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GERIATRIC MEDICINE | RESEARCH ARTICLE

Relationships between falls, age, independence, balance, physical activity, and upper limb function in elderly Brazilians

Daniel Marinho Cezar da Cruz[1]*, Tatiane de Carvalho Lima[1], Lauren Jane Nock[2], Mirela de Oliveira Figueiredo[1] and Debora Caires Paulisso[1]

Received: 25 January 2017
Accepted: 06 August 2017
First Published: 17 August 2017

*Corresponding author: Daniel Marinho Cezar da Cruz, Department of Occupational Therapy - Center of Biological and Health Sciences (CCBS), Federal University of São Carlos (UFSCar), São Carlos, Brasil
E-mails: cruzdmc@gmail.com, danielcruz@ufscar.br

Reviewing editor:
Albert Lee, The Chinese University of Hong Kong, Hong Kong

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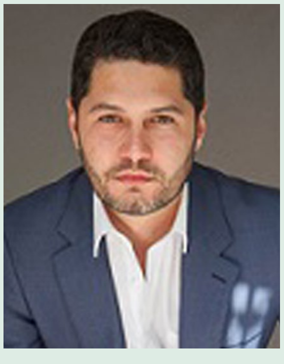
Abstract: *Background*: Falls are the most serious and frequent household accidents occurring in the elderly; their prevention is important in decreasing morbidity, mortality, and medical costs. This study aimed to identify and correlate factors such as gender, level of independence in daily activities, balance, physical activity, and function of the upper limbs within the elderly population. *Methods*: This was a correlational and cross-sectional study with a quantitative approach. Forty-three elderly participants were selected from a Primary Health Care Unit in the city of São Carlos, São Paulo, Brazil. Collection instruments included a questionnaire, the Berg Balance Scale, the Functional Independence Measure, and the Box and Blocks Test. Data were analysed using Pearson correlation. *Results*: Most participants were women (46.5%) between 60 and 70 years old being 58% of the sample. The total number of falls for older women was 31. The number of falls increased proportionally with the increasing age of the participant ($r = 0.41$) ($p = 0.0063$). The greater the number



Daniel Marinho Cezar da Cruz

ABOUT THE AUTHORS

The paper is part of a research group from Universidade Federal de Sao Carlos, Sao Paulo, Brazil, Department of Occupational Therapy.

Daniel Marinho Cezar da Cruz is an occupational therapist and an adjunct professor in Department of Occupational Therapy, Universidade Federal de São Carlos, Brazil. His researches focus in activities of daily life, assistive technology and motor skills development.

Tatiane de Carvalho Lima is a student of the Occupational Therapy undergraduate course, CCBS, UFSCar, São Carlos, Brasil.

Lauren Jane Nock is an occupational therapy graduate with a BSc (Hons) from School of Health and Life Sciences, Coventry University, Coventry, United Kingdom.

Mirela de Oliveira Figueiredo is an occupational therapist and has a Ph.D. in Special Education (Federal University of San Carlos-UFSCAR). The author is an adjunct professor in the Department of Occupational Therapy, Federal University of São Carlos (UFSCAR).

Debora Caires Paulisso is a master in Occupational Therapy in the Department of Occupational Therapy, CCBS, UFSCar, São Carlos, Brasil.

PUBLIC INTEREST STATEMENT

Falls are the most serious and frequent household accidents occurring in the elderly; their prevention is important in decreasing morbidity, mortality, and medical costs works. This article describes some of the variables effects of falls, based on data gathered via Primary Health Care Unit in the city of São Carlos, São Paulo, Brazil. It was found the number of falls increased proportionally with the increasing age of the elderly. The greater the number of falls, the lower the performance in balance and independence was. Understanding these effects can improve and strengthen future development of preventative strategies, focusing on physical activity and its importance in prevention against falls.

of falls, the lower the performance in balance ($r = -0.47$) ($p = 0.0015$) and independence ($r = -0.63$) ($p \leq 0.0001$). *Conclusion*: This study resulted in evidence that can strengthen the development of preventative strategies, focusing on physical activity and its importance in the prevention of falls.

Subjects: Public Health Policy and Practice; Gerontology; Occupational Therapy

Keywords: falls prevention; occupational therapy; risk of falls

1. Introduction

Worldwide, the elderly population has increased progressively according to Kumar, Vendhan, Awasthi, Tiwari, and Sharma (2008), and falls are one of the concerns of geriatric medicine as they affect the health of this population. Falls are the most common household accident, and the main cause of accidental death in people above 65 years of age and survivors of falls may present contusions, fractures, disabilities and, consequently, dependence (Fuller & Col, 2000; Kumar et al., 2008).

Non-fatal injuries from falls in the elderly affect women disproportionately, and the need to determine the reasons, such as a difference in the circumstances surrounding the fall, persists to identify targets for prevention strategies (Callis, 2016; Stevens & Sogolow, 2005). There are important factors that can be addressed in order to reduce falls, such as balance, the habit of regular exercise, adaptation of the home furniture, use of special shoes or other assistive devices, and medication routine, among others (Henry-Sánchez, Kurichi, Xie, Pan, & Stineman, 2012; Karlsson, Magnusson, Von Schewelov, & Rosengren, 2013). There is evidence, such as the study by Henry-Sánchez et al. (2012) that found younger elderly people with many limitations in their activities of daily living and insufficient accessibility in their homes are more likely to fall, and such falls have serious consequences on the health of those elderly individuals. A follow-up of a study by Ramirez et al. (2010) on the elderly population also identified aspects of cognition, such as familiarity with the environment, and visual acuity as potential causes of falls.

Considering that factors such as fear of falling as well as the loss of mobility and autonomy directly influence the increase in the number of falls, Anders, Dapp, Laub, and von Renteln-Kruse (2007) emphasized that intervention programmes in communities are important to provide guidance in the prevention of falls.

International surveys have investigated the rate of falls among the elderly population, with different aspects of prevention (Henry-Sánchez et al., 2012; Murden, McRae, Kaner, & Bucknam, 1991; Ramirez et al., 2010; Yun, 2012). Intervention programmes are an important strategy.

Interventions on multi-factor risks help reduce falls and injuries, and can be applied by health service providers, contributing to improving the quality of life of the survivors (Henry-Sánchez et al., 2012). A primary programme of fall prevention, developed by Albert et al. (2014) in the United States has reduced the rate of falls by 17% during the monitoring period, showing the effectiveness of prevention and health education.

Occupational therapists can contribute as part of a multidisciplinary team, for example, in the promotion of health for the elderly through prevention groups to strengthen the security of the physical environment inside and outside the homes (Tan et al., 2014). The purpose of our study was to describe and correlate the variables: falls, balance, age, gender, physical activity, and upper limb function in the elderly. There were no studies found to correlate all variables in the way they were done in this study. In the literature, studies that analysed falls in the elderly focusing only on gender, or in upper limb function, or only on the independence, or physical activity were found.

Our hypothesis was that a higher rate of falls in the elderly is directly related to reduced independence, limitations of upper limb function, difficulty with balance, and lack of physical activity.

2. Materials and methods

This is a cross-sectional and correlational research with a quantitative approach.

2.1. Sample and inclusion criteria

This study included 43 elderly participants, at least 60 years of age, who were residents of the city of São Carlos, São Paulo, Brazil with the ability to walk independently. The participants were recruited from a Primary Health Care Unit. Primary care is the initial care of all patients in the health system. Its objective is to guide the prevention of diseases, to solve the possible cases of diseases and to direct the most serious cases to higher levels of care. It functions as a filter capable of organizing the flow of services in health networks, from the simplest to the most complex. Inclusion criteria were elderly individuals with no diagnosis of neurological diseases. An elderly person was classified as independent when the score of the Functional Independence Measure was equal to or greater than 108, according to Granger and Hamilton (1992).

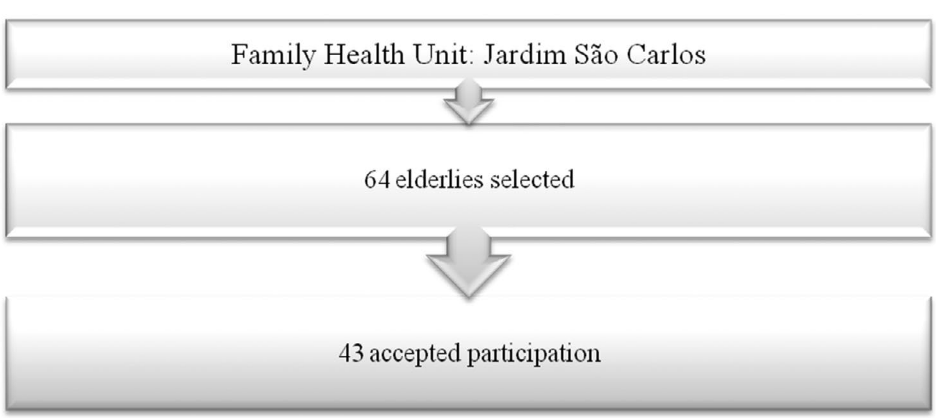
Exclusion criteria were elderly people who could only walk using auxiliary mobility devices, such as walkers, canes, and crutches, as well as those with cognitive deficiencies preventing the applications of the tests chosen for the research. To determine the presence of cognitive deficits, screening was implemented using the Mini Mental State Exam. Elderly persons with a score under 17 points were excluded as 17 points is considered the high limit for participants with low educational level (Murden et al., 1991). All participants interviewed scored ≥17–30, and were elected to participate in the research.

Figure 1 shows the sample selection process. At the Primary Health Care Unit of Jardim São Carlos, 64 elderly participants were selected. A meeting was held with the local health team, presenting all the inclusion and exclusion criteria for the sample, indicating 64 elderly individuals with positive characteristics for the study. Subsequently, attempts were made to contact the 64 elderly people indicated by the health unit. From this, 14 declined the invitation to participate in the study and 7 were not found to be at home in more than three attempts made by the researchers. The other 43 participants accepted to participate in the research and fit all inclusion criteria.

There were no participants excluded from the research, all meeting the criteria requested and, after the initial agreement, there was no participant renunciation.

All the ethical procedures recommended by the resolutions in force have been guaranteed, and there are no conflicts of interest, including specific financial interests and relationships and affiliations. The work was approved by the Ethics Committee in Research with Human Beings of the Federal

Figure 1. Selected sample (n = 43).



University of São Carlos (Process nº 2013/22882-5), respecting the ethical principles based on Resolution 196/96 of the National Health Council on the ethical and legal research aspects involving human beings.

2.2. Instruments

(1) Mini Mental State Exam: consists of a screening instrument for cognitive functions, with questions grouped into seven categories, each one evaluating specific functions: time orientation (5 points), spatial orientation (5 points), registration (3 points), attention and calculation (5 points), memory recall (3 points), language (8 points) and visual-constructive capacity (1 point). The score may range from 0 points indicating the greatest level of cognitive disorder of the individual, to a maximum of 30 points that corresponds to normal cognitive ability (Folstein, Folstein, & McHugh, 1975; Lindsay et al., 2016; Lourenço & Veras, 2006; Murden et al., 1991).

(2) For the collection of data, a questionnaire was developed for the characterization of the elderly participants and to account for the number of falls. The questionnaire included 18 questions regarding activities performed by the elderly. For the practice of physical activity, there was a question about performing a specific physical exercise with an answer choice of yes or no. If the answer was yes, there was a space to note its weekly frequency, with response options of 1, 2, 3, 4, or more than 4 times per week. The number of falls in the period of one year was assessed with scores ranging from 0 to 4 with 0 being no falls. The researchers pre-tested the questionnaire on 5 randomly selected elderly people, according to the selection criteria for inclusion/exclusion of the research (see Figure 2).

(3) Berg Balance Scale: validated in 1988 by Berg, Wood-Dauphinée, Williams, and Gayton (1989) and adapted for application in Brazil by Miyamoto, Lombardi Junior, Berg, Ramos, and Natour (2004), determines the factors for low independence and risk for falls among the elderly population based on the quality of the performance, need for assistance, and time taken to complete tasks. The instrument has 14 items, each with a score of 0 to 4 points, depending on the difficulty. The total maximum score is 56 points; lower scores indicate a higher risk of fall (Berg et al., 1989; Miyamoto et al., 2004).

Figure 2. The questionnaire for the categorization and record of the number of falls.

Questionnaire for elderly categorization and record on the number of falls.

Name:
Age:
Gender: ( ) Feminine ( ) Masculine
Education: ( ) Incomplete primary education ( ) Complete primary education ( ) Incomplete Secondary education ( ) Complete Secondary Education ( ) Incomplete Higher Education ( ) Complete Higher education
Present status: ( ) Active ( ) Retiree
Who do you live with? ( ) Alone ( ) Spouse ( ) Children ( ) Other
Do you suffer from any of the following diseases? ( ) Diabetes Mellitus ( ) Systemic Arterial Hypertension ( ) Cardiac Diseases ( ) Bone Diseases
Do you take any medication? ( ) Yes ( ) No **If yes, which?** :______________.
In a year, have you suffered any fall? ( ) Yes ( ) No If yes, mark the number of times: ( )1 ( )2 ( )3 ( )4 or more
Where did you fall? ( ) At home ( ) In the street/Sidewalk
What was the cause of the fall? ( ) Environmental ( ) Health problems ( ) Balance ( ) Other. **What?** :______________.
Did you suffer any trauma? ( ) Yes ( ) No
If yes, in which part of the body? ( ) Upper limbs ( ) Lower limbs ( ) Head ( ) Body
Do you practice any physical activity? ( ) Yes ( ) No. **If yes, which one?** _________.
If yes, how many times per week: ( )1 ( )2 ( )3 ( ) 4 or more

(4) Functional Independence Measure (FIM): Linacre, Heinemann, Wright, Granger, and Hamilton (1994) describes the FIM as assessing the individual's performance with a set of 18 tasks relating to sub-scales of self-care, sphincter control, transfers, locomotion, communication, and social cognition. The motion and cognitive FIM provides minimum and maximum scores between 18 points, complete dependence (total assistance) to 126 points, complete independence. It should be clarified that in our research only the independent elderly were considered, however; this does not exclude the fact that the sample varies as to the level of dependence, for example, when an elderly person makes use of some assistance device, shows slowness, or performs the activity with some degree of risk. As such, even though independent on all items, the possibility existed of a scoring variation between 7 (complete independence) and 6 (modified independence).

(5) Box and Blocks Test: This test assesses the skill and manual dexterity of the upper limbs. The test uses a wooden box with a compartment higher than the edges of the box, separating it into two compartments of equal size. There are 150 wood blocks shaped as coloured cubes (primary colours), and divided by colour (Hebert, Lewicke, Williams, & Vette, 2014; Mathiowetz, Volland, Kashman, & Weber, 1985). The box is placed horizontally in front of the person, to provide for a complete overview of the area. The blocks are placed to the side of the upper limb to be tested and instruction is given to the individual to pass one block at a time to the other side, going over the elevated compartment, to the wood base on the other side, without letting it fall (Hebert et al., 2014; Mathiowetz et al., 1985). The test starts with the dominant limb and is repeated with the non-dominant one. For initial training, 15 s are allowed; for the test, 1 min is allowed for each limb. The test result is a score of the maximum number of blocks transferred per minute, from one compartment to another. There is no penalty if a block falls out of the box, but if more than one block is transferred at a time, one point will be deducted from the final count (Hebert et al., 2014; Mathiowetz et al., 1985).

According to standard data for the elderly population without disabilities (Mathiowetz et al., 1985), the average number of blocks transferred in a minute for women aged between 60 and 64 years is 76.1 (right hand) and 73.6 (left hand); for the elderly between 65 and 69 years, the number of blocks transferred is 72.0 (right hand) and 71.3 (left hand). Scores for the elderly between 70 and 74 years of age are 68.6 (right hand) and 68.3 (left hand). Elderly people aged over 75 years scored 65.0 (right hand) and 63.6 (left hand). For men between 60 and 64 years, the standard data indicate their scores as 71.3 (right hand) and 70.5 (left hand). The elderly between 65 and 69 years, scored 68.4 (right hand) and 67.4 (left hand). Elderly persons between 70 and 74 years transferred 66.3 (right hand). The scores for elderly persons aged 75 years and older are 63.0 (right hand) and 61.3 (left hand).

2.3. Procedures for data collection
The application of the instruments was carried out over a period of three months by a single researcher during home visits, previously scheduled by telephone. The data collection period lasted three months. Applications of the assessment instruments were carried out in a single visit with an average duration of 50 min for most of the participants, but for those who showed a potential of tiredness during the application of the tests, such application was completed in two visits. The order of application of the instruments was Mini Mental State Examination to determine whether the elderly person fit into the research criteria, a questionnaire on falls, and the applications of the Berg Balance Scale, FIM, and Box and Blocks Test.

3. Data analysis
Data was transposed to an Excel spreadsheet, and a descriptive analysis was completed, including graphics, tables, and calculations of main descriptive statistics (mean, standard deviation, median, minimum, and maximum).

Tests for equality of means were made using ANOVA, and the association between qualitative variables were established using the χ^2 test. A correlation method was adopted, using the analysis of correlation of Pearson variables: age, gender, number of falls, physical activity, balance, upper limb function, and independence.

4. Results

It can be seen in Table 1 that most of the participants are female, between 60 and 70 years old, retired, and residing with a spouse. It should be pointed out that 34 of the participants reported systemic arterial hypertension and, in relation to physical activity, 19 reported practising some kind of activity, especially walking.

A test was performed to compare the means with samples of different sizes and assuming equality between the variances of each category. In this case, an equality of variances was assumed between the compared samples, shown in the proximity of the standard deviations in Table 2.

The variables of age and number of falls have moderate positive correlations for all tests (Age/Independence $r = -0.48$, Age/Upper Limb $r = -0.44$, Age/Balance $r = -0.51$) (Number of falls/Independence $r = -0.62$, Number of falls/Balance $r = -0.46$). This data carries the exception in the

Table 1. Sample categorization

Characteristics		Number (%)
Gender	Female	25 (58.1)
	Male	18 (41.9)
Age	60–70 years	20 (46.5)
	71–80 years	8 (18.6)
	81–90 years	14 (32.6)
	91–95 years	1 (2.3)
With whom they reside	Alone	16 (37.2)
	The spouse	19 (44.2)
	Children/other	8 (18.6)
Economic status	Retirees	36 (83.7)
	Active	7 (16.3)
Diseases present*	Systemic arterial Hypertension	34 (79.1)
	Diabetes mellitus	10 (23.3)
	Heart diseases	5 (11.6)
	Osteopathy	19 (44.2)
Physical activity	Yes	19 (44.2)
	No	24 (55.8)
Practiced physical activity	Walking	16 (37.2)
	Water aerobics	3 (6.9)
	Physical activities group	3 (6.9)
	Stretching	2 (4.6)
	Bodybuilding	2 (4.6)
Frequency of exercise per week	1x	3 (7)
	2x	8 (18.6)
	3x	2 (4.6)
	4x or more	6 (13.9)
Proportion who ever had a fall in past 1 year		72%
Proportion who did not have a fall in past 1 year		28%
Mean (SD) on number of fall among those who ever had a fall		2.09

*For the diseases and practiced physical activity present, participants could include more than one option.

Table 2. Result of the instruments applied by ANOVA and association between qualitative variables (χ^2 test)

Variable	Overall	Stratified by gender			Stratified by physical activity		
		F	M	*p*-values	No	Yes	*p*-values
N	43	25	18		24	19	
Age (mean (SD))	73.58 (9.71)	72.76 (9.71)	74.72 (9.87)	0.520	76.29 (9.21)	70.16 (9.45)	0.038
Number of falls (mean (SD))	1.51 (1.33)	1.44 (1.33)	1.61 (1.38)	0.683	1.67 (1.58)	1.32 (0.95)	0.398
FIM (mean (SD))	123.16 (2.78)	123.04 (3.19)	123.33 (2.14)	0.737	123.08 (2.96)	123.26 (2.60)	0.836
Box and blocks test (mean (SD))	60.60 (12.60)	59.32 (12.88)	62.39 (12.35)	0.438	58.50 (11.51)	63.26 (13.71)	0.223
Berg Balance Scale (mean (SD))	50.42 (5.25)	50.36 (5.37)	50.50 (5.24)	0.933	48.29 (5.71)	53.11 (3.00)	0.002
Physical activity = Yes (%)	19 (44.20)	13 (52.00)	6 (33.30)	0.366			
Gender = M (%)	18 (41.90)						

case of correlation between the Number of falls and the Upper limb function test, which has a weak negative correlation (see Table 3).

For upper limb function, the analysis was made from the sum of the averages of blocks transferred in the Box and Blocks Test, for both upper limbs (right and left). The practice of physical activity in absolute values was higher among women, although no correlations per gender have been found.

Table 3. Pearson correlation coefficients between age, number of falls, independence, upper limb function and balance (*N* = 43)

	Age	Number of falls	Independence (FIM)	Upper limb function (box and blocks test)	Balance (Berg Balance Scale)
Age	1.00	0.41	−0.49	−0.45	−0.51
p-value		0.0063	0.0009	0.0025	0.0004
Number of falls	0.41		−0.63	−0.29	−0.47
p-value	0.0063	1.00	<0.0001	0.0586	0.0015
Independence (FIM)	−0.49	−0.63		0.56	0.54
p-value	0.0009	<0.0001	1.00	<0.0001	0.0002
Upper limb function (Box and blocks test)	−0.51	−0.47	0.54	1.00	0.62
p-value	0.0004	0.0015	0.0002		<0.0001
Balance (Berg balance scale)	−0.45	−0.29	0.56	0.62	1.00
p-value	0.0025	0.0586	<0.0001	<0.0001	

5. Discussion

The results of our research refer to a sample of elderly participants with an average age of 73.58 years, confirmed by the literature as the age with the largest number of falls among the elderly. Previous research data indicate that 28–35% of people older than 65 years will fall at least once a year. The proportion increases to 42% when the person is over 75 years (Harvey et al., 2016; Henry-Sánchez et al., 2012).

Throughout this research, It was observed that male participants had a higher average age than women, as well as a higher number of falls, while women were likely to perform more activities. With regard to the risk factors related to gender, Yun (2012) states that women have a greater fear of falls. The research of Pluskiewicz, Adamczyk, Czekajło, Grzeszczak, and Drozdzowska (2016) showed that, in addition to factors such as age, location of the fall, and comorbidities, injuries from falls are common among women.

Sjögren and Stjernberg (2010) investigated, for a period of 1 year, a sample of 999 elderly persons, with 60 or more years of age. They analysed the manner in which outdoor physical activities were performed, and what factors influenced their achievement. The authors found that elderly men and women have different needs and opportunities for physical activities, and women are more limited than men. Among the factors relative to those differences were the following: residing alone, inability to cover unexpected health costs, fear of suffering injuries, falls, and increasing age. As such, a home-based programme that includes physical exercise and teaches safe, ergonomic strategies is a good example of an intervention that may help to prevent falls (Anders et al., 2007; Gillespie et al., 2012; Iinattiniemi, Jokelainen, & Luukinen, 2009).

We observed that older people with less independence were likely to fall more often. The Activities of Daily Living (ADLs) assessment is an important indicator of risk because elders often fall during the performance of their ADLs. In addition, Yun (2012) noted that difficulty in performing ADLs is also one of the main reasons for falls among the elderly. Related to this, the fear of falling may reduce the performance of such activities leading to inactivity, which may generate loss of strength and have a negative impact on physical health.

Concerning the practice of physical activity, it was identified that the average age and number of falls among the elderly who did not perform any physical activity was greater than among those who did. It was not surprising to find that the elderly performing a physical activity presented better balance and functions of the upper limbs. Although, in our research, we could not find gender differences, the study of Gschwind et al. (2015) related physical activity with the risk of falls among elderly women and confirmed this analysis showing that elderly people classified as active and moderately active had a lower risk of falls when compared to the older inactive population.

It is therefore important that the elderly remain active, including physical activity as part of their daily life. A study related to risk factors associated with falls of elderly people concluded that elderly people who did not perform physical activities or discontinued such activities had increased risk of falls (Henry-Sánchez et al., 2012; Yamashita, Noe, & Bailer, 2012). Other studies also recommended physical activity as an important step towards the reduction of falls (Albert et al., 2014; Gillespie et al., 2012; Gschwind et al., 2015; Henry-Sánchez et al., 2012; Karlsson et al., 2013; Sjögren & Stjernberg, 2010; Uusi-Rasi et al., 2012).

Owing to the complex nature of interactions of the elderly with their environment, in addition to physical activities as a means of prevention, vitamin D intake has been pointed out by Uusi-Rasi et al. (2012) as an effective measure for reducing the risk of falls because of its direct action on muscle function.

The significant relationships between age, number of falls, balance, and independence found in this study was not surprising; however, it was anticipated that there would be a correlation between the number of falls and the functions of the upper limbs. Hyndman, Ashburn, and Stack (2002) showed that participants who have had two or more falls also had a significant reduction of the upper limb function when compared to those who had not fallen. A possible hypothesis explaining the divergence of our results from the literature could be the type of measurement we used to evaluate the upper limb function, as the Box and Blocks test is a less accurate instrument that evaluates the upper limb function using time-based criteria.

However, in this research, it was found that upper limb function was associated with balance and variables related to independence. In the literature, no studies were found relating the variables of independence, balance, and upper limb function as a result of the applications of the FIM, Berg Balance Scale and Box and Blocks Test. The relationships identified in our research provide evidence regarding falls in the elderly population that may promote the development of programmes for health promotion and fall prevention among the elderly. For example, by using physical activity programs, focusing on upper limb function, with balance being fundamental for stability and reciprocation while walking, in addition to contributing to protection reactions and static and dynamic balance (Albert et al., 2014; Gschwind et al., 2015).

This study was conducted on independent elderly people in order to verify the existence of key variables for risk prevention of falls for that population, as well as to develop methods for prevention. The results showed correlations between significant variables present in the life of the elderly through the use of highly reliable assessment tools. This allows for the consideration of health strategies and programmes to promote physical activity, maintenance of balance, and independence, as well as adaptation of environments within homes of senior citizens, in health service facilities, and within other spaces dedicated to, or highly used by the elderly, that may help to prevent falls.

6. Conclusion

The results of our research showed positive associations between age and the number of falls, independence, balance, and upper limb function as well as between upper limb function and balance. These types of correlations indicate that the increase in one variable results in the increase of another and vice versa. As age increases, the number of falls increases, independence decreases, and upper limb function and balance decrease.

Our research contributes evidence of factors associated with falls among the Brazilian elderly population that can stimulate further research regarding cultural and social factors that may influence the risk of falls. Future research should investigate what type of activities elderly individuals are performing when they fall. Such data might encourage interventions based on the occupational needs of the elderly. Our research brings evidence of the benefits of developing programmes within Primary Health Care. For example, occupational therapy can create groups of activities that can preserve upper limb function during daily activities, as well as assess the environment and create adaptations as needed to help prevent falls. Occupational therapists can also assess the need for care devices.

7. Limitations

This research presents several limitations. The relatively small sample does not allow for generalization of the observed results. Elderly people with neurological disorders were excluded from the survey.

Elderly persons with chronic diseases were included, which created difficulty in controlling variables resulting from the diseases, such as sensitivity of the body and visual acuity. This may have influenced the data.

We point out that the questionnaire for the record of falls limited the response of participants to the number of falls as 4 or more. This could have been a bias in the detection of the actual number of falls, resulting in failure to identify other possible correlations. However, only two participants mentioned having 4 or more falls, bias possibly eliminated through the statistical analysis.

No gender differences were identified with correlations to other variables studied. This could be due to the small sample size. This creates the need for further research to identify the effects of cultural differences related to gender in incidence of falls in each country or continent.

Funding
This work was supported by the FAPESP - Fundação de Amparo à Pesquisa do Estado de São Paulo (Foundation for Research Support of the State of São Paulo) [grant number 2013-228825].

Competing Interests
The authors declare no competing interest.

Author details
Daniel Marinho Cezar da Cruz[1]
E-mail: cruzdmc@gmail.com
Tatiane de Carvalho Lima[1]
E-mail: tatianelima012@gmail.com
Lauren Jane Nock[2]
E-mail: lauren_nock-10@hotmail.co.uk
Mirela de Oliveira Figueiredo[1]
E-mail: mirelafigueiredo@gmail.com
Debora Caires Paulisso[1]
E-mail: debora_caires2@hotmail.com
[1] Department of Occupational Therapy - Center of Biological and Health Sciences (CCBS), Federal University of São Carlos (UFSCar), São Carlos, Brazil.
[2] School of Health and Life Sciences, Coventry University, Coventry, UK.

Citation information
Cite this article as: Relationships between falls, age, independence, balance, physical activity, and upper limb function in elderly Brazilians, Daniel Marinho Cezar da Cruz, Tatiane de Carvalho Lima, Lauren Jane Nock, Mirela de Oliveira Figueiredo & Debora Caires Paulisso, *Cogent Medicine* (2017), 4: 1367058.

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