Factors Associated with the Risk of Falls of Nursing Home Residents Aged 80 or Older

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Keywords
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Abstract

Background: Falls are the leading cause of mortality and morbidity in older and represents one of the major and most costly public health problems worldwide.

Purpose: Evaluate the influences of lower limb muscle performance, static balance, functional independence and quality of life on fall risk as assessed with the timed up and go (TUG) test.

Design: Cross-sectional study.

Methods: Fifty-two residents aged 80 or older were assessed and distributed in one of the two study groups (no risk of falls; risk of falls) according to the time to complete the TUG test. A Kistler force platform and linear transducer was used to determine lower limb muscle performance. Postural Stability (static balance) was measured by recording the center of pressure. The Euro-Qol-5 dimension was used to assess Health-related quality of life and the Barthel index was used to examine functional status. Student’s t-test was performed to evaluate the differences between groups. Correlations between variables were analyzed using Spearman or Pearson coefficient. ROC (receiver operating characteristic) analysis was used to determine the cut-off points related to a decrease in the risk of a fall.

Findings: Participants of no-fall risk group showed better lower limb performance, quality of life, and functional status. Cut-off points were determined for each outcome.

Conclusions: Risk of falls in nursing home residents over the age of 80 is associated with lower limb muscle performance, functional status, and quality of life.

Clinical Relevance: Cut-off points can be used by clinicians when working toward fall prevention and could help in determining the optimal lower limb muscle performance level for preventing falls.

Introduction

Falls are one of the major and most costly public health problems worldwide (Hartholt et al., 2011). About 30% of community-dwelling older adults fall at least once a year and this percentage increases to 43% for those living in nursing homes (Rubenstein & Josephson, 2002) and 50% for those over the age of 80 (Inouye, Brown, & Tinetti, 2009). Thus, falls are the leading cause of mortality (Petridou et al., 2007) and morbidity (Health Quality Ontario, 2008) among older adults. Independence in activities performed on a daily basis is compromised in people susceptible to falls (Chu, Chiu, & Chi, 2006). Due to reduced function in those who fall, health-related
quality of life (HRQoL) is often reduced in this population (Iglesias, Manca, & Torgerson, 2009).

Due to the prevalence of falls, it is important to identify fall risk-related factors to effectively design interventions that address this issue. Although fall risk is multifactorial, reduced strength is the most common cause of falls among nursing home residents (Joyner, 2005; Robbins et al., 1989; Rubenstein & Josephson, 2002). Moreover, older people living in nursing homes experience reduced mobility and poor balance when compared with their peers living in the community (Nitz & Josephson, 2011). In addition, it has been suggested that lower limb power may have more influence than muscle strength on static balance (Orr, 2010). Therefore, these factors seem to be directly related to fall risk and the resulting functional dependency that lead to a poor quality of life (Caserotti, 2010). Despite this, few studies have been conducted to determine the association between the risk of a fall and lower limb muscle performance, movement speed, functional status and HRQoL in nursing home residents over 80 years of age (Orr, 2010). Therefore, the aim was to study the influences of these parameters on fall risk as assessed with the timed up and go (TUG) test in nursing home residents over 80 years of age.

Methods

Participants and Study Design

A cross-sectional study was conducted. Participants were recruited from two local nursing homes (both in Seville, Spain). The study was approved by the Ethics Committee of the University of Seville (Seville, Spain) and was conducted following the ethical guidelines of the Declaration of Helsinki. Fifty two volunteers gave their written informed consent after receiving detailed information about the aims and study procedures. The inclusion criteria required that participants had to be more than 79 years old and be living in a nursing home. Participants were excluded if they had cognitive or functional disorders, comorbidities, acute thrombosis, or its high risk, not well balanced with medical treatment or severe vertigo that prevented them from following instructions during the tests.

Procedures and Outcome Measures

All outcome measures were performed by one researcher with previous experience in these procedures. Participants were asked to report their age and gender. The number of years in the nursing home, health conditions, and medications were also recorded. Participants’ weight, height, and waist, and hip circumference were measured, and body-mass index (kg/m²) and waist-to-hip ratio were calculated. Body-fat percentage (BF %) was also estimated using a handheld impedance analyser (Omron BF-306; Omron Healthcare Europe BV, Hoofddorp, The Netherlands) according to the manufacturer’s instructions (Deurenberg et al., 2001).

The TUG test is one of the most common tests used in older populations to examine balance, gait speed, and functional ability related to the performance of basic daily life activities (Herman, Giladi, & Hausdorff, 2011; Podsiadlo & Richardson, 1991). This test has demonstrated good inter-rater reliability, with an intra-class correlation of 0.80 (Yeung, Wessel, Stratford, & MacDermid, 2008). It has been suggested that a score of 13.5 seconds or more in the TUG test increases the risk of falls in older adults living in the community (Allison, Painter, Emory, Whitehurst, & Raby, 2013; Gunter, White, Hayes, & Snow, 2000; Shumway-Cook, Brauer, & Woollacott, 2000). Fall risk was assessed using the TUG test (Podsiadlo & Richardson, 1991). The participants had to stand up from a standard chair, walk 3 m to and around a cone, and return to the chair in a comfortable and safe walking speed (Podsiadlo & Richardson, 1991). The best time of two trials (1-minute rest period between trials) were recorded. Those participants scoring 13.5 seconds or more were considered to be at risk of falls (Allison et al., 2013; Gunter et al., 2000; Shumway-Cook et al., 2000) and this value was used to determine placement into the two study groups (no risk of falls; risk of falls).

The EuroQol-5 dimension (EQ-5D) was used to assess Health-Related Quality of Life (HRQoL) of the participants in the study. EQ-5D has good test–retest reliability (van Agt, Essink-Bot, Krabbe, & Bonsel, 1994). This test includes five dimensions (mobility, personal care, usual activities, pain/discomfort, and anxiety/depression), each of which has three levels (no problems, some problems, or extreme problems/unable to). The juxtaposition of the levels for these five dimensions correlates to a five-digit number, which reflect 243 possible health status values. These health status values can be converted to a health functional index or a “utility” (EQ-5DUTILITY) using time-trade off values (EuroQol utility: 1 = full functional quality of life, 0 = death). The EQ-5D-3L also includes a vertical 20-cm Visual Analogue Scale (EQ-5DVAS), which is used by participants to rate their own health between 0
(worst imaginable health state) and 100 (best imaginable health state), thereby providing an overall numerical estimate of their HRQoL (EuroQol Group, 1990).

The Barthel index (BI) was used to assess functional status. BI has fair to good inter-rater reliability in elderly population (Richards et al., 2000) and excellent inter-rater reliability ($r = .849$) in rehabilitation patients (Rollnik, 2011). This test is comprised of 10 items (bathing, grooming, feeding, dressing, bowel, bladder, toilet uses, stairs, transfer, and mobility) that measure a person’s activities of daily living. Total scores are calculated by summing the individual item scores. Scores are weighted and range from 0 (dependence) to 100 (independence) (Mahoney & Barthel, 1965).

Lower limb muscle performance was assessed using the 30-seconds Chair Sit to Stand (30-s CSTS) test (Rikli, 2001). This test has an excellent test–retest reliability ($r = .89$) and an excellent inter-rater reliability ($r = .95$) (Jones, Rikli, & Beam, 1999). The participants were instructed to perform the task starting and finishing in the seated position. The number of times within 30 seconds that the participant could raise to a full stand from a seated position “as fast as possible”, with the back straight and feet flat on the floor without using the arms, was counted. Peak velocity of each repetition as well as the average velocity of an approximate center of mass point was recorded using a linear transducer (Model TF-100; T-Force System Ergotech, Murcia, Spain) and peak force was recorded by a Kistler force platform, type 9281A (Kistler Instruments AG, Winterthur, Switzerland). Peak force was then normalized by weight. From these data, the maximum power was calculated (peak force normalized by weight of participants multiplied by peak velocity).

Postural Stability was measured using a Kistler force platform, type 9281A (Kistler Instruments AG) by recording the anterior–posterior (AP) and medial–lateral (ML) center of pressure (COP) excursions in a quiet standing posture. These parameters (AP and ML COP excursions), sampled at 1000 Hz, were calculated for three tasks, including a dual-task cognitive challenge: (1) standing on the force platform with the eyes open, (2) standing on the force platform with the eyes open and performing a cognitive task, and (3) standing on the force platform with the eyes closed. For each condition, three trials were performed. Each trial lasted 30 seconds and was followed by a rest period of 1 minute. Participants were asked to keep their feet at the width of their hips and in a natural, comfortable position during tests. For data analysis, only the final 20 seconds of each trial were used (Prieto, Myklebust, Hoffmann, Lovett, & Myklebust, 1996). The cognitive task was counting backwards by 3’s as fast and as accurately as possible, beginning with a randomly selected number from a range of 100–200. The importance of this test is that the successful performance of dual-task situations affords increased levels of attentional demand for the regulation of balance (Woolacott & Shumway-Cook, 2002) and higher levels of postural sway and greater stride-to-stride variability have been shown during dual-tasking compared to single-tasking in older adults (Granacher, Bridenbaugh, Muehlbauer, Wehrle, & Kressig, 2011).

Statistical Analysis

All statistical analyses were performed using the Statistical Package for Social Sciences (SPSS, v.17.0 for WINDOWS; SPSS Inc., Chicago, IL, USA). The level of significance was set at $p \leq .05$ for all tests performed. Data are presented as means ± SD, unless otherwise stated. Kolmogorov–Smirnov test shows that data were normally distributed. Student’s $t$-test for independent samples was performed to evaluate the differences in variables between the two fall risk groups. The 95% confidence interval of the mean difference was reported.

Associations between the TUG test score and the variables of the study were tested using Spearman rank coefficient for categorical variables and using Pearson coefficient for continuous variables. The level of relationship was determined based on the recommendations of Cohen (Cohen, 1988), a coefficient between 0.1 and 0.29 was considered low; a coefficient between 0.3 and 0.49 was considered moderate and more than 0.5 was considered high. Chi square analysis and derived odd ratios were used to assess the level of association between the risk of a fall and the different dimensions of the EQ-5D. This analysis was also used to evaluate the level of association between the risk of a fall and the dependence status as evaluated by the BI (i.e., those scoring 100 in the BI were considered to be independent) (Mahoney & Barthel, 1965).

For the variables associated with the TUG test score, ROC analysis was used to determine the cut-off points related to a decrease in the risk of a fall. Presenting no risk of falling according to the TUG test score served as the external criterion for constructing the ROC curves. Sensitivity and specificity were used to determine the cut-off values (giving equal weight to both parameters) for
each test that was performed. The area under the curve (AUC) (and the 95% confidence interval) and its significance for the ROC curve was then determined through the non-parametric estimation method since the binomial method may introduce bias as the data were not normally distributed (Hsieh & Turnbull, 1996).

Results
Of the 52 volunteers, 31 participants had TUG test scores greater than 13.5 seconds suggesting that these participants were at risk of falling (mean age 84.5 ± 7.9). Participants who had TUG test scores less than the selected cut-off were classified as “no risk of falling” (mean age 82.6 ± 7.9). No significant differences were found between the groups for body composition, clinical, and demographic variables (p > .05, Table 1).

Table 2 shows lower limb muscle performance. Participants in the “no risk of falls” group showed a statistically significant increase in the number of stands in the 30-s CSTS (p = .001). Participants in the “no risk of falls” also demonstrated a statistically significant increase in 30-s CSTS-lower limb peak power (p < .001), 30-s CSTS-peak velocity (p < .001) 30-s CSTS-peak force (p = .041) and 30-s CSTS-average velocity (p < .001) when compared with those participants in the “with risk of falls” group (Table 2). On the other hand, statistically significance differences were not achieved on static balance values between the two groups of study (p > .05, Table 3).

Participants in the “no risk of falls” group exhibited better HRQoL as reflected by the greater EQ-5DVAS (p = .004) and EQ-5DUTILITY (p < .001) values when compared to the “with risk of falls” group (Table 4). Comparable results were achieved for the mobility, self-care and daily activities EQ-5D dimensions (p < .001, Table 4). Similarly, those participants in the “no risk of falls” group reported better (higher score) functional status when compared with those in the “with risk of falls” group (p < .001, Table 4).

Table 5 shows the correlation coefficients between the TUG test score and the other study variables. There was a moderate to strong inverse correlation between the TUG test score and the number of stands in the 30-s CSTS, lower limb peak and average velocity and peak power, with correlation coefficients ranging from −.233 to −.712 (p < .001).

A negative, moderate to strong correlation was also found between the TUG test score and the EQ-5DUTILITY and EQ-5DVAS (correlation coefficients −.713 and −.456; p < .01). With the exception of Pain/discomfort, all EQ-5D dimensions were found to correlate with the TUG test score (p < .05). Similarly, a strong, positive correlation was found between this score and functional status as assessed with the BI (p < .01, Table 5).

An increase in risk of falls (i.e., TUG test score ≥ 13.5) was detected in those participants reporting more mobility, self-care, and daily activities problems (EQ-5D questionnaire) with Odd Ratios of 16.87, 13.15, and 36.37, respectively (p < .01). Likewise, functional independence (BI = 100) was associated with the risk of falls (p < .01, Table 6).

Table 7 shows the cut-off points, sensitivity, specificity, and area under the ROC curve values for each tested variable. The ROC curves show that all variables present acceptable sensitivity and specificity. The AUCs show similar results, thus yielding an AUC above 0.68 in all cases (p < .05).

Post hoc statistical power was calculated for each study variable using mean (SD), alpha (<.05), sample size of the groups and effect size values. With the exception of static balance variables, statistical power was above .90 for all study variables (data not shown).

Discussion
Identification of risk factors for falling is a first step in designing effective interventions for preventing falls. Some
function-related outcomes such as reduced lower limb strength have been established as key modifiable function-related risk factor for falls (Kadono & Pavol, 2013). This study aimed to identify factors related to increased risk of falls among people over 80 years of age living in nursing home. One of the novelties of this study was the determination of cut-off points for factors related to fall risk in this population. This information could be useful

Table 2 Lower limb muscle performance differences between groups of the study (n = 52)

| Variables                  | No Risk of Falls (n = 21) | Risk of Falls (n = 31) | p    | Mean Difference (95% CI) |
|----------------------------|---------------------------|------------------------|------|--------------------------|
| Timed Up and Go Test (s)   | 10.7 (1.5)                | 23.8 (9.1)             | <.001| -13.2 (−17.2 to −9.1)   |
| 30-s CSTS (number of times)| 8.1 (2.8)                 | 5.7 (2.4)              | .001 | 2.5 (1.0 to 3.9)         |
| 30-s CSTS Vmax (m/s)       | 0.8 (0.2)                 | 0.3 (0.1)              | <.001| 0.3 (0.2 to 0.3)         |
| 30-s CSTS Vmed (m/s)       | 0.5 (0.1)                 | 0.3 (0.1)              | <.001| 0.2 (0.2 to 0.3)         |
| 30-s CSTS Peak force (N/Kg)| 11.1 (0.9)                | 10.3 (1.4)             | .041 | 0.74 (0.03 to 1.4)       |
| 30-s CSTS Peak Power (W)   | 6.6 (1.8)                 | 3.6 (1.7)              | <.001| 2.9 (1.9 to 3.9)         |

Values are mean (SD); Risk of falls group: Time up and Go score ≥13.5; group that had access to usual care; With no risk of falls group: Timed Up and Go score <13.5; 30-s CSTS Vmax: Peak velocity as determined by the 30 seconds sit to stand test; 30-s CSTS Vmed: Average velocity as determined by the 30 seconds sit to stand test; 30-s CSTS Peak force: Peak force as determined by the 30 seconds sit to stand and normalized by weight of participants; 30-s CSTS Peak Power: Peak power as determined by the 30 seconds sit to stand test; p: p-value from Student’s t-test for independent measurement.

Table 3 Static balance characteristics of octogenarians aged 80+ with no risk of falls and with risk of falls (n = 52)

| Variables                  | No Risk of Falls (n = 21) | Risk of Falls (n = 31) | p  | Mean Difference (95% CI) |
|----------------------------|---------------------------|------------------------|----|--------------------------|
| Eyes open ML/AP            | 7.09 (11.24)              | 8.82 (11.41)           | .592| -1.72 (−8.16 to 4.71)   |
| Eyes close ML/AP           | 8.81 (8.65)               | 6.96 (6.59)            | .386| 1.85 (−2.40 to 6.10)    |
| Cognitive-interference ML/AP| 7.48 (10.86)             | 6.47 (6.43)            | .675| 1.01 (−3.80 to 5.83)    |

Values are mean (SD).
ML/AP, anterior–posterior/medial lateral center of pressure excursion ratio.
Risk of falls group: Timed Up and Go score ≥13.5; Without risk of falls group: Timed Up and Go score <13.5; p: p-value from Student’s t-test for independent measurement.

Table 4 Quality of life and functional independence in older adults (n = 52)

| Variables                  | No Risk of Falls (n = 21) | Risk of Falls (n = 31) | p   | Mean Difference (95% CI) |
|----------------------------|---------------------------|------------------------|-----|--------------------------|
| Quality of life (EQ-5D dimensions) |                           |                        |     |                          |
| Mobility, problems (%)     | 28.6                      | 87.1                   | <.001| -58.5 (−75.3 to −41.8)  |
| Self-care, problems (%)    | 9.5                       | 58.1                   | <.001| -48.5 (−69.1 to −28.0)  |
| Daily activities, problems (%)| 4.8                      | 64.5                   | <.001| -59.7 (−80.1 to −39.4)  |
| Pain/discomfort, problems (%)| 71.4                     | 61.3                   | .451| 10.1 (−5.1 to 25.4)     |
| Anxiety/depression, problems (%)| 19.0                     | 38.7                   | .132| -19.6 (−40.8 to 1.5)    |
| EQ-5DUSTILITY              | 0.9 (0.1)                 | 0.7 (0.1)              | <.001| 0.2 (0.1 to 0.2)        |
| EQ-SDVASC                  | 79.9 (13.7)               | 62.5 (24.2)            | .004| 17.5 (5.7 to 29.2)      |
| Functional independence (Barthel index) |                  |                        |     |                          |
| Total score                | 93.8 (11.3)               | 78.7 (16.3)            | .001| 15.1 (6.7 to 23.3)      |
| Dependent (%)              | 42.9                      | 87.1                   | .001| –                        |

Values are mean (SD).
Risk of falls group: Timed Up and Go score ≥13.5; Without risk of falls group: Timed Up and Go score <13.5; p, p-value from Student’s t-test for independent measurement* or chi square.
Total score: mean (SD) for the group in Barthel Index; Dependent: those participants in the study scoring <100 in the Barthel Index.

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Table 5: Correlation coefficients between risk of falls (Timed Up and Go test score ≥13.5) and lower limb performance, quality of life or functional independence in the participants in the study (n = 52)

| Variables                              | Timed Up and Go Test (s) |
|----------------------------------------|--------------------------|
| Lower limb performance                 |                          |
| 30-s CSTS (number of times)            | -0.524**                  |
| 30-s CSTS Vmax (cm/s)                  | -0.715**                  |
| 30-s CSTS Vmed (cm/s)                  | -0.707**                  |
| 30-s CSTS Peak force (N/kg)            | -0.233**                  |
| 30-s CSTS Power (W)                   | -0.712**                  |
| Quality of life (EQ-5D dimensions)     |                          |
| Mobility                               | 0.595**                  |
| Self-care                              | 0.631**                  |
| Daily activities (1–2)                 | 0.777**                  |
| Pain/discomfort (1–2)                 | 0.127**                  |
| Anxiety/depression (1–2)               | 0.354‡                   |
| EQ-SDUTILITY (0–1)                     | -0.713**                  |
| EQ-SDVAS (0–100)                       | -0.456**                  |
| Functional independence (Barthel index)|                          |
| Barthel (0–100)                        | -0.659**                  |
| Dependent (1–2)                       | 0.512**                  |
| Static balance                         |                          |
| Eyes open                              |                          |
| MU/AP                                  | 0.040†                   |
| Eyes open cognitive interference       |                          |
| MU/AP                                  | -0.174†                  |
| Eyes closed                            |                          |
| MU/AP                                  | -0.083†                  |

Pearson† or Spearman‡ correlation coefficients.
30-s CSTS Vmax: Peak velocity as determined by the 30 seconds sit to stand test; 30-s CSTS Vmed: Average velocity as determined by the 30 seconds sit to stand test; 30-s CSTS Peak force: Peak force as determined by the 30 seconds sit to stand test and normalized by weight of participants; 30-s CSTS Peak Power: Peak power as determined by the 30 seconds sit to stand test; Dependent: 1—No dependence (score of 70 or less on the Barthel index) and 2—dependent (score of less than 100 on the Barthel index); ML/AP: anterior–posterior/medial lateral center of pressure excursion; Ratio For quality of life dimensions (i.e., mobility, self-care, daily activities, pain/discomfort, and anxiety/depression) 1 means no problems and 2 means problems.

*Correlation is significant at .05 level.
**Correlation is significant at .01 level.

Table 6: Association between the risk of falling (Timed Up and Go score ≥13.5) and Quality of life dimensions (EQ-5D) or Functional Independence (Barthel index = 100) in the study participants (n = 52)

| Variables                              | OR (95% CI) | p     |
|----------------------------------------|-------------|-------|
| Quality of life (EQ-5D) dimensions     |             |       |
| Mobility                               | 16.87 (4.01–69.38) | <.001 |
| Self care                              | 13.15 (2.60–66.62) | <.001 |
| Daily activities                       | 36.37 (4.28–308.72) | <.001 |
| Pain/discomfort                        | 0.63 (0.192–2.08)  | .451  |
| Anxiety/depression                     | 2.68 (0.726–9.92)  | .132  |
| Functional independence (Barthel index)| 9.00 (2.31–35.06) | <.001 |

EQ-SD, European quality of life questionnaire; χ², chi square value; OR, odds ratio.

over 80 years of age. Also, there was an association between the risk of falls, HRQoL and functional status. The TUG test score was used due to its ability to identify those older adults who were most prone to falling (Allison et al., 2013; Gunter et al., 2000; Shumway-Cook et al., 2000).

Functional capacity of those who are at risk of falls is lower compared to those without risk of falls in community-dwelling older adults (Perry, Carville, Smith, Rutherford, & Newham, 2007; Shimada et al., 2011; Smee, Anson, Waddington, & Berry, 2012). Therefore, functional capacity can be a major determinant in the risk of falls among community-dwelling older adults. For example, gait performance is reduced in fallers when compared to nonfallers (Shimada et al., 2011). Furthermore, Smee et al. (2012) reported that there is a 75% probability that physical functional performance (reduced balance and reduced strength) is a significant component of the model for fall risk.

In this study, those participants at risk of a fall had less peak power, force and velocity in the 30-s CSTS task. These results are consistent with other studies that have examined the production of rapid muscle force and muscle power with respect to the aging process. Thus, these factors are directly related to fall prevention and the risk of functional dependency (Caserotti, 2010; Petrella, Kim, Tuggle, Hall, & Bamman, 2005). Our results are consistent with the scientific literature addressing this association. Toraman and Yildirim (2010) reported a decrease in the 30-s CSTS in older adults at risk of falls. Using a similar sample size, Perry et al. (2007) observed that older adults who had suffered falls generated less power in a leg extension trial when compared to those who had not
fallen. Bonnefoy, Jauffret, and Jusot (2007) also confirmed this in a similar population and showed that peak velocity was associated with a risk of falling. Therefore, it appears that peak velocity is a significant determinant of power production, especially in older adults with mobility limitations (Pojednic et al., 2012). Hence, muscle power or contraction velocity may have a greater influence on balance performance than muscle strength (Orr, 2010). The current findings strongly support the relationship established in the current literature between the risk of falls and lower limb muscle performance and extend this relationship with apply to older adults aged 80 years or more who are living in nursing homes.

Moreover, in this study, those participants at risk of falls showed a trend toward an increased (worse) score in the mean displacement of COP-related variables than those not at risk of falls. However, a clear association between these variables and the risk of falling was not detected. It seems that postural stability contributes to functional performance in older adults (Pizzigalli, Filippini, Ahmaidi, Jullien, & Rainoldi, 2011) and therefore can positively impact fall incidence in this population (Maki, Holliday, & Topper, 1994).

However, this relationship is not clear as other authors could not confirm this association (Petrella et al., 2012) and neither could results of this study.

Participants who exhibited a high risk of falling in this study also demonstrated lower functional status as assessed by means of the BI. These results are consistent with the findings of other studies conducted with community-dwelling adults aged 79 or older (Ferrer et al., 2012; Grundstrom, Guse, & Layde, 2012). This relationship has also been confirmed in healthy community-dwelling older adults (Chu et al., 2006; Okamura et al., 2009) as well as older women who were attending a geriatric outpatient clinic (Aoyama, Suzuki, Onishi, & Kuzuya, 2011). This fact could reflect the importance of maintaining good functional status to perform daily life activities (Brach & VanSwearingen, 2002). Therefore, the dimensions that correlated with an increased risk of falling were mobility, self-care, and daily life activities (Painter et al., 2012), hence supporting the relationship between risk of falling and HRQoL as assessed by the EQ-5D found in this study (Davis et al., 2012; Ozcan, Donat, Gelecek, Ozdirenc, & Karadibak, 2005).

Several cut-off points have been determined in this study. These points could help in determining the optimal lower limb muscle performance level for preventing falls in older adults aged 80 years or more who are living in nursing homes. For example, a goal to prevent falls could be to achieve a peak force of 11.09 N/kg, or 6.5 times in 30-s CSTS. Similar conclusions could be made for all of the physical components being evaluated (peak and average velocity and peak power). These cut-off points calculated using ROC curves can be used by clinicians, when working toward fall prevention as a way of establish a starting point for designing an effective intervention that should include exercises aimed to improve strength and power at lower limb. Whole-body vibration including dynamic exercises seems to be an effective alterternative. Ultimately, the aim was to improve performance of ADL (activities of daily living) and last quality of life of nursing home residents. (Álvarez-Barbosa et al., 2014).

### Study Limitations

Some limitations need to be recognized in this study. An important shortcoming of this study is the fact that

| Variables                      | Cut-off | Sensitivity (%) | Specificity (%) | AUC (cm²) | p     | SE     | 95% Interval Confidence |
|--------------------------------|---------|-----------------|-----------------|-----------|-------|--------|------------------------|
| 30-s CSTS (number of times)    | 6.50    | 71              | 60              | 0.744     | .003  | 0.069  | 0.609–0.878             |
| 30-s CSTS Vmax (cm/s)          | 0.45    | 81              | 74              | 0.873     | <.001 | 0.049  | 0.777–0.969             |
| 30-s CSTS Vmed (cm/s)          | 0.38    | 81              | 80              | 0.889     | <.001 | 0.046  | 0.798–0.979             |
| 30-s CSTS Peak Power (W)       | 5.07    | 81              | 70              | 0.863     | <.001 | 0.050  | 0.765–0.962             |
| 30-s CSTS Peak force (N/kg)    | 11.09   | 67              | 77              | 0.679     | .031  | 0.086  | 0.511–0.847             |

AUC: area under the receiver-operating curve (maximum = 1.0); SE: standard error; 30-s CSTS Vmax: Peak velocity as determined by the 30 seconds sit to stand test; 30-s CSTS Vmed: Average velocity as determined by the 30 seconds sit to stand test; 30-s CSTS Peak force: Peak force as determined by the 30 seconds sit to stand test and normalized by weight of participants; 30-s CSTS Peak Power: Peak power as determined by the 30 seconds sit to stand test; p: statistical significance set at .05.
The accuracy of 13.5 seconds as TUG cut-score to discriminate fellers from non-fallers is controversial (Schoene et al., 2013). Shcone et al., concluded in a meta-analysis that TUG might not be useful for discriminating fallers from non-fallers in healthy, high-functioning population of older adults but would be of more use in less-healthy, lower functioning group. Moreover, the selected TUG cut-score has been validated among community dwelling older people and using standard method (i.e., natural comfortable pace). Here, a modification of the test (i.e., doing the task as fast as possible) was applied (Rikli, 2001). Besides, we did not have access to fall history. Thus, participants might be incorrectly classified into fallers or non-fallers. However, the aim of this study was not to differentiate between those that fell from those that did not. We were looking here at those at risk of falling (i.e., future falls) and factors associated to this risk of falling. With this purpose, the TUG test was used. Some authors have claimed the usefulness of the TUG test to discriminate between those older adults living in nursing homes that are at risk of falling and those that are not at risk of falling (Schoene et al., 2013). Another study use 13.5 as cut-score to discriminate frail elderly people at risk of falling from those that are not at risk of falling according to the TUG test score (Podsiadlo & Richardson, 1991). In any case, it seems that TUG test is related to some of the fall risk factors (i.e., lower limb function; Podsiadlo & Richardson, 1991) so working with this test may still provide advantages.

A further shortcoming was related to the research design used. As a cross-sectional design was used, a causative interpretation is not possible. Another shortcoming is the incidental character of our sample which introduces some level of selection bias. Moreover, a risk of self-selection bias needs to be recognized as data were not obtained on those that decided not to take part in the study due to the voluntary nature of the study.

Along with these limitations, the small sample size does not allow for definitive conclusions (therefore, statistical power achieved for static balance variables and were below accepted threshold) but the results provide an indication of what further research may show. Future, larger prospective studies are required to confirm the relationships demonstrated in this study.

Conclusions

The results of this study show that the risk of falls in older adults aged 80 years or more who are living in nursing homes is associated with lower limb muscle performance (peak power and velocity), functional status and HRQoL. Cut-off points were presented with the main objective of guiding exercise-based interventions for preventing falls in the studied population. However, these results need to be prospectively confirmed.

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