



Predictors of Incidence of Fall in Elderly Women; A Six-Month Cohort Study

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ABSTRACT

Objective: To determine the incidence and predictive factors of the falls in elderly women in Northern Iran.

Methods: A total of 717 elderly women aged 60 years and above in Amirkola, Northern of Iran participated in this study. Age, history of falls during the 12 months leading to the study, accompanying diseases, status of balance, cognitive status, orthostatic hypotension, state of depressive symptoms, strength of quadriceps muscles and serum vitamin D level were assessed as independent variables during baseline measurement. Incidence of fall (dependent variable) was recorded during a six-month follow-up period.

Results: Of the participants, 7.8% had experience of fall, out of which 50.0% experienced it once, 25.0% twice, and the rest three times or more. With aging, the incidence of orthostatic hypotension also increased and symptomatic depression became aggravated. In the final model, the variables of the number of accompanying diseases (RR=1.78, 95% CI: 1.00-3.18), severe cognitive impairment (RR=12.70, 95% CI: 3.05-52.86), and depressive symptoms (RR=3.19, 95% CI: 1.48-6.86) remained as strong associated variables for incidence of fall.

Conclusion: With increasing severity of depressive symptoms and cognitive impairment along with the comorbidities, incidence of fall also increases in the elderly. Thus, psychological aspects of the elderly and comorbidities in this group should be taken care of seriously.

Keywords: Fall; Women; Cohort; Risk factor.

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Introduction

Ageing phenomenon occurs across the whole globe [1], and it is at an unprecedented rate

[2]. United Nations reported that by 2050, one-fifth of the world's population will be over 60 years of age [3]. With ageing, functional capacity declines. These changes may affect the daily activity of a

Ageing of SID

person including sitting and standing up off chairs and rapid response to external factors impairing balance in order to maintain and recover balance [4]. All these can result in increased risk of fall [5]. Fall may be the first sign of weakness and disability of the neuromuscular or musculoskeletal system [6]. Falls significantly affect the quality of life [7]. It is a prevailing issue among the elderly, which is associated with social isolation and diseases [8]. According to a report, one-third of the elderly, who are 65 years and above, experience fall every year, half of whom have had the experience for more than once [9]. This commonly leads to hospitalization of the affected elderly. Around 5-6% of the falls causes injury for the elderly, with 1% of cases being related to hip fracture [10].

Some studies have mentioned age above 65, being female, diminished physical activity, weakness of the muscular power, fear of falling, cognitive impairments, lack of balance and orthostatic hypotension as the risk factors for fall [11-15]. There are some evidences suggesting that women fall more than men [16, 17]. Women are probably more at risk of diminished bone mineral density due to menopause compared to men, which can justify the discrepancy between falls and fractures in men and women [18]. Fracture in the post-menopausal period can have very severe consequences ranging from hospitalization to diminished quality of life [19]. Identifying the factors associated with elderly falls can contribute to discovering the causes of this event [20]. Also, detecting these factors can be useful in developing strategies for controlling the threatening risk factors mitigating the rate of incidence. This study was performed to determine the associated factors in falls among women. Through this, one can develop a program to prevent and reduce the rate of fall among women aged 60 years or older.

Materials and Methods

Study Population

This cohort study is part of the Amirkola Health

and Ageing Project (AHAP). According to the latest census, there were 1076 women aged 60 years or older living in the 34 districts in Amirkola town when this study began. People were informed about the study in talks in mosques and also via posters distributed throughout the city [21]. After notifying and inviting the elderly to participate in the study, 732 people agreed to participate in the research (Figure 1). Age of 60 and above, being a resident in Amirkola Town during the study and willingness to participate in the study were the inclusion criteria.

Basic Measures

Basic assessment of the participants across various health dimensions was performed using different questionnaires and tests in the Center for Social Determinants of Health (SDH) Research Centre of the Babol University of Medical Sciences. These assessments and questionnaires included balance, orthostatic hypotension, cognitive impairments, status of depressive symptoms, quadriceps muscles strength, serum level of vitamin D, history of fall over the last year, and number of comorbidities. The balance was measured by Berg Balance Test [22]. According to this test, participants were grouped into low fall risk (normal balance state), moderate (moderate balance impairment), and severe (severe balance impairment). In other words, acquiring low score represented improper balance state. To determine orthostatic hypotension, the blood pressure of the participants was assessed in both supine and sitting positions. Difference of 20 mmHg or more for systolic blood pressure and 10 or more for diastolic blood pressure in both states were considered as orthostatic hypotension. The Mini Mental State Examination (MMSE Mini) was employed to investigate the cognitive status of the elderly [23]. Based on the scores acquired by the participants, they were assigned into normal state as well as mild, moderate, and severe cognitive impairment groups. In the studied population, depression was classified as normal, mild, moderate, and severe according to Geriatric Depression Scale (GDS). To examine

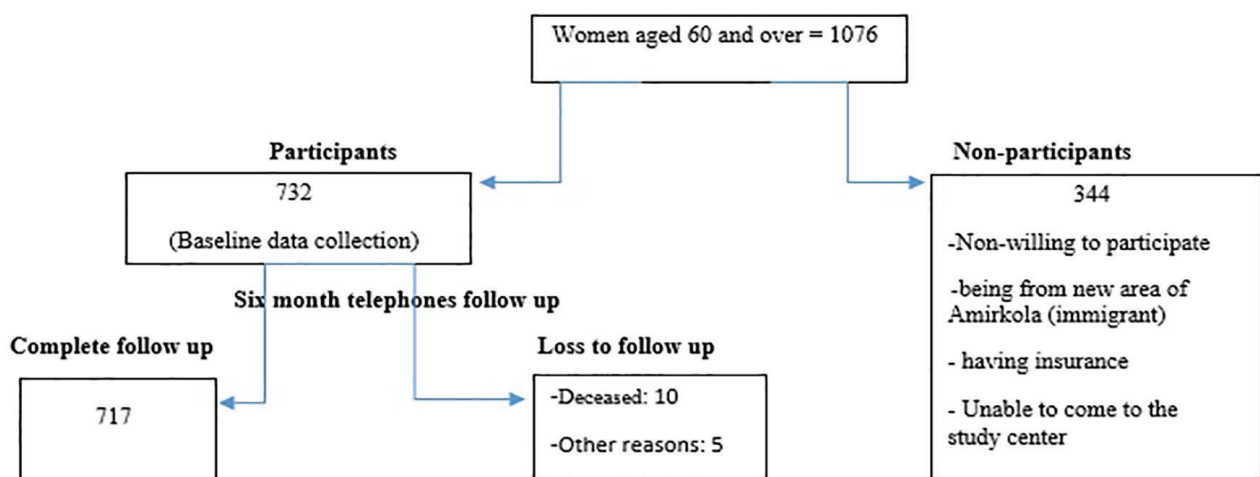


Fig. 1. Flowchart of the data collection process and follow up.

Analysis of *SID*

and determine the comorbidities, the elderly was requested to have their health insurance booklet and all the drugs they consumed by the time of visit. The power of quadriceps muscle (Leg strength) was calculated using an analog scale, and the maximum force exerted by the patient to the spring gauge was recorded in terms of kg, and for individual left and right legs. Vitamin D levels were recorded based on blood tests and a serum level of 30 was considered as cut point. Further, each participant was asked about possible history of fall in the last year. Once the preliminary evaluations were gathered and the basic information was collected for each old woman, follow-up was done for six months, together with inquiry on possible history of fall (a two value variable, with and without fall).

Statistical Analysis

To describe the quantitative variable (age), mean and standard deviation were reported, while for qualitative variables, proportion was employed. Incidence of fall along with confidence interval was

reported in terms of each level of the independent variables. Negative Binomial model was used to investigate the relationship between each independent variable and fall. Relative Risk was also reported in crude and adjusted states for comparison. To examine the relationship between ageing and prevalence of depression and orthostatic hypotension, logistic regression was employed. Also, correlation test was utilized to study the relationship between age and score of balance and cognitive state tests. Data analysis was performed using IBM SPSS Statistics for Windows, Version 22.0. The significance level was also considered $p < 0.05$. The research proposal for comprehensive investigation of geriatric health in Amirkola Town was approved in the 32nd meeting of Ethics committee at Babol University of Medical Sciences on October 12, 2010. Further, the thesis proposal entitled "Investigating the incidence and risk factors and predictive model for fall among the elderly in Amirkola Town: a population-based study, with the code IR.TUMS.VCR.REC.1395.54 was approved in the ethics committee in research at

Table 1. The incidence and relative risks of fall by different risk factors

Variable	Frequency (%)	number of participants with fall (incidence: 95% CI)	Relative Risk: 95% CI	
			Crude	Adjusted
Age groups				
60-69	449 (62.6)	32 (7.1: 4.8 -10.0)	1	1
70-79	223 (31.1)	21 (9.4: 5.8-14.3)	1.32: 0.78-2.23	1.12: 0.63-1.99
80≤	45 (6.2)	3 (6.7: 1.3-19.4)	0.93: 0.29-2.93	0.56: 0.17-1.81
History of fall				
Yes	160 (22.3)	20 (12.5: 7.6-19.3)	1.95: 1.12-3.25	1.47: 0.85-2.52
No	557 (77.7)	36 (6.5: 4.5-8.9)	1	1
Number of other diseases				
<3	394 (55.0)	21 (5.3: 3.2-8.1)	1	1
3≤	323 (45.0)	35 (10.8: 7.5-15.1)	2.03: 1.20-3.42	1.71: 1.07-3.01
Balance state				
Normal	635 (88.5)	45 (7.0: 5.2-9.3)	1	1
Intermediate impairment	71 (10.0)	9 (12.7: 5.7-24)	1.78: 0.91-3.50	1.46: 0.67-3.20
Severe impairment	11 (1.5)	2 (18.2: 2.2-65.6)	2.56: 0.71-9.27	2.14: 0.46-9.88
Cognitive state				
Normal	466 (65.0)	31 (6.7: 4.5-9.4)	1	1
Mild impairment	161 (22.5)	14 (8.7: 4.7-14.5)	1.13: 0.59-2.14	0.93: 0.49-1.75
Intermediate & Severe impairment	90 (12.5)	9 (12.0: 6.1-20.6)	1.97: 1.05-3.47	1.81: 1.0-2.90
Orthostatic hypotension				
Negative	621 (86.6)	48 (7.7: 5.8-10.5)	1	1
Positive	96 (14.4)	7 (7.3: 2.9-15.1)	0.92: 0.42-1.97	0.61: 0.27-1.40
Depression status				
Normal	286 (40.0)	13 (4.5: 2.4-7.7)	1	1
Mild impairment	248 (34.5)	15 (6.0: 3.3-9.9)	1.33: 0.64-2.72	1.11: 0.51-2.42
Intermediate impairment	118 (16.5)	16 (13.6: 7.7-22.0)	2.98: 1.48-6.00	2.24: 1.03-4.84
Severe impairment	65 (9.0)	12 (18.5: 9.5-32.2)	4.06: 1.94-8.48	3.15: 1.48-6.72
Quadriceps muscle strength				
Normal	337 (47.0)	22 (6.6: 4.1-10.1)	1	1
Weak	380 (53.0)	35 (9.2: 6.3-12.9)	1.39: 0.82-2.35	1.16: 0.65-2.06
Vitamin D level				
Sufficient ≥30	254 (35.4)	19 (7.5: 4.5-11.6)	1	1
Deficient <30	463 (64.6)	37 (7.9: 5.6-11.01)	1.07: 0.63-1.83	1.09: 0.63-1.88

Results

Of the 732 participants whose baseline information had been collected, 10 (1.3%) participants were excluded due to death and five (0.6%) others left the study for different reasons during the follow-up period (Figure 1). None of the excluded participants were related to falling. The mean age of the participants was 68.5 ± 6.9 , with medians of 67.0 and 25 and 75 percentiles of 62.0 and 75.0, respectively. A total of 56 participants (7.8%, 95% CI: 5.9-10.0) reported a history of fall, out of which 50.0% experienced it once, 25.0% twice, and the rest experienced it three times or more. According to Table 1, the age group, 60-69 years old, had the highest fall incidence and largest frequency of participants. According to GDS test, in 60.1% of participants, varying degrees of depression were observed. Further, BBT test showed that 11.5% of elderly women had problem with balance. There is a reverse linear relationship between the scores of cognitive test ($r=-0.29$, $p<0.001$) and balance ($r=-0.48$, $p<0.001$) with age. In contrast, this relationship between presence of orthostatic hypotension (OR=1.03 $p=0.01$) as well as depressive symptoms (OR=1.02, $p=0.05$) and age was in the same line. In other words, with ageing, the odds of Presence of orthostatic hypotension and depressive symptoms increased. On the other hand, the serum level of Vitamin D in the fall and non-fall groups showed no difference and the mean serum level of vitamin D in the two groups was within the normal range (≥ 30) ($p=0.783$). In the crude model, cognitive impairments, status of depressive symptoms, history of fall over the last year and number of comorbidities had a significant statistical relationship with the fall, but in the adjusted model, cognitive impairments, status of depressive symptoms and number of comorbidities remained as strong predictors in the model.

Discussion

The results of the study suggest that only 7.8% of the participants had experienced fall during the six-month follow-up period. This result was low in comparison with other studies [24-26] which reported this value to be over 30% within one-year follow-up period. In addition, fall had an ascending trend in the studied population with age up to 80 years of age, while this trend was not statistically significant. However, some studies reported that a significant association existed between age and fall, with older individuals being more at risk of fall. In other words, with ageing, the extent of fall also grows in the elderly [27, 28]. Low incidence of fall and lack of relationship between age and fall in the present study may be due to underreporting by participants in the study, causing underestimation.

On the other hand, as the study was population based and due to presence of all age spectrum of the elderly and the high frequency of young elderly, together with its difference with other studies which have mostly focused on the elderly in hospice care or rehabilitation centers, and as typically the elderly in these centers are more vulnerable than other old people, these could be other reasons for the low incidence. Although the extent of fall was lower than in other studies across all of the three age groups, the incidence demonstrated a descending trend after growth until 80 years old, which can be due to reduction and limitation of daily activities due to senility in this age group.

Curcio *et al.*, [29] reported that the elderly with the history of fall may experience diminished level of activity and function as well as distressing signs of depression. On the other hand, increased risk of fall is associated with diminished mobility in response to lack of physical activity and senescence [30]. In the present study, in spite of the 1.4-fold probability of fall for the elderly with the history of fall over the past 12 months leading to the study, the difference was not statistically significant, which is incongruent with the results obtained by Chan *et al.*, [31]. In justifying the indifference observed among the elderly with the history of fall and those without such a history, it can be stated that experience of fall alone cannot limit physical activity and predict fall effectively, as other factors affected by fall such as the consequences of fall and the intensity of the possible injuries cause fear from falling again and eventually diminished level of physical activity in the old person, and can predispose the person to subsequent falls.

The relationship between fall and diseases has been examined in several studies. Prevalence of fall increases with increased number of chronic diseases, and chronic diseases are an important predictor in the elderly, especially women. The diseases through direct and indirect effects such as reduced physical activity, weakness of muscular power, and balance impairment cause increased risk of fall [8]. The result of this study is in line with those in the study aforementioned, and a significant difference was observed between fall and presence of disease. Generally, previous studies have found that the elderly with one or several diseases are significantly more at risk of fall [32, 33].

Diminished balance during senescence, especially with aging, is considered a permanent concern [34]. In the present study, it was found that an inverse relationship existed between age and score of balance, as older women had a lower score in balance. In his study, by comparing balance among the elderly, Aslan *et al.*, also reported that the results of functional reach (FR), the time up and go (TUG), sit to stand (STS), and step test (ST) all confirmed better outcome of balance tests in middle-aged elderly compared to old elderly [28].

In contrast, in the present study, it was not possible to find a significant relationship between fall among the participants and their balance test score, which is not in line with the results of previous studies [25, 35] which reported balance score as a strong predictor for fall. It can be justified that although lack of balance is considered a necessary condition for fall, it is not sufficient, i.e. it only increases the chance of fall, and occurrence of fall requires other accelerating variables including both environmental and individual variables. On the other hand, considering Table 1, it is observed that out of the 82 participants with different degrees of imbalance, over 71 had mild balance impairment, without any significant difference with the balance score of normal people. Only (11.5%) of the participants gave false report in the very unsuitable balance group, causing diminished statistical power of study and thus not reporting significant relationship.

According to researches, mild changes in cognition (perception) especially in the area of executive function contribute to instability and imbalance [36]. Glyson *et al.*, reported that with one score reductions in the MMSE test, the risk of fall increases by 20% [37]. Furthermore, Chen *et al.* stated that cognitive impairments can be a serious risk factor for fall [38]. In the present study also there was an inverse and significant relationship between age and score of cognitive impairment test, whereby with elevation of age, the score of this variable declined. In addition, in the multiple model, participants with extreme cognitive impairment were significantly more at risk of fall. Confirming the results of the present study, in the research conducted on elderly drivers, it was found that the cognitive and physical functions directly and indirectly affected behaviors leading to fall, where those with older ages had less suitable cognitive status [39].

Orthostatic hypotension is common among the elderly [40]. Estimation of precise prevalence of this disease depends on the time of measuring blood pressure. According to some reports, this disease mostly occurs in the morning [41, 42]. The reason is attributed to the long rest of pressure receptors during the night [42]. According to the study, prevalence of this disease in the elderly of 65 years old and above living in nursing home was around 20%, while for those with 75 years of age and above and for disabled elderly it grew to around 30 and 50%, respectively [40]. Confirming the results of the aforementioned study, in the present study the frequency of this impairment in the elderly increased with age, with the 80-year-old age group showing the maximum frequency. In contrast, investigating the relationship between this impairment and the dependent variable studied here, no significant relationship was observed. This is in line with the findings of some studies [8, 25, 43], while incongruent with others [44, 45]. This may be due to the differences in the

definition of this impairment and application of different instruments in the studies or adaptation of the elderly to this phenomenon.

Depression incurs huge costs to the elderly due to its serious adverse effects on general health including disorder in balance and walking [46]. The results of this study showed that age has a direct relationship with severity of depression symptoms in the elderly, as older individuals had more symptoms of depression compared to the others. Furthermore, in the final analysis it was found that this factor is considered a fall predictor, and with progression of depressive symptoms, probability of fall also increased. The findings of the present study are in accordance with other studies [8, 47, 48], which had reported depression as a risk factor for fall.

In spite of the better score of strength of quadriceps muscles in the people without fall compared to the elderly with history of fall in the uni-variable model, after adjustment for other variables, it was not possible to report a relationship between strength of quadriceps muscles and fall. However, several studies have emphasized the importance of power muscles to take proper steps and stand up off a chair (keeping balance) [49, 50]. In line with the present study, the investigations [4, 51] have also suggested lack of relationship between this variable and fall. Justifying this lack of relationship, it can be stated that the crucial issue in risk-free conductance of daily activities is having dynamic balance and keeping and controlling the center of gravity of the body. Poor balance could be a combination of chronic waste of neuromuscular and nervous systems resulting from genetics, lifestyle, and other factors, where the strength of lower body muscles is one of these factors. Another reason could be the fact that 50% of fallers reported only one time of fall during the follow-up period. According to the studies of Lord and Keskin [51, 52], in which three-fourths of the participants had reported only one time of fall, the results of some physiological tests including reaction time, lower muscular power, and balance have been the same among those with history of fall and others without it.

Insufficient absorption of nutrients in the elderly is common, which causes malnutrition and mostly remains undiagnosed. Inadequate absorption of vitamins and minerals is associated with functional disorder of muscles [53]. There is an assumption that deficiency of vitamin D may cause diminished executive function and fall [54]. In the present study, no significant relationship was observed between this vitamin and probability of fall in the studied group. The reason can be related to the fact that the mean serum level of vitamin D was not different between the two groups, and even it was within the normal range (over 30). On the other hand, according to the study [55], the possible mechanism causing the effect of this vitamin in reduction of fall was the presence of these receptors on muscles, whose

Arthritis of SID deficiency caused myopathy.

In this study, a significant relationship was not observed between some of the variables (age, state of balance, etc.) which had been stated as important predictors of fall in other studies, with incidence of fall. In addition to the reasons mentioned for each individual variable, the common reason could be the low power of study due to low incidence of the event in the studied population and the heterogeneity of the comparison groups.

The main limitation of this study is lack of data about non-respondents. Another limitation is failure to measure some of the factors affecting the fall, such as fear of fall. A fairly good number of participants, low loss to follow-up and the wide range of variables studied were as strengths of study.

Fall among the elderly is a multidimensional phenomenon. In this study, it was found that mental status of people including the variable of geriatric depression symptoms (GDS) and the cognitive

impairments along with the comorbidities are important predictors of fall in the elderly. In other words, with aggravation of status of depression and cognitive impairments alongside the accompanying diseases, incidence of fall also grows among old people. Therefore, special attention should be given by healthcare providers and the authorities concerning the psychological issues of the elderly and comorbidities in this group.

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