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Factors associated with the risk of falls of nursing home residents aged 80 or older.

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TITLE

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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 test. **Design:** Cross-sectional. **Methods:** Fifty-two residents aged 80 or older were assessed and distributed in one of the two study groups according to the time to complete the Timed Up and Go Test. A Kistler force platform and linear transducer was used to determinate lower limb muscle performance. Postural Stability was measured by recording the center of pressure. The EuroQol-5 dimension was used to assess Health-Related Quality of Life and the Barthel Index was used to examine functional status. Student t-test was performed to evaluate the differences between groups. Correlations between variables were analyzed using Spearman or Pearson coefficient. ROC 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

Keywords: Nursing homes, Lower extremity, Aging, Accidental falls, Quality of life.

Key Practice Points:

- Fifty-two nursing home residents aged 80 or older were grouped according to the time taken to complete the Timed up and Go Test.
- Participants in the 'no risk of falls' group reported better (higher score) functional status and quality of life when compared with those in the 'with risk of falls' group
- The risk of falling was associated with lower limb muscle performance as assessed by 30-s CSTS-peak power, 30-s CSTS-peak force and 30-s CSTS-velocity in nursing home residents over 80 years of age.
- Cut-off 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 home

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, 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. Despite the fact that fall risk is multi-factorial, 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 2 local nursing homes (both in Seville, Spain). 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. 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.

Procedures and Outcome Measures

All outcome measures were performed by one researcher with previously experience in this 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 (BMI; kg/m^2) 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 meters to and around a cone, and return to the chair in a comfortable and safe walking speed (Podsiadlo & Richardson, 1991). The best time of 2 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 2 study groups.

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 a 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' ($EQ\text{-}5D_{UTILITY}$), 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-5D$_{VAS}$) 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, 1990).

The Barthel Index (BI) was used to assess functional status. BI has fair to good inter-ratter reliability in elderly population (Richards et al., 2000) and excellent inter-ratter reliability (r=0.849) in rehabilitation patients (Rollnik, 2011).This test is comprised of 10 items (bathing, grooming, feeding, dressing, bowels, 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 (J. Rikli, 2001). This test has an excellent test-retest reliability (r=0.89) and an excellent inter-ratter reliability (r = 0.95) (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, Winterthur, Switzerland) 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 3 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, 3 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 (Woollacott & 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 $p \leq 0.05$ for all tests performed. Data are presented as means ± standard deviation (SD), unless otherwise stated. Kolmogorov-Smirnov test shows that data were normally distributed. Student t-test for independent samples was performed to evaluate the differences in variables between the 2 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 Barthel index (i.e. those scoring 100 in the Barthel index 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

Out 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 ($p > 0.05$) (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 ($p = 0.001$). Participants in the 'no risk of falls' also demonstrated a statistically significant increase in 30-s CSTS-lower limb peak power ($p < 0.001$), 30-s CSTS-peak velocity ($p < 0.001$) 30-s CSTS-peak force ($p = 0.041$) and 30-s CSTS-average velocity (p < 0.001) when compared to 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 > 0.05) (Table 3).

Participants in the 'no risk of falls' group exhibited better HRQoL as reflected by the greater EQ-$5D_{VAS}$ (p = 0.004) and EQ-$5D_{UTILITY}$ (p < 0.001) 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 < 0.001) (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 < 0.001) (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 and force, with correlation coefficients ranging from -0.233 to -0.712 (p < 0.001).

A negative, moderate to strong correlation was also found between the TUG test score and the EQ-$5D_{UTILITY}$ and EQ-$5D_{VAS}$ (correlation coefficients -0.713 and -0.456; p < 0.01). With the exception of Pain/discomfort, all EQ-5D dimensions were found to correlate with the TUG test score (p < 0.05). Similarly, a strong, positive correlation was found between this score and functional status as assessed with the Barthel Index (p < 0.01) (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< 0.01). Likewise, functional independence (Barthel Index = 100) was associated with the risk of falls ($p < 0.01$) (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 ($p < 0.05$).

Post-hoc statistical power was calculated for each study variable using mean (SD), alpha (<0.05), sample size of the groups and effect size values. With the exception of static balance variables, statistical power was above 0.90 for all study variables (data not shown).

Comment [FÁ1]: A esto se referia imagino con lo de post-hoc

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 has been established as key modifiable function-related risk factor for falls (Kadono & Pavol, 2013). The current 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 in designing effective interventions to decrease the incidence of falls in older adults living in nursing homes.

The main finding of the current study was that the risk of falling was associated with lower limb muscle performance as assessed by 30-s CSTS-peak power, 30-s CSTS-peak force and 30-s CSTS-velocity in nursing home residents 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 non-fallers (Shimada et al., 2011). Furthermore, Smee et al. (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 the current 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; J. K. Petrella, Kim, Tuggle, Hall, & Bamman, 2005). Our results are consistent with the scientific literature addressing this association. Toraman et al.

(Toraman & 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. (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 et al. (Bonnefoy, Jauffret, & 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 to apply to older adults aged 80 years or more who are living in nursing homes.

Moreover, in the current study, those participants at risk of falls showed a trend towards 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 (M. Petrella et al., 2012) and neither could results of the current study.

Participants who exhibited a high risk of falling in the current study also demonstrated lower functional status as assessed by means of the Barthel Index. 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 in order 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).

As a practical novelty, 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 cutoff 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 efficacy alterternative. Ultimately, the aim is to improve performance of ADL and lastly 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 accuracy of 13.5 s as TUG cut-score to discriminate fallers from not 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 (T. J. Rikli, 2001). Besides, authors didn't have access to fall history. Thus, participants might be incorrectly classified into fallers or not fallers. However, the aim of this study was not to differentiate between those that fell from those that didn't. 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 not (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. Because 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 the current study.

CONCLUSIONS

The results of the current 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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Manuscript - Rehabilitation Nursing: RNJ-15-01-000467 titled, "Factors associated with the risk of falls of nursing home residents aged 80 or older,"

Dear editor and reviewers,

This letter accompanies the resubmission of a research article titled *"***Factors associated with the risk of falls of nursing home residents aged 80 or older +** to the ***Rehabilitation Nursing.***. We are thankful for the excellent feedback that we received and have taken appropriate action to resolve the outstanding issues with this article. In the remainder of the letter, we will outline (in red) how we have incorporated the feedback from the referees into a new draft.

Reviewer: 1

This is a nicely written manuscript. One concern I have is the "cut-off points" you refer to in the discussion section. The only "cut off point" I see noted is the TUG cut off point. Can you clarify that either in the results or the discussion. Also, many of the measurement tools used in the study may not be tools used to assess patients in the nursing home setting. What are the implications for this and how can the results be used in the nursing home setting? Finally, please include psychometric properties for all of the measurement tools. Thank you.

Thanks for commenting on these issues. The TUG cut off point is a pre-existing, previously validated cut-off points used to discriminate between people at risk of falls and people without risk of falling. The rest of the cut-off points result from the ROC curves analyses performed on the rest of the study variables (and using risk of falling as state variable). This has been clarified in both the results and discussion sections.

We agree on that some of the assessment performed in this study might not be feasible for most of the nursing home residents (this is also noticed in limitations). However, the results from this study might be useful to design exercise programs aimed to reduce the risk of falling in the nursing home population. This is now in the manuscript.

The psychometric properties of instruments have been added to the manuscript

Reviewer: 2

This is a well-written, well-designed study that adds to the literature of rehabilitation nursing. Make sure your citations are all in correct APA format.

Thanks for your comments on our work. References have been checked.

Reviewer: 3

Major concern: the cut-off level for each test is not clearly explained in the discussion section. The authors need to revise this section and elaborate more on the cut-off level for each test.

Thanks for your comments in this issue. We have provided with more information on cut-off points and their implications.

Minor concern

1. Page 2, abstract: Consider adding a background/introduction statement

A background has been added to the abstract according to your suggestions

2. Page 2, abstract: The clinical relevance subsection in the abstract needs to be revised – see comment below on the conclusion section below

The clinical relevance subsection in abstract has been revised according to your suggestion

3. Page 2, abstract: Methods: there is not mentioning of TUG test

TUG test is mentioned now in the abstract

4. Page 4, paragraph 1, lines 4, 8 and 9: Please check how to cite the reference in the text throughout the entire manuscript. For example: "age of 80. (Inouye, Brown, & Tinetti, 2009)" change it to "age of 80 (Inouye, Brown, & Tinetti, 2009)."

References have been checked.

5. Page 4, paragraph 2, line 3: Joyner, 2005, is this a reference for the statement that "risk if multifactorial" or is it for "reduced strength"? The current placement of the reference is inappropriate

Thanks for commenting on this issue. Reference "Joyner, 2005" has been relocated to the end of the sentence as is the appropriate place for that reference.

6. Page 5, paragraph 2: Any inclusion criteria other than the age and living in nursing homes? exclusion criteria other than ability to follow instruction? Any comorbidity, physical abilities For example: the TUG was used in this study and the TUG requires that the participant is able to walk without any assistance. Is that in the inclusion and exclusion criteria?

We have now provided with more details on the inclusion and exclusion criteria. Thanks for commenting on this.

7. Page 6, paragraph 1, line 10: Was the instruction for the TUG to perform the skill "as fast as possible" for the TUG we use the comfortable walking speed. This is important issue when using the 13.5 seconds as cut off level. The authors should provide more details explaining how they used the 13.5 seconds as cut off level to discriminate between faller and non faller, were TUG in other studies used the 13.5 tested at comfortable speed or fast speed?
TUG test was administered following guidelines (Podsiadlo and Richardson, 1991): "in a comfortable and safe walking speed". Studies references in the text referring to the chosen TUG cut-off point performed the TUG test with following same instructions. This is now modified in the manuscript

8. Page 5: Procedures and Outcome Measures: who performed the assessment? Was one person? How much experience in those tests?

Assessment was performed always by one researcher with previous experience on the assessment of the same outcomes. This has been added to the manuscript.

9. Page 6, paragraph 1, lines 11-12: Please revise

The sentence in line 11-12 has been reorganised to clarify the idea.

10. Page 6, paragraph 1, lines 8 and 13: The reference was listed in 8 as "Shumway, Brauer and Woollacott while in line 13 it was listed Shumway, when I checked the reference list, the list has only Shumway, Brauer and Woollacott. Please revise. Also check the same reference on page 12, paragraph 3, line 6

Thanks for commenting on this issue. According to APA style, when a study has more than one author, the first time that appears in the text, all authors must be mentioned, after that, when you cited this study again you should cited only with the first author. For that reason in line 8 the reference was cited as "Shumway, Brauer and Woollacott" and after that the same study is cited "Shumway et al,"

11. Page 7, paragraph 1, lines 4-5: Please revise, please check the referencing style of the journal on how to cite this reference

This citation has been revised and modified according to the APA style

12. Graphs: I suggest that the authors add graphs that show the difference between fallers and non fallers

Thanks for commenting on this issue. The authors prefer to keep the results of the study in table format so that the magnitudes and differences between groups can be better appreciated.

13. Page 17, paragraph 1, lines 3-5: This statement needs to be revised, there is no discussion in the manuscript on how the cut-off level can be used to guide the intervention for preventing falls.

A paragraph has been added to explain how the info on the cut-off points could be useful to guide interventions for preventing falls in nursing home residents.

Reviewer 4
Areas of Strength:
Aside from the reference citations that are not in APA format which make the article hard to read; the topic is of interest and pertinent to rehabilitation nurses.

Thanks for your comment. References have been checked and now are in APA format.

Areas for Improvement:

The title needs to be the same throughout the manuscript; there are two titles contained within the manuscript submitted and they are different.

Thanks for your comment. The title "**Factors associated with the risk of falls of nursing home residents aged 80 or older"** could be read through the entire manuscript, including cover letter and title page.

APA format for citations needs to be in APA format. Many references are older than 5 years, but some are classic and some are citations for the measurement tools for data collection.
Please clarify the cut-off points for the outcomes throughout the manuscript.

Citations have been revised according to APA style. We have provided with more information on cut-off points and their implications throughout the manuscript.

Methods: For the EQ-5D, Barthal Index, CSTS test and Kistler force platform, please report if these measures are reliable and valid, e.g. give statistical information. Was a statistician included on this project? If not, please have a statistician confirm the results and the data in the Tables.

Info on psychometric properties of the different outcomes used in this study has been now added to the method section. A statistician has checked the statistical analyses performed and confirm the rightness of all of them.

Results: Statistical tests chosen, applied, and reported seem appropriate. For the Post-hoc statistical power: would it be best to show the results in a Table?

Thanks for your comment on this. Data on post-hoc statistical power for each variable is now provided in the results sections.

Discussion: 'Cut-off points' are still not clear in this report. These points are hard to determine in practice. What is a more logical way to use the results? One idea is presented on page 15. Are there more ways to translate this information or easily use these cut-off points for clinical practice settings?

We agree on that some of the assessment performed in this study might not be feasible for most of the nursing home residents (this is also noticed in limitations). However, the results from this study might be useful to design exercise programs aimed to reduce the risk of falling in the nursing home population. This is now in the manuscript.

Study limitations seem appropriate.

What are the implications for practice based on these results: lower limb performance, functional status and quality of life? More details are needed for each finding. For instance, what would an exercise program look like focused on lower limb performance, e.g., what interventions would the exercise program contain? Nurses need to be able to apply these results to older adults.

Thanks for your comments on this. More info on the kind of exercises to be performed has been added to the manuscript where appropriate.

Abstract: How were data analyzed; what statistical tests were applied?
Please give more information about cut-off points in the abstract as this is not clear as written.

More information has been added to the abstract regarding statistical analysis and cut-off points.

Key Practice Points: Spell out TUG test. What are cut-off points? Be more specific of how these results impact practice and fall prevention for rehabilitation nurses.

TUG test has been spelled out and more specific info on how the results from this study could be apply to help in preventing falls for rehabilitation nurses added.

Table 1.
Characteristics of the participants in the study (n= 52)

Variables	No risk of falls (n= 21)	Risk of falls (n= 31)	*p*
Demographics variables			
Age (years)	82.6 (7.9)	84.5 (7.9)	0.392[a]
Gender (% females)	66.7	83.9	0.149[b]
Body composition			
BMI (Kg/m^2)	27.4 (3.2)	28.9 (5.7)	0.292[a]
WHR	0.9 (0.1)	0.9 (0.1)	0.241[a]
Body fat (%)	40.5 (7.1)	41.5 (7.7)	0.621[a]
Clinical variables			
Years living in nursing home	3.3 (2.9)	3.0 (3.3)	0.742[a]
Number of medications	5.8 (3.9)	6.7 (3.1)	0.391[a]
Number of health conditions	3.3 (2.5)	3.3 (2.3)	0.937[a]

Values are mean (SD) unless otherwise indicated; BMI: Body Mass Index; WHR: Waist to Hip Ratio; *p*: p value from *Student-t* test for independent measurement (a) or chi square analysis (b).

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)	<0.001	-13.2 (-17.2 to -9.1)
30-s CSTS (number of times)	8.1 (2.8)	5.7 (2.4)	0.001	2.5 (1.0 to 3.9)
30-s CSTS Vmax (m/s)	0.6 (0.2)	0.3 (0.1)	<0.001	0.3 (0.2 to 0.3)
30-s CSTS Vmed (m/s)	0.5 (0.1)	0.3 (0.1)	<0.001	0.2 (0.2 to 0.3)
30-s CSTS Peak force (N/Kg)	11.1 (0.9)	10.3 (1.4)	0.041	0.74 (0.03 to 1.4)
30-s CSTS Peak Power (W)	6.6 (1.8)	3.6 (1.7)	<0.001	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; Without 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 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: p value from Student-t test for independent measurement

Table 3.
Static balance characteristics of octogenarians aged 80+ with risk of falling and without risk of falling (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)	0.592	-1.72 (-8.16 to 4.71)
Eyes-close ML/AP	8.81 (8.65)	6.96 (6.59)	0.386	1.85 (-2.40 to 6.10)
Cognitive-interference ML/AP	7.48 (10.86)	6.47 (6.43)	0.675	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-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^a	Mean difference (95%CI)
Quality of Life (EQ-5D dimensions)				
Mobility, problems (%)	28.6	87.1	<0.001	-58.5 (-75.3 to -41.8)
Self-care, problems (%)	9.5	58.1	<0.001	-48.5 (-69.1 to -28.0)
Daily Activities, problems (%)	4.8	64.5	<0.001	-59.7 (-80.1 to -39.4)
Pain/Discomfort, problems (%)	71.4	61.3	0.451	10.1 (-5.1 to 25.4)
Anxiety/Depression, problems (%)	19.0	38.7	0.132	-19.6 (-40.8 to 1.5)
$EQ\text{-}5D_{UTILITY}$	0.9 (0.1)	0.7 (0.1)	<0.001	0.2 (0.1 to 0.2)
$EQ\text{-}5D_{VAS}$	79.9 (13.7)	62.5 (24.2)	0.004	17.5 (5.7 to 29.2)
Functional Independence (Barthel Index)				
Total score	93.8 (11.3)	78.7 (16.3)	0.001	15.1 (6.7 to 23.3)
Dependent (%)	42.9	87.1	0.001	-

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-t test* for independent measurement (a) or chi square (b); Total score: mean (SD) for the group in Barthel index; Dependent: those participants in the study scoring <100 in the Barthel Index.

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** [(a)]
30-s CSTS Vmax (cm/s)	-0.715** [(a)]
30-s CSTS Vmed (cm/s)	-0.707** [(a)]
30-s CSTS Peak force (N/kg)	-0.233** [(a)]
30-s CSTS Power (W)	-0.712** [(a)]
Quality of Life (EQ-5D dimensions)	
Mobility (1-2)A negative	0.595** [(b)]
Self-care (1-2)	0.631** [(b)]
Daily Activities (1-2)	0.777** [(b)]
Pain/Discomfort (1-2)	0.127 [(b)]
Anxiety/Depression (1-2)	0.354* [(b)]
$EQ\text{-}5D_{UTILITY}$ (0-1)	-0.713** [(a)]
$EQ\text{-}5D_{VAS}$ (0-100)	-0.456** [(a)]
Functional Independence (Barthel index)	
Barthel (0-100)	-0.659** [(a)]
Dependent (1-2)	0.512** [(b)]
Static balance	
Eyes Open	
ML/AP	0.040 [(a)]
Eyes Open coginitive interference	
ML/AP	-0.174 [(a)]
Eyes Closed	
ML/AP	-0.083 [(a)]

Pearson (a) or Spearman (b) 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 0.01 level
* Correlation is significant at 0.05 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 value
Quality of Life (EQ-5D) dimensions		
Mobility	16.87 (4.01 to 69.38)	<0.001
Self Care	13.15 (2.60 to 66.62)	<0.001
Daily activities	36.37 (4.28 to 308.72)	<0.001
Pain/Discomfort	0.63 (0.192 to 2.08)	0.451
Anxiety/Depresion	2.68 (0.726 to 9.92)	0.132
Functional Independence (Barthel Index)	9.00 (2.31 to 35.06)	<0.001

EQ-5D: European Quality of Life questionnaire; x^2: chi square value; OR: Odds ratio

Table 7.
Cut-off scores, sensitivity, specificity, and area under the receiver-operating curve for the variables that statistically differ between those with and without risk of falls among participants of the study (n=52)

Variables	Cut-off	Sensitivity (%)	Specificity (%)	AUC (cm^2)	*p*	SE	AUC 95% Interval Confidence
30-s CSTS (number of times)	6.50	71	60	0.744	0.003	0.069	0.609 to 0.878
30-s CSTS Vmax (cm/s)	0.45	81	74	0.873	<0.001	0.049	0.777 to 0.969
30-s CSTS Vmed (cm/s)	0.38	81	80	0.889	<0.001	0.046	0.798 to 0.979
30-s CSTS Peak Power (W)	5.07	81	70	0.863	<0.001	0.050	0.765 to 0.962
30-s CSTS Peak force (N/Kg)	11.09	67	77	0.679	0.031	0.086	0.511 to 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 0.05.