5. Voermans NC, Snijders AH, Schoon Y, Bloem BR. Why old people fall (and how to stop them). Pract Neurol. 2007;7(3): 158–171. doi:10.1136/jnnp.2007.120980.
6. Tinetti ME, Williams CS. The effect of falls and fall injuries on functioning in community-dwelling older persons. J Gerontol A Biol Sci Med Sci. 1998;53(2):M112–119.
7. Stel VS, Smit JH, Pluijm SMF, Lips P. Consequences of falling in older men and women and risk factors for health service use and functional decline. Age Ageing. 2003;33(1):58–65. doi:10.1093/ageing/afh028.
8. Tinetti ME, Williams CS. Falls, injuries due to falls, and the risk of admission to a nursing home. N Engl J Med. 1997;337(18):1279–1284. doi:10.1056/NEJM199710303371806.
9. Yamashita T, Noe DA, Bailer AJ. Risk Factors of Falls in Community-Dwelling Older Adults: Logistic Regression Tree Analysis. The Gerontologist. 2012;52(6):822–832. doi:10.1093/geront/gns043.
10. Rose DJ. Preventing falls among older adults: no "one size suits all" intervention strategy. J Rehabil Res Dev. 2008;45(8): 1153–1166.
11. Graafmans WC, Ooms ME, Hofstee HM, Bezemer PD, Bouter LM, Lips P. Falls in the elderly: a prospective study of risk factors and risk profiles. Am J Epidemiol. 1996;143(11): 1129–1136.
12. Pluijm SMF, Smit JH, Tromp EAM, et al. A risk profile for identifying community-dwelling elderly with a high risk of recurrent falling: results of a 3-year prospective study. Osteoporos Int J Establ Result Coop Eur Found Osteoporos Natl Osteoporos Found Usa. 2006;17(3):417–425. doi:10.1007/s00198-005-0002-0.
13. Tromp AM, Pluijm SM, Smit JH, Deeg DJ, Bouter LM, Lips P. Fall-risk screening test: a prospective study on predictors for falls in community-dwelling elderly. J Clin Epidemiol. 2001;54(8):837–844.
14. Stalenhoef PA, Diederiks JPM, Knottnerus JA, Kester ADM, Crebolder HFJM. A risk model for the prediction of recurrent falls in community-dwelling elderly: a prospective cohort study. J Clin Epidemiol. 2002;55(11):1088–1094.
15. Chan BKS, Marshall LM, Winters KM, Faulkner KA, Schwartz AV, Orwoll ES. Incident Fall Risk and Physical Activity and Physical Performance among Older Men: The Osteoporotic Fractures in Men Study. Am J Epidemiol. 2007;165(6):696–703. doi:10.1093/aje/kwk050.
16. Stel VS, Pluijm SMF, Deeg DJH, Smit JH, Bouter LM, Lips P. A classification tree for predicting recurrent falling in community-dwelling older persons. J Am Geriatr Soc. 2003;51(10):1356–1364.
17. Moniz-Pereira V, Carnide F, Machado M, André H, Veloso AP. Falls in Portuguese older people: procedures and preliminary results of the study Biomechanics of Locomotion in the elderly. Acta Reum Port. 2012;37(4):324–332.
18. Lamb SE, Jørstad-Stein EC, Hauer K, Becker C. Development of a common outcome data set for fall injury prevention trials: the Prevention of Falls Network Europe consensus. J Am Geriatr Soc. 2005;53(9):1618–1622. doi:10.1111/j.1532-5415.2005.53455.x.
19. Dipietro L, Caspersen CJ, Ostfeld AM, Nadel ER. A survey for assessing physical activity among older adults. Med Sci Sports Exerc. 1993;25(5):628–642.
20. Rikli RE, Jones CJ. Development and Validation of a Functional Fitness Test for Community-Residing Older Adults. J Aging Phys Act. 1999;7:129–161.
21. Rose DJ, Lucchese N, Wiersma LD. Development of a Multidimensional Balance Scale for Use With Functionally Independent Older Adults. Arch Phys Med Rehabil. 2006;87(11): 1478–1485. doi:10.1016/j.apmr.2006.07.263.
22. Rose DJ, Jones CJ, Lucchese N. Predicting the Probability of Falls in Community-Residing Older Adults Using the 8-Foot Up-and-Go: A New Measure of Functional Mobility. J Aging Phys Act. 2002;10(4):466–475.
23. Hernandez D, Rose DJ. Predicting Which Older Adults Will or Will Not Fall Using the Fullerton Advanced Balance Scale. Arch Phys Med Rehabil. 2008;89(12):2309–2315. doi:10.1016/j.apmr.2008.05.020.
24. Cervi A, Franceschini S do CC, Priore SE. Análise crítica do uso do índice de massa corporal para idosos. Rev Nutr. 2005;18(6). doi:10.1590/S1415-52732005000600007.
25. Heiat A, National Institutes of Health (NIH: the NIH Consensus Conference on Health Implications of Obesity in 1985), United States Department of Agriculture (the 1990 Department of Agriculture's Dietary Guidelines for Americans), National Heart, Lung, and Blood Institute. Impact of age on definition of standards for ideal weight. Prev Cardiol. 2003;6(2):104–107.
26. Heiat A, Vaccarino V, Krumholz HM. An evidence-based assessment of federal guidelines for overweight and obesity as they apply to elderly persons. Arch Intern Med. 2001;161(9):1194–1203.
27. Sorkin JD, Muller DC, Andres R. Longitudinal change in the heights of men and women: consequential effects on body mass index. Epidemiol Rev. 1999;21(2):247–260.
28. Archer KJ, Lemeshow S, Hosmer DW. Goodness-of-fit tests for logistic regression models when data are collected using a complex sampling design. Comput Stat Data Anal. 2007;51(9): 4450–4464. doi:10.1016/j.csda.2006.07.006.
29. Zweig MH, Campbell G. Receiver-operating characteristic (ROC) plots: a fundamental evaluation tool in clinical medicine. Clin Chem. 1993;39(4):561–577.
30. Suresh K, Chandrashekara S. Sample size estimation and power analysis for clinical research studies. J Hum Reprod Sci. 2012;5(1):7–13. doi:10.4103/0974-1208.97779.
31. Orfila F, Ferrer M, Lamarca R, Tebe C, Domingo-Salvany A, Alonso J. Gender differences in health-related quality of life among the elderly: The role of objective functional capacity and chronic conditions. Soc Sci Med. 2006;63(9):2367–2380. doi:10.1016/j.socscimed.2006.06.017.
32. Hartikainen S, Lönnroos E, Louhivuori K. Medication as a risk factor for falls: critical systematic review. J Gerontol A Biol Sci Med Sci. 2007;62(10):1172–1181.
33. Collins K, Rooney BL, Smalley KJ, Havens S. Functional fit-

ness, disease and independence in community-dwelling older adults in western Wisconsin. Wmj Off Publ State Med Soc Wis. 2004;103(1):42–48.
34. Hadjistavropoulos T, Delbaere K, Fitzgerald TD. Reconceptualizing the Role of Fear of Falling and Balance Confidence in Fall Risk. J Aging Health. 2010;23(1):3–23. doi:10.1177/0898264310378039.
35. Thibaud M, Bloch F, Tournoux-Facon C, et al. Impact of physical activity and sedentary behaviour on fall risks in older people: a systematic review and meta-analysis of observational studies. Eur Rev Aging Phys Act. 2012;9(1):5–15. doi:10.1007/s11556-011-0081-1.
36. Peeters GMEE, Schoor NM, Pluijm SMF, Deeg DJH, Lips P. Is there a U-shaped association between physical activity and falling in older persons? Osteoporos Int. 2009;21(7):1189–1195. doi:10.1007/s00198-009-1053-4.
37. U.S. Department of Health and Human Services. Physical Activity and Health: A Report of the Surgeon General. Atlanta. GA: U.S. Department of Health and Human Services, Centers for Disease Control and Prevention, National Center for Chronic Disease Prevention and Health Promotion; 1996.
38. Visser M, Pluijm SMF, Stel VS, Bosscher RJ, Deeg DJH. Physical activity as a determinant of change in mobility performance: the Longitudinal Aging Study Amsterdam. J Am Geriatr Soc. 2002;50(11):1774–1781.
39. Fleming J, Matthews FE, Brayne C. Falls in advanced old age: recalled falls and prospective follow-up of over-90-year-olds in the Cambridge City over-75s Cohort study. Bmc Geriatr. 2008;8:6. doi:10.1186/1471-2318-8-6.
40. Ganz DA, Higashi T, Rubenstein LZ. Monitoring Falls in Cohort Studies of Community-Dwelling Older People: Effect of the Recall Interval. J Am Geriatr Soc. 2005;53(12):2190–2194. doi:10.1111/j.1532-5415.2005.00509.x.