Analysis of extrinsic and intrinsic factors that predispose elderly individuals to fall

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Summary

Objective: In a sample of elderly individuals from Porto Alegre – RS, Brazil, to analyze the intrinsic and extrinsic factors that predispose them to the risk of falls and fractures. **Methods:** The study included a random sample of 267 elderly individuals, to whom two balance tests were applied: the Functional Reach Test (FRT) and the Timed Up and Go Test (TUG). The elderly also answered a questionnaire (13 questions divided into four categories) on sociodemographic and health factors. **Results:** Elderly individuals from both genders (76.8% women), aged between 60 and 90 years (mean = 70.22 years, SD = ± 7.30 years) participated in the study. A statistically significant association ($p < 0.05$) was found between age, self-perception of eyesight, type of dwelling, last monthly income, and the FRT; the same was found between age range, self-rated health ($p < 0.001$) and the TUG. **Conclusion:** It was identified that, in the sample of elderly individuals living in Porto Alegre – RS, Brazil, the intrinsic factors that predispose to the risk of falls and fractures are older age, poor self-perception of eyesight, and poor self-rated health; the extrinsic factors are type of dwelling (living in a house) and a monthly income ≤ one minimum wage.

Keywords: Elderly; fall accidents; risk factors; postural balance.

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Introduction

Balance is the result of the harmonious interaction of several body systems: vestibular, visual, somatosensory, and musculoskeletal[1]. Each system has components that may show functional loss with the aging process, hindering the operation and implementation of the motor response responsible for maintaining posture control and body balance which, in turn, can lead to functional impairment in the elderly due to falls and increase morbidity and mortality levels in this population, as a result of fractures[1,2].

Falls can be defined as episodes of imbalance that cause the elderly to fall to the ground. The fall can be determined by any accidental contact with nearby surfaces, such as a chair or desk[3].

Many risk factors for falls have been reported in elderly individuals from different communities[4-6]. The etiology of the fall is usually multifactorial[3,7], resulting from the interaction between predisposing and precipitating factors, which may be intrinsic and extrinsic[8]. Intrinsic factors can be defined as those related to the subject himself/herself, who may have impaired function of the systems that comprise postural control, diseases, and cognitive and behavioral disorders, presenting an incapacity to maintain or restore balance when necessary. Extrinsic factors are those related to the environment such as lighting, walking surface, loose carpets, and high or narrow steps[4,8]. There is, however, divergence regarding extrinsic risk factors for falls, as it is thought that they cannot be considered only in terms of the environmental factors where the elderly individuals live, because there is also the interference of cultural, religious, age, and ethnic factors[9].

Statistics show that between the years 1997 and 2007, there was an increase in the elderly population, and with it, an associated increase in mortality rates due to falls[10]. Falls can have harmful physical[11-13], functional[14], and psychosocial[11,15] consequences. Severe tissue injuries and fractures (especially femoral) result in hospitalization and rehabilitation costs for these elderly individuals[3,7] who, in most cases, cannot recover their functional status prior to the fall[6], as they develop mobility limitations with lifestyle changes, becoming partially or totally dependent in basic and instrumental activities of daily living. There is also fear of repeated falls, depression, low self-esteem, and shame derived from dependence, which decrease the optimism about the future, thereby reducing the quality of life[16].

The importance of identifying risk factors for falls in the elderly is the possibility to plan strategies for prevention, environmental reorganization, and functional rehabilitation[3,7,17]. Thus, a multiprofessional and interdisciplinary approach is necessary to attain a higher degree of efficiency for the proposed strategies, in order to minimize the risk of falls and thereby avoid dependence and reduce elderly morbidity and mortality[6]. Although studies are being conducted and published, the importance of further studies on the topic to clarify the risk factors for falls remains due to its complexity and correlation with different aspects of life[18-21].

The objective of this study is to analyze a sample of elderly individuals from the city of Porto Alegre (state of Rio Grande do Sul, Brazil), assessing the intrinsic and extrinsic factors that predispose to the risk of falls and fractures.

Methods

The present study was developed based on data collected for the Multidimensional Study of the Elderly of Porto Alegre (Estudo Multidimensional dos Idosos de Porto Alegre - EMIPOA), consisting of a multidisciplinary team of teachers and scholars from nine different undergraduate courses of the Pontifícia Universidade Católica do Rio Grande do Sul (PUCRS). The results of EMIPOA have been published in national and international journals[22-27].

EMIPOA participants were elderly individuals of both genders who were part of a population sample of 1,164 elderly community residents. The original population sample consisted of 0.69% of the population of Porto Alegre. The percentage of 0.69% reflects the elderly distribution ratio in Porto Alegre in relation to the overall population distribution, a calculation based on the predictive correction of population growth for the year 2005 based on the 2000 population census conducted by the Brazilian Institute of Geography and Statistics (Instituto Brasileiro de Geografia e Estatística – IBGE). The random sample was stratified by the regional census of the municipality. All elderly individuals were contacted at home, when data on socioeconomic status and type of housing were obtained. Those who agreed to participate in the second phase of the study, which occurred during the multidisciplinary assessment, were taken to the PUCRS, with transportation subsidized by the research fund.

EMIPOA was approved by the PUCRS Ethics and Research Committee under No. 0502935. All professionals involved with data collection signed a liability term regarding data according to Goldim's model (2000), guaranteeing anonymity and confidentiality of information[28].

Sample

The present study consisted of a sample of 267 elderly patients evaluated in EMIPOA of both genders (males = 23.2%) aged ≥ 60 years (mean = 70.22, SD = 7.30 ± years), with the most prevalent age range being 60 to 69 years (51.3%).

The inclusion criteria were: age ≥ 60 years, being a resident of the municipality, and consent to participate in the study. The study excluded bedridden individuals and those unable to move, and those with cognitive impairment or severe psychiatric disorders that would preclude the understanding and application of tests.

Collection instruments

For the EMIPOA, the elderly answered a questionnaire consisting of 121 questions, divided into 11 categories, of which the present study used 13 questions from four different categories. Thus, data were collected on: gender, age, marital status, type of housing (house, apartment, room/shack/hut), housing construction materials (bricks, wood, mixed/others) and electricity status (yes/no), last monthly income (no income, up to one minimum wage [MW], between one and three MWs, between three and six MWs, more than six MWs), and health perception. For this last category, four dichotomous questions were asked: (1) In general, would you say that your health is bad or good?; (2) How is your eyesight at the moment, regular/bad or good?; (3) How is your hearing at the moment, do you have difficulty hearing or do you hear without difficulty?; (4) Have you had fractures after 50 years of age without being involved in a traffic accident, yes or no?

After the questionnaire was applied, the EMIPOA also required the following data: (1) clinical history; (2) physical examination; (3) laboratory tests (triglycerides, cholesterol, and glucose measurements); (4) psycho-cognitive assessments (Memory Complaint Questionnaire [MAC-Q][29], Mini-mental State Examination – [MMSE][30] and Verbal Fluency)[31]; and (5) functional tests, including the Functional Reach Test (FRT)[32] and the Timed Up and Go Test (TUG)[33]. Among the mentioned assessment tools, it must be emphasized that for the present study, only the data from FRT and TUG, and part of the questionnaire and demographic data, were used.

FRT and TUG

The FRT[32] and the TUG[33] are two of the instruments used to assess the risk of falls and static and dynamic body balance in the elderly, and may help, among other things, to establish an effective rehabilitation program. Both tests are used in research[18,34] and clinical practice[35] as they are easy to apply, comprising the multidimensional evaluation of the elderly proposed by Moraes (2010), and have been validated in Brazil[18,34,36].

In the FRT[32], the elderly stands barefoot, with his/her feet on the ground, placed sideways to a wall on which there is a metric tape fixed in the horizontal position. To start the test, the elderly individual must place the upper limb at a 90° shoulder flexion, and the center of the shoulder joint must coincide with the zero centimeter of the tape. The length of the elderly person's arm with an open hand and fingers stretched to tip of the middle finger is recorded. From this position, the elderly must make a maximum forward inclination of the torso, with the upper limb reaching as far as possible, without leaning on the wall and/or tape, without using the other upper limb as support, and without removing the heels from the ground. The arm moves along the horizontal tape and the distance in centimeters between the initial annotation of the length of the arm and the final displacement from the trunk to the tip of the middle finger is the functional reach of the elderly person. The test should be performed three times and the greatest distance reached is recorded. Frail elderly individuals with a reach less than 15 cm are four times more likely to experience falls than those with a reach of 25 cm.

The TUG[33] records the time taken for the elderly person to rise from a chair without arms, wearing his/her own shoes and using any usual assistive devices (none, cane, or walker). The elderly individual is instructed to walk a distance of three meters, make a 180º turn, and return to sit on the same chair. Timing starts when the elderly's back moves away from the chair and ends when the back touches the chair again. The results indicate: (1) TUG up to ten seconds – elderly shows no alterations in balance and has low risk of falls; (2) TUG between 11 and 20 seconds – elderly with no significant balance alteration, but is somewhat frail and has a medium risk of falls; (3) TUG > 20 seconds and < 30 seconds – elderly in need of intervention; and (4) TUG > 30 seconds – elderly at high risk of falls, dependent in ADLs and with altered mobility[14].

Data analysis

A specific database was created for EMIPOA, which was used for entering data collected during all phases of the research. For this purpose, the Access® software for Windows®, release 2003 was used. The verification of the collected data, as well as the correction of errors, was performed when transferring the data to an Excel® spreadsheet for Windows®, release 2003.

For data analysis, the Statistical Package for Social Sciences (SPSS®) for Windows®, release 11.5, was used. The descriptions were made through measures of frequency, means and standard deviations, with 95% confidence intervals (95%CI).

To compare the means of the FRT and the TUG between groups defined by intrinsic and extrinsic factors, bivariate analyses were performed using Student's *t*-test for independent samples, taking into account the equality of variances, previously tested by Levene's test. When the studied factors were categorical, polytomous or ordinal, one-way analysis of variance (one-way ANOVA) was used, with Bonferroni's post-test (post hoc test). Pearson's correlation test was also used to associate the variables TUG and FRT and age. The chi-squared test was used to compare the categorical variables of last monthly income and housing type.

Results

The results are shown in Table 1. Overall, data on 267 elderly were used in this study; however, for the FRT, values of 227 subjects were used due to data loss.

Functional Reach Test

The group obtained a mean value in the FRT of 17.6 ± 6.1 cm (minimum = 4.0 cm, maximum = 33.5 cm).

The correlation between the FRT value and age was -0.103 ($p > 0.05$). The correlation between the balance tests was -0.159 ($p < 0.05$).

Among the factors that were related to the FRT, the variables that presented statistical significance ($p < 0.05$) were age, self-perception of eyesight, housing type, and last monthly income, demonstrating that these variables influenced the mean measures of the functional reach of the studied subjects (Table 1).

Student's *t*-test for independent samples demonstrated that the elderly aged 60-69 years had a significantly higher mean functional reach (18.6 ± 6.6 cm) than the elderly older than 70 years (16.5 ± 5.4 cm). Subjects with self-reported good eyesight had significantly higher average FRT (19.0 ± 5.4 cm) than subjects with self-perceived fair or poor eyesight (17.0 ± 6.3 cm).

Bonferroni's post-test demonstrated, for the variable type of housing, a difference (2.2 cm, 95% CI: 0.12-4.37) between the means of the subjects that lived in a house (16.9 ± 5.9 cm) and in an apartment (19.1 ± 6.3 cm); therefore, those who lived in a house had a significantly lower mean FRT than those individuals who lived in an apartment. The same test showed that subjects with monthly income between three and six MWs had a significantly higher average FRT value (20.3 ± 6.8 cm) than subjects who had a last monthly income up to one MW (16.5 ± 5.8 cm).

The chi-squared test was applied to the two last analyses between the variables type of housing and last monthly income to verify whether living in a house or apartment was associated with lower income. The analysis showed that among those living in a house, the majority (n = 74, 40.4%) received up to one MW; among those who lived in an apartment, the majority (n = 30, 38%) received one to three MW. If those with no income are added to those receiving up to one MW, the majority also lives in a house (n = 79, 43.1%). Therefore, most apartment dwellers have higher monthly income than those living in houses.

Other factors such as gender, self-perception of hearing, self-rated health, types of housing construction materials, presence of electricity, and fracture involvement did not influence the functional reach measures ($p > 0.05$).

Timed Up and Go Test

The sample of elderly individuals had a mean TUG of 12.7 ± 5.5 seconds. The correlation between the values of the TUG and age was 0.264 ($p < 0.001$). The factors related with the TUG test were age and self-rated health ($p < 0.001$). The remaining variables tested had no effect on the dynamic balance test ($p > 0.05$) (Table 1).

Discussion

The aging process gives rise to several structural and functional alterations responsible for changes in the psychomotor balance function[1,16]. The present study showed a functional decline through the correlation between age and the TUG test. The correlation, although weak, was observed, showing that the variable has an association, as expected, but with high dispersion. This finding is consistent with the literature, which states that aging has a heterogeneity characteristic[37,38]. For this study, other particularities of individuals, such as physical activity, or an index to verify the performance of daily living activities, were not considered, suggesting that individuals could have different degrees of physical performance[39-41].

This study compared balance measured through the FRT and TUG tests with different variables, in order to discover which are the intrinsic and extrinsic factors that predispose to the risk of falls in the elderly.

The variable age was an intrinsic factor for the risk of falls in this study. Advancing age was associated with decreasing FRT values and with increasing TUG values, both statistically significant. The results are similar to those in two different studies[42,43], which found a decline in the FRT related to increasing age in healthy individuals. Duncan et al., in two other studies, reported that the FRT is a strong indicator of the risk of falls, and that increased age negatively influences the test results[32,44].

The results show a significant difference regarding age, i.e., elderly individuals with a higher mean age had at least one fall episode compared to the group with a lower mean age, who did not have any fall episodes[44]. Other studies have reported a higher prevalence of falls[19,45-47], concluding that the older the age of the individual, the greater the risk of falling due to a decrease in the quality and quantity of information necessary for achieving efficient postural control. Lin and Liao discuss the full applications and results of the FRT, stating that there is no clear association between FRT and alterations due to the aging process[48].

The self-perception of eyesight, reported by the research subjects, influences the FRT. Elderly individuals with good self-perception had a better mean score in the test than the individuals with regular and poor eyesight. Perracini and Ramos corroborate this result by reporting that there is an association between poor or very poor self-perceived eyesight and the occurrence and recurrence of falls, with an impact on the daily performance of the elderly[20]. Lord states that, although the studies retrieved did not show consistency on the association between visual acuity and the increase in the number of falls, eyesight is an important component of balance[49]. A reduced visual capacity to detect environmental hazards seems to be the disability most commonly associated with falls, especially under challenging conditions, where the proprioceptive information of the feet and ankles is reduced[50].

Table 1 – Means, standard deviations (SD), and probability (p) of Maximum Functional Reach and Timed Up and Go tests performed by the sample of elderly individuals

Variable	Maximum Functional Reach (cm) Mean (SD)	p	Timed Up and Go (sec) Mean (SD)	p
Intrinsic factors				
Gender[a]				
Male	18.6 ± 6.7	0.330	12.1 ± 5.0	0.313
Female	17.4 ± 6.0		12.9 ± 5.6	
Age range[a]				
60-69 years	18.6 ± 6.6	< 0.05	11.2 ± 3.2	< 0.001
> 70 years	16.5 ± 5.4		14.4 ± 6.8	
Hearing[a]				
Hears with difficulty	17.2 ± 6.1	0.470	13.3 ± 5.8	0.228
Hears without difficulty	17.8 ± 6.2		12.4 ± 5.3	
Eyesight[a]				
Very poor/poor	17.0 ± 6.3	< 0.05	13.1 ± 6.0	0.097
Good	19.0 ± 5.4		11.9 ± 3.9	
Health self-perception[a]				
Poor	17.7 ± 6.4	0.812	13.7 ± 6.5	< 0.001
Good	17.5 ± 5.8		11.3 ± 2.7	
Presence of fractures[a]				
Yes	17.7 ± 6.2	0.691	12.6 ± 4.6	0.466
No	17.3 ± 6.1		13.2 ± 7.7	
Extrinsic factors				
Type of housing[b]				
House	16.9 ± 5.9		13.1 ± 5.8	
Apartment	19.1 ± 6.3	< 0.05	11.9 ± 4.8	0.215
Room/hut/shack	15.5 ± 9.9		11.04 ± 2.2	
Materials used in housing construction[b]				
Brickwork	17.8 ± 6.2		12.7 ± 5.7	
Wood	15.9 ± 5.7	0.358	12.5 ± 4.5	0.985
Mixed/others	16.5 ± 5.9		12.7 ± 3.3	
Electricity at home[a]				
Yes	17.6 ± 6.1	0.218	10.9 ± 2.0	0.154
No	10.0		12.9 ± 5.6	
Last monthly income[b]				
No income	15.7 ± 4.6		12.1 ± 2.6	
Up to 1 MW	16.5 ± 5.8		13.7 ± 5.4	
1-3 MWs	17.3 ± 6.1	< 0.05	13.0 ± 6.1	0.073
3-6 MWs	20.3 ± 6.8		11.4 ± 4.8	
> 6 MWs	18.4 ± 5.7		11.0 ± 4.0	

[a]Student's *t*-test for independent groups considering equal variances; [b]one-way ANOVA with Bonferroni's post-test; SD, standart deviation; p, probability; MW, minimum wage.

Another intrinsic factor that was shown to influence the TUG test was self-rated health, which was also associated with balance issues in other studies[19,45,46]. The perception of health is also a predictor of morbidity and mortality: individuals with restrictions and limitations develop dissatisfactions that reflect on the perceived health status[19].

In the present study, in which the value of the TUG was better for those who reported good self-perceived health, this characteristic also appears to influence issues related to postural control, with the consequent risk for falls.

Among the extrinsic factors that influence the FRT are the last monthly income and type of housing. The variable last monthly income influences the FRT, so that individuals with higher income (3 to 6 MWs) have better scores than those with lower income (1 MW). The extrinsic factor income is very little explored in the literature. It should be noted, however, that the better FRT of individuals with higher income is likely related to the fact that they probably have more access to medical resources and more knowledge about the prevention of bodily alterations, which directly or indirectly can lead to improved physical capacity.

Regarding the variable type of housing, the functional reach of elderly individuals living in apartments was significantly better than those living in houses. At first, the idea that living in a house offers more space and allows for better mobility and physical activity, thus providing better postural control and FRT scores, was not demonstrated in this study. To better clarify this issue, another review was conducted, this time comparing the last monthly income of the elderly with the type of housing.

It was observed that most of those living in apartments have a higher income than those living in a house. Thus, in this specific group, living in an apartment is associated with a higher income and, therefore, higher values at the FRT. In the literature, no study that assessed the association between type of housing and the FRT or another balance test used to evaluate postural control was retrieved, so that the data found could be discussed. Further studies are, therefore, needed to corroborate or contest this finding, directing the analysis to the type of housing, that is, apartment *versus* house.

The study by Muir et al. concluded that impaired balance is associated with increased risk of falls in the elderly[51]. In the present study, the results of the functional reach test showed mean values that, according to the literature, predispose individuals to fall[32]. Regarding the TUG test, according to the considerations by Podsiadlo and Richardson, the mean score obtained demonstrated the test normality in the elderly, but with some frailty in terms of balance[33]. As the studied sample showed no scores compatible with important balance difficulties, the results of these tests may explain the lack of statistical significance of some analyzed variables. The present study did not show the influence of certain socioeconomic factors, as well as of certain aspects of physical health, similarly to what was demonstrated by Gai et al.[18].

A possible limitation of this study is that data were not collected on the number of falls among the elderly, an important item for the effective evaluation of falls. It is suggested that, in future studies, the elderly are divided into at least two groups to compare those with loss of balance and those who do not have this functional deficit, so that associations can be made between sociodemographic factors and those related to physical health. Furthermore, other tests can be added to the FRT and the TUG to assess balance, such as quantitative posturography, as suggested by Swanenburg et al.[52].

Conclusion

Considering the analyzed data, it can be concluded that in this sample of elderly individuals from Porto Alegre, the intrinsic factors that predispose to the risk of falls and fractures are older age, poor self-perception of eyesight, and poor health perception, and that the extrinsic factors are type of housing (living in a house) and a monthly income ≤ one MW.

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