Association between the occurrence of falls and the performance on the Incremental Shuttle Walk Test in elderly women

Associação entre a ocorrência de quedas e o desempenho no *Incremental Shuttle Walk Test* em mulheres idosas

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Abstract

Background: Because the incremental shuttle walk test (ISWT) requires agility in its performance, we hypothesized that the test may be associated with balance and risk of falls in the elderly. **Objective:** To evaluate and compare the association between the performance on the ISWT, the timed up and go (TUG) and the occurrence of falls in the elderly. **Method:** Thirty-three elderly individuals (68±7 years) performed the TUG and the ISWT. Balance was assessed using the Berg Scale (BBS). Participants who fell at least twice in the last 12 months were placed in the "falls" group (FG) and all other participants comprised the control group (CG). **Results:** There were seventeen elderly women in the FG and 16 in the CG. Participants from the FG had a significant worse performance ($p<0.05$) on the TUG (8.01±0.22 vs. 6.22±0.21 s), BBS (51±3 vs. 55±1 points) and ISWT [313±79 (92±15%pred.) vs. 395±75 m (113±19%pred.)] than participants from the CG. The ISWT significantly correlated with the TUG ($r=-0.75$, $p<0.001$), BBS ($r=0.50$, $p=0.002$) and number of falls ($r=0.36$, $p=0.031$). After logistic regression, the TUG was determinant ($p=0.03$) and the ISWT showed a tendency to determine the occurrence of falls ($p=0.05$). **Conclusion:** The ISWT was a valid measure to assess the risk of falls and balance and therefore, may be useful for the simultaneous assessment of cardiorespiratory fitness and balance in older women.

Keywords: walking; postural balance; falls; rehabilitation; elderly.

Resumo

Contextualização: Levantamos a hipótese de que o *Incremental Shuttle Walk Test* (ISWT), por exigir agilidade do examinado, possa estar associado ao equilíbrio e ao risco de quedas em idosos. **Objetivos:** Avaliar e comparar as associações entre os desempenhos no ISWT e no *Timed Up and Go* (TUG) e a ocorrência de quedas em idosos. **Método:** Trinta e três idosas (68±7 anos) realizaram o ISWT e o TUG. O equilíbrio foi avaliado pela Escala de Equilíbrio de Berg (EEB). As participantes que caíram, pelo menos, duas vezes nos últimos 12 meses foram alocadas no grupo "quedas" (GQ), e as demais compuseram o grupo controle (GC). **Resultados:** O GQ foi composto por 17 idosas, e 16 compuseram o GC. O GQ apresentou pior desempenho ($p<0,05$) no TUG (8,01±0,22 vs. 6,22±0,21 s), na EEB (51±3 vs. 55±1 pontos) e no ISWT [313±79 (92±15%prev.) vs. 395±75 m (113±19%prev.)]. A distância percorrida no ISWT correlacionou-se com o TUG ($r=-0,75$; $p<0,001$), com a EEB ($r=0,50$; $p=0,002$) e com o número de quedas ($r=0,36$; $p=0,031$). Após regressão logística, o TUG foi determinante ($p=0,03$), e a ISWT mostrou tendência para determinar a ocorrência de quedas ($p=0,05$). **Conclusão:** O ISWT foi válido para avaliar o risco de quedas e o equilíbrio e pode ser útil como ferramenta de avaliação simultânea da aptidão cardiorrespiratória e do equilíbrio em mulheres idosas.

Palavras-chave: caminhada; equilíbrio postural; quedas; reabilitação; idosos.

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Introduction

Due to an increase in life expectancy, the elderly population has significantly increased over the last years. The physiologic process of aging often lead to frailty, which in turn can leave the elderly more susceptible to illness and disabling events such as falls. Prevalent conditions in the elderly have gained important social attention due to growing demand they imposed into health services. Hospital admissions are more frequent and length of stay are longer in the elderly when compared to other age groups[1].

Falls are one of the main factors that lead an elderly to hospitalization and decreased quality of life. Both incidence and complications related to falls significantly increase as age progresses over 60 years. The prevalence of falls among Brazilian elders has been reported to be 34.8% and significantly higher in women (40.1%). In the same study, it was found that among those that fell, 12.1% had a fracture as consequence[2]. It is also worth noting that hospital admissions after a fall are very costly[3,4]. In this context, it is necessary to identify factors that predispose an elderly to the risk of falls. This identification would allow the prevention of falls and its complications in addition to a decrease in the use of health resources.

One of the main factors predisposing an elderly to falls is a reduction in functional mobility and balance. Independent mobility or "basic mobility" refers to the individual's capacity to perform movements or routine exercises, such as to get up or sit down on a conventional chair, to enter and leave a bathroom and to walk at least a few steps. Based on this, Mathias, Nayak and Isaacs[5] validated a test called "Get Up and Go" to evaluate balance. Podsiadlo and Richardson[6] developed the timed version of the "Get Up and Go" (Timed Up and Go - TUG) with the objective to quantitatively evaluate functional mobility and balance. The time spent to complete the test has direct correlation with the individual's mobility level.

Recently, several studies have confirmed the validity of the TUG as a tool to assess balance and risk of falls in the elderly. Shumway-Cook, Brauer and Woollacott[7] observed that the TUG associated with cognitive or manual tasks was also valid to evaluate the risk of falls in non-institutionalized elderly, with good sensitivity (87%) and specificity (87%).

Walking tests were developed with the objective to assess functional capacity in a simple and inexpensive manner. The Incremental Shuttle Walk Test (ISWT) was developed by Singh et al.[8]. Recently, Spagnuolo et al.[9] observed that the distance walked on the ISWT was correlated with balance (r=0.61) evaluated through the Berg Balance Scale (BBS). This correlation was similar to the one observed between the performances of the TUG and the BBS (r=-0.65). There are few studies that have evaluated the association between the performance on the ISWT, balance and occurrence of falls.

There is a close relationship between balance and predisposition to falls. Physical fitness is also considered as one of the predictors of falls[10]. However, the correlation between cardiorespiratory fitness and balance and/or the risk of falls has not been sufficiently evaluated. For instance, the association among the distance walked during the six minutes walking test (6MWT) and the occurrence of falls have been described to be inconssitent[11]. Several interventions have been described to reduce the rate of falls. Strengthening/endurance, aerobic training and balance training can prevent falls and improve bone mass[12].

The ISWT is considered simple, inexpensive, reproducible and have shown consistent correlation with maximal oxygen uptake ($\dot{V}O_{2max}$)[8]. Its validity has already been described in several clinical situations[13-15]. The test, due to its character of successive back and forth turns in a course of 10 m, demands the individual to be agile in order to complete it with satisfactory performance. Accordingly, we have raised the hypothesis that the performance on the ISWT may show consistent association with balance and occurrence of falls in non-institutionalized elderly. If this hypothesis is confirmed, the ISWT could be valid for simultaneous evaluation of cardiorespiratory fitness, balance and risk of falls in this population. The objectives of the present study were to evaluate and compare the associations between the performances on the ISWT, the TUG, the BBS and the occurrence of falls in non-institutionalized elderly women.

Method

Individuals

Thirty-three women aged 60 years and over (68+7 years), recruited through local newspaper advertising were evaluated. The main inclusion criteria for this study were the capacity to walk at least 10 m without an assistant device and to understand simple instructions (verbal command) for the performance of the tests. The exclusion criteria for this study were any evidence of neuromuscular or metabolic impairment that could prevent the performance of physical exercise or the presence of heart or pulmonary conditions. During the health screening, participants were inquired on the presence of arterial hypertension, dyslipidemia, diabetes mellitus, smoking, sedentary lifestyle and occurrence of falls for characterization of the sample and distribution of the groups: falls and controls. Obesity was evaluated using the cut-off point

for body mass index of ≥30 kg/m^2. Participants were informed about the procedures and possible risks related to the study and signed the informed consent term. The study was approved by the Ethics in Human Research Committee of the Universidade Federal de São Paulo (UNIFESP), São Paulo, SP, Brazil (1623/07).

Occurrence of falls

Falls were defined as "unintentional events that result in an unexpected change in an individual's position to a level below the initial position, with inability to correct it in a timely manner"[2]. Occurrence of falls was evaluated by anamnesis. Participants who suffered at least two falls in the last 12 months were allocated into the fall group (FG), and those who reported one or less falls in this period were allocated in the control group (CG). After determining the presence or absence of falls, study tests were performed using the following sequence.

Balance

Balance was initially assessed using the BBS. This test consists of 14 items that quantitatively evaluate balance and risk of falls. The test is rated through the examiner's observation of individuals test performance. Each item is scored from 0 to 4, with 0 corresponding to the incapacity of performing the task and 4 representing normal performance. The total score is obtained by summing the scores of the 14 items[16].

The TUG was performed based on the protocol described by Podsiadlo and Richardson[6], using a standardized chair with support for the back and arms. The test was performed along a 3 meters flat and covered course. The original protocol was slightly modified so it would represent the participant's maximum ability to perform the test. The instruction to the participants was modified as follows: "Please, when you listen the word GO, get up, walk as fast as possible with safety until the line to 3 m ahead, turn around the mark on the floor, return to the chair and sit down again without hesitation". The verbal encouragement "as fast as possible" was the key-modification in the original protocol of TUG[6]. This procedure was done because the present sample was composed of asymptomatic individuals and because this methodology was previously described as the most appropriate to evaluate the association between balance and risk of falls of non-institutionalized elderly[17]. Three tests were conducted with approximately 30 seconds of interval between them to minimize the learning effect. The time necessary to perform the tests was recorded and the lowest recorded time was used in the analysis.

Incremental Shuttle Walk Test

The ISWT was performed as described by Singh et al.[8]. Participants walked along a covered 10 m course, delimited by two cones, at progressive speeds (increase of 0.17 m/s per minute), imposed by signal sounds recorded on a CD. Women were orientated, to increase the walking speed every minute under the examiners' verbal command during subsequent stages of 1 minute each until exhaustion. The end of the test was determined by the participant, for any reason, or by the examiner, when the individual did not maintain the speed required to complete the course (i.e., >0.5 m from the nearest cone at the moment of the signal sound). Blood pressure, heart rate (RS800, POLAR, Finland), dyspnea and fatigue of the lower limbs were measured before and after each test. Two tests, with an interval of 30 minutes among them, were performed to minimize learning effect. The distance walked on the ISWT (ISWD), obtained on the second test, was registered in meters and as a percentile of the predicted values[18].

Statistical analysis

The statistical analysis was performed using SPSS software, version 15 (SPSS, Inc, Chicago, IL, USA). Data are presented as mean ± standard deviation. The following statistical tests were performed: Kolmogorov-Smirnov test, for analysis of data distribution and Pearson or Spearman Correlation Coefficients, for the evaluation of correlations between the studied variables. Seventeen elderly women had at least two falls in the 12 months prior to the study and composed the FG. All other women (n=16) composed the CG. Average scores of the main variables were compared between the FG and the CG using Student's *t* test or Mann-Whitney test according to the distribution of each variable. Logistic regressions were conducted using the occurrence of falls as dependent variable and the ISWT and the TUG as independent variables. P values smaller than 0.05 were considered statistically significant.

Results

Characteristics of the 33 volunteers are presented in Table 1. Participants had BMI mean values representative

of obesity level I. Of the studied sample, 16 women were hypertensive (FG=7; CG=9), 19 were dyslipidemic (FG=10; CG=9) and five were diabetic (FG =3; CG=2). Thirteen women reported to be sedentary, and one of them was a smoker. The ISWD was within the normal range. The heart rate reached at the end of the ISWT was 77±11% of the estimated maximum, with 13 participants (40%) reaching values between 86-100%. No participant interrupted the test because of symptoms, and no adverse event was reported at the end of the ISWT. The time required to perform the three TUGs were 7.66±1.35, 7.42±1.38 and 7.25±1.21, seconds respectively.

Comparisons between the groups FG and CG are observed in Table 2. FG showed more advanced age and worse performances ($p<0.05$) on the TUG, BBS and ISWT.

There were significant correlations between the ISWT and the TUG and the BBS scores (Figure 1).

After logistic regression analysis (Table 3), the TUG was selected as determinant of the occurrence of falls ($p=0.033$). The ISWD demonstrated a trend to determine the occurrence of falls ($p=0.057$).

Table 1. General characteristics of the sample studied (n=33).

Variables	Mean±standard deviation
Age (years)	69±7
Weight (kg)	71±14
Height (m)	1.56±0.06
BMI (kg/m^2)	28±5
2nd ISWD (m)	353±87
2nd ISWD (% predicted)	102±20
Best TUG (s)	7.14±1.25
BBS	53±3

BMI=body mass index; ISWD=incremental shuttle walk distance; TUG=timed up and go test; BBS=Berg balance scale.

Table 2. Comparison between participants in the "falls" group and the control group.

Variables	FG (n=17)	CG (n=16)
Age (years)*	71±7	66±6
Weight (kg)	68±14	75±14
Height (m)	1.56±0.06	1.55±0.07
BMI (kg/m^2)	27±5	30±4
2nd ISWD (m)†	313±79	395±75
2nd ISWD (% predicted)†	92±15	113±19
Best TUG (s)‡	8.01±0.90	6.22±0.85
BBS‡	51±3	55±1

BMI=body mass index; ISWD=incremental shuttle walk distance; TUG=timed up and go test; BBS=Berg balance scale. *$p<0.05$; †$p<0.01$; ‡$p<0.001$.

Discussion

The present study evaluated the association between the performances on the incremental shuttle walking test, balance and the occurrence of falls in elderly women. Participants who reported at least two falls in the last 12 months showed worse performance on the ISWT and the TUG, as well as on the BBS. This is the first study to evaluate the association between the ISWD and the occurrence of falls.

The FG walked on average 82 m less than the CG. This difference is higher than the one considered clinically significant (47.5 m), determined for example in patients with chronic obstructive pulmonary disease[14]. Although this difference for asymptomatic individuals has not been defined, the present results reinforce the validity of the ISWT in discriminating individuals with different performances. Additionally, it was also observed that the tests commonly used for evaluating physical mobility, such as the TUG and the BBS, showed consistent correlations with the ISWD. Spagnuolo et al.[9] observed that the ISWD was significantly correlated with the TUG ($r=0.65$; $p<0.0001$) and with the BBS score ($r=0.61$; $p=0.003$) in healthy elderly. The present results suggest the usefulness of the ISWT for the simultaneous evaluation of cardiorespiratory fitness and balance in this age group. The ISWT demands a progressive increase in speed associated with agility to perform successive round

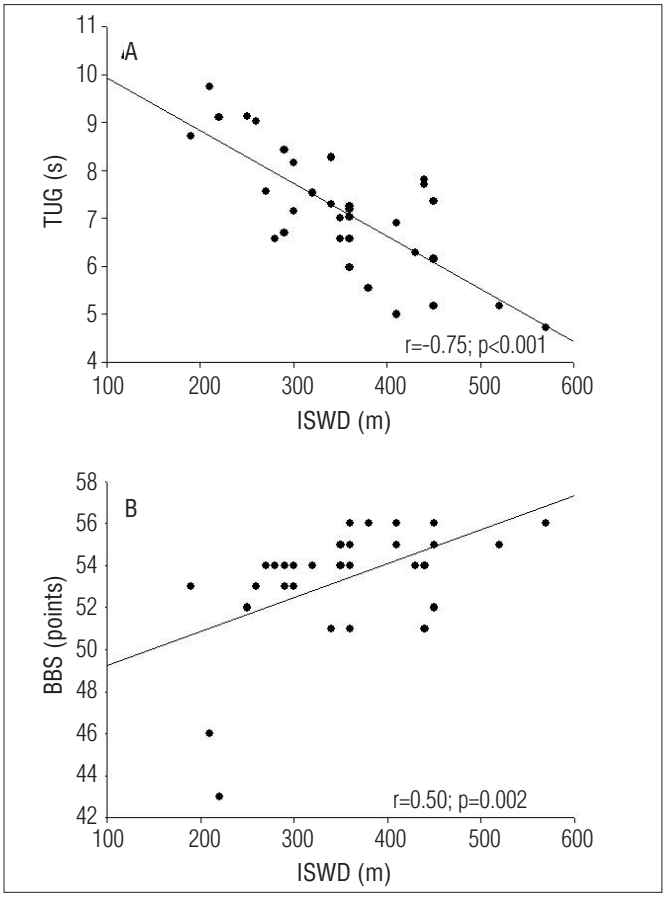

Figure 1. Significant correlations between the incremental shuttle walk distance (ISWD), the Timed Up and Go (TUG) (A) and the Berg balance scale (BBS) (B).

Table 3. Results of multiple logistic regression for the occurrence of falls using performances obtained on the Incremental Shuttle Walk Test and the Timed Up and Go test as independent variables.

Variables	β	Standard error	p	Expo (β)	95%CI for expo (β)	
					Lower limit	Upper limit
TUG (s)	1.160	0.543	0.033	3.190	1.101	9.243
ISWT (% predicted)	-0.058	0.034	0.057	0.994	0.883	1.109
Constant	-2.676	5.238	0.609	0.069		

TUG=timed up and go; ISWD=incremental shuttle walk distance.

trips. This aspect may partly explain the consistent association of the ISWD with the occurrence of falls, as well as with TUG and the BBS. The results suggest that the ISWT could be useful in the evaluation of balance and risk of falls in an elderly population.

The present study confirms the large association of the TUG and the BBS on balance and occurrence of falls in elderly women. The volunteer's ability to walk as fast as possible, to turn around a cone located 3 m from the starting point, to return and to sit down depends on the integrity and proper function of body systems, such as muscular strength and proprioception. These same systems are responsible to provide appropriate corporal adjustment in unbalance situations, avoiding falls.

The results of this study demonstrated that the ISWD values were significantly lower in the FG. A reduced cardiorespiratory fitness is closely associated with a reduction in the ability to perform activities of daily living that are in turn associated with a greater incidence of falls[10]. The present findings suggest that older women who suffered falls also had poorer physical mobility and lower cardiorespiratory fitness. The relationship between balance and cardiorespiratory fitness is controversial. However, Misic et al.[19] observed in 55 healthy adult and senior individuals, a significant correlation between TUG and $\dot{V}O_{2peak}$ (r=0.46; p<0.05) and between the usual gait speed and $\dot{V}O_{2peak}$ (r=0.55; p <0.05). Toraman and Yildirim[10] showed that in addition to the decline of peripheral muscular strength, agility and dynamic balance, the decline of aerobic capacity was determinant for the increase in the risk of falls in individuals with 73±6 years.

The capacity to perform daily activities with satisfactory degree of completion has great implications for independence and quality of life, especially seniors who show alterations inherent to senescence[10]. Therefore, the identification of a propensity to fall has significant clinical relevance as it allows the development of preventive strategies. In this context, the ISWT has promising clinical application, augmented by the test's high reproducibility[13], easy execution, low operational cost and little needs of space. The findings of this study suggest that the IWST, in addition to being an established tool for the evaluation of cardiorespiratory fitness can also be useful in the evaluation of balance and risk of falls.

The results showed that the age of the FG was significantly higher compared to the CG. In fact, functional capacity declines with age. Advanced age has been reported to have negative impact on the performance of TUG, the BBS and the ISWT in asymptomatic elderly[18,20]. Although the ISWT only showned a trend for determining the occurrence of falls, the ISWD values used in the logistic regression, was expressed in percentile of the predicted values, which was calculated by multiple regression equation adjusted for age, body mass, height and gender[18]. In this case, the influence of the ISWT, observed in the present study, was free from the confounding effects of age. We can speculate that the ISWD in percentages, as well as the performance on the TUG, may be useful in the evaluation of the risk of falls.

Some limitations of the present study should be considered. The sample size may explain the trend of the ISWT to determine the occurrence of falls. Probably, there was Type error II, and the continuity of the study could have increased the statistical power of the logistic regression. However, the differences in performance on the ISWD between groups (FG and CG) was substantial, which makes the results clinically useful. The sample was composed by women with obesity level I, which might have influenced the performance on ISWT. However, the BMI was not significantly different between FG and CG and the ISWD values were corrected for weight and height according to the equation used to predict the ISWD for Brazilians[18].

Physical exercise particularly used to improve balance, muscular strength/endurance and the walking ability should be emphasized in fall prevention programs[21,22]. In spite of the beneficial effects of physical exercise in this context, the incidence of falls continues to increase around the world[1]. New knowledge about the best strategy and intensity of strength training to prevent falls in elderly are necessary[23]. Furthermore, environmental modifications, reduction in the use of medications, treatment of postural hypotension and treatment of lower limb problems, as well as the use of appropriate footwear, may also play important role on the prevention of falls. Future studies should investigate how exercise training aiming at improving aerobic capacity (i.e.,

on the ISWT) could result in the prevention of falls and improvement of balance in the elderly.

Conclusion

The ISWT showed significant association with the occurrence of falls and consistent correlation with physical mobility and balance. The results suggest the usefulness of the ISWT as a tool for the simultaneous evaluation of cardiorespiratory fitness and balance in elderly women.

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References

1. Maia BC, Viana PS, Arantes PMM, Alencar MA. Consequencias das quedas em idosos vivendo na comunidade. Rev Bras Geriatr Gerontol. 2011;14(2):381-93.
2. Siqueira FV, Facchini LA, Piccini RX, Tomasi E, Thumé E, Silveira DS, et al. [Prevalence of falls and associated factors in the elderly]. Rev Saúde Pública. 2007;41(5):749-56.
3. Nurmi I, Lüthje P. Incidence and costs of falls and fall injuries among elderly in institutional care. Scand J Prim Health Care. 2002;20(2):118-22.
4. Commodore DI. Falls in the elderly population: a look at incidence, risks, healthcare costs, and preventive strategies. Rehabil Nurs. 1995;20(2):84-9.
5. Mathias S, Nayak US, Isaacs B. Balance in elderly patients: the "get-up and go" test. Arch Phys Med Rehabil. 1986;67(6):387-9.
6. Podsiadlo D, Richardson S. The timed "Up & Go": a test of basic functional mobility for frail elderly persons. J Am Geriatr Soc. 1991;39(2):142-8.
7. Shumway-Cook A, Brauer S, Woollacott M. Predicting the probability for falls in community-dwelling older adults using the Timed Up & Go Test. Phys Ther. 2000;80(9):896-903.
8. Singh SJ, Morgan MD, Scott S, Walters D, Hardman AE. Development of a shuttle walking test of disability in patients with chronic airways obstruction. Thorax. 1992;47(12):1019-24.
9. Spagnuolo DL, Jürgensen SP, Iwama AM, Dourado VZ. Walking for the assessment of balance in healthy subjects older than 40 years. Gerontology. 2010;56(5):467-73.
10. Toraman A, Yildirim NU. The falling risk and physical fitness in older people. Arch Gerontol Geriatr. 2010;51(2):222-6.
11. Keskin D, Borman P, Ersöz M, Kurtaran A, Bodur H, Akyüz M. The risk factors related to falling in elderly females. Geriatr Nurs. 2008;29(1):58-63.
12. Grisso JA. Prevention of falls in patients with osteoporosis. J Clin Rheumatol. 1997;3(2 Suppl):62-4.
13. Dyer CA, Singh SJ, Stockley RA, Sinclair AJ, Hill SL. The incremental shuttle walking test in elderly people with chronic airflow limitation. Thorax. 2002;57(1):34-8.
14. Singh SJ, Jones PW, Evans R, Morgan MD. Minimum clinically important improvement for the incremental shuttle walking test. Thorax. 2008;63(9):775-7.
15. Singh SJ. Walking for the assessment of patients with chronic obstructive pulmonary disease. Eur Respir Mon. 2007;40(1):148-64.
16. Berg KO, Maki BE, Williams JI, Holliday PJ, Wood-Dauphinee SL. Clinical and laboratory measures of postural balance in an elderly population. Arch Phys Med Rehabil. 1992;73(11):1073-80.
17. Thrane G, Joakimsen RM, Thornquist E. The association between timed up and go test and history of falls: the Tromso study. BMC Geriatr. 2007;7:1.
18. Jürgensen SP, Antunes LC, Tanni SE, Banov MC, Lucheta PA, Bucceroni AF, et al. The incremental shuttle walk test in older Brazilian adults. Respiration. 2011;81(3):223-8.
19. Misic MM, Rosengren KS, Woods JA, Evans EM. Muscle quality, aerobic fitness and fat mass predict lower-extremity physical function in community-dwelling older adults. Gerontology. 2007;53(5):260-6.
20. Steffen TM, Hacker TA, Mollinger L. Age- and gender-related test performance in community-dwelling elderly people: Six-Minute Walk Test, Berg Balance Scale, Timed Up & Go Test, and gait speeds. Phys Ther. 2002;82(2):128-37.
21. Shubert TE. Evidence-based exercise prescription for balance and falls prevention: a current review of the literature. J Geriatr Phys Ther. 2011;34(3):100-8.
22. Hernandez SSS, Coelho FGM, Gobbi S, Stella F. [Effects of physical activity on cognitive functions, balance and risk of falls in elderly patients with Alzheimer's dementia]. Rev Bras Fisioter. 2010;14(1):68-74.
23. Howe TE, Rochester L, Neil F, Skelton DA, Ballinger C. Exercise for improving balance in older people. Cochrane Database Syst Rev. 2011;11:CD004963.