Physical Activity Level and Risk of Falling in Community-Dwelling Older Adults: Systematic Review and Meta-Analysis

Wuber J.S. Soares, Alexandre D. Lopes, Eduardo Nogueira, Victor Candido, Suzana A. de Moraes, and Monica R. Perracini

This systematic review examines the association between physical activity (PA) level and risk of falling in community-dwelling older adults. A search of PubMed, Embase, CINAHL, SPORTDiscus, and Web of Science was performed in January 2017. Four prospective cohort studies investigating the incidence of falls in a period of at least 12 months and its association with the level of PA in people aged 60 years and older were reviewed and pooled for meta-analysis. The pooled risk ratio (RR) for being a recurrent faller (2,420 participants) was 39% higher among those who were in the lowest PA level (RR = 1.39; 95% confidence interval [1.17, 1.65]; $I^2 = 0\%$, $p = .43$; $p < .0001$). The association between being a faller (7,927 participants) and PA level was inconclusive. This review identified that the benefit of general PA for preventing falls is associated with the adopted PA level.

Keywords: accidental falls, aging, longitudinal studies, risk factors

Globally, falls in community-dwelling older adults are among the 10th leading cause of sequelae of disorders and injuries that contribute to years lived with disability. Overall, falls accounted for 41% of the total number of years lived with a disability caused by injuries (Vos et al., 2013). Fall-related costs are expected to increase substantially in coming years due to population aging, particularly the costs associated with hospitalization, long-term care, and fractures (Heinrich, Rapp, Rissmann, Becker, & König, 2010).

The physical activity (PA) level is an important indicator of healthy and active aging (Haskell et al., 2007; World Health Organization, 2015) and has been identified as a lifestyle factor that may influence the risk of falls and fractures among older adults (Gregg, Pereira, & Caspersen, 2000). The effects of PA on the physiology of aging and on overall health include a decrease in all-cause mortality and improvement on functional status, psychological status, and well-being (Bauman, Merom, Bull, Buchner, & Fiatarone Singh, 2016; Nelson et al., 2007). Most of the biological risk factors for falling result from the interaction of physiological aging, disuse, chronic diseases, and medical conditions and can be modifiable by appropriate exercise programs (Sherrington & Tiedemann, 2015; Vieira, Palmer, & Chaves, 2016). Consequently, there may be a plausible explanation in recommending the increase of PA level to reduce the risk of falling.

However, except for the effectiveness of structured exercises in preventing falls in community-dwelling older adults (Sherrington et al., 2017), we do not yet know whether the increase in the PA level can reduce falls (Gregg et al., 2000; Thibaud et al., 2011). Contradictory results from observational studies suggest that either older adults at higher levels of PA (Chan et al., 2007; Jefferis et al., 2015) are at an increased risk of falling, particularly those performing moderately to highly intense activities, or those at lower levels of PA or who are sedentary are at an increased risk of falling (Thibaud et al., 2011). However, the U-shaped association between PA and risk of falling was not confirmed (Peeters, van Schoor, Pluijm, Deeg, & Lips, 2010), and some studies observed that the relationship between PA levels and falls is mediated by age (Cauley et al., 2013) and physical functioning status, such as mobility problems and walking speed (Klenk et al., 2015). Therefore, the association between PA level and the risk of falling until now has been poorly understood and is open to discussion (Gregg et al., 2000; Klenk et al., 2015).

The prior attempt to gather evidence on the relationship between PA and falls indicated that physically active older adults ("yes" or "no") were at a lower risk of falling compared with those who were physically inactive or sedentary, but only when the outcome of injuries was included and when the length of falls ascertainment was less than 12 months (Thibaud et al., 2011). However, this systematic review was mostly based on cross-sectional studies and on limited measures of PA, and it used single self-report questions not from validated PA questionnaires nor from objective measures of PA, as well as retrospective methods of ascertaining fall events (Thibaud et al., 2011), hindering robust conclusions to guide PA recommendations for falls prevention. Furthermore, recently some important prospective studies were conducted to determine the shape of the association between PA and falls (Cauley et al., 2013; Klenk et al., 2015). To overcome this gap, we systematically reviewed and meta-analyzed available studies to quantify the associations between PA level and risk of falling in community-dwelling older adults based on identified prospective cohort studies.

Method

Study Design

This is a meta-analysis and systematic review of prospective cohort studies. A protocol describing this review was recorded in International prospective register of systematic reviews, protocol number: CRD42016037384 and used the Preferred Reporting Items for Systematic Reviews and Meta-Analyses guidelines.
Search Strategy

We carried out electronic searches of MEDLINE via PubMed (1946 to January 04, 2017), Embase (1981 to January 04, 2017), CINAHL (1988 to January 05, 2017), SPORTDiscus (1977 to January 05, 2017), and Web of Science (1945 to January 06, 2017) for prospective cohort studies examining the association between PA and falls. The search was conducted and was limited to scientific articles and without restriction of language or year of publication. In addition, a manual search of the bibliographies of relevant papers was also carried out.

Four thematic blocks of words and a series of synonyms and variants were used for the research strategy: (“aged” OR “older adult” OR “elderly”) AND (“accidental falls” OR “falling” OR “faller”) AND (“physical activity” OR “energy expenditure” OR “exercise” OR “physical fitness”) AND (“risk factor” OR “exposure” OR “relative risk”). The Appendix presents the search strategies in detail.

Selection of Studies

This review included prospective cohort studies investigating the incidence of falls in a period of at least 6 months and its association with the level of PA in community-dwelling older adults aged 60 years or older.

This review considered original studies that reported the number of falls or fallers during the follow-up period (any fall, recurrent falls, and injurious falls). Falls were considered as “an unexpected event in which the participants come to rest on the ground, floor, or lower level” (Lamb, Jorstad-Stein, Hauer, Becker, & Prevention of Falls Network Europe and Outcomes Consensus Group, 2005). Studies that did not report how fall events were monitored at follow-up (calendars or periodic phone calls) were excluded to avoid recall bias. Cross-sectional or case-control observational studies were not included. Studies that investigated specific illnesses or health conditions such as Parkinson’s disease, stroke, dementia, and dizziness or that investigated participants living in other settings, such as nursing homes and hospitals, were excluded. In addition, we excluded studies that did not measure the level of PA using full-validated questionnaires or motion sensors, such as pedometers or accelerometers.

Data Extraction

Selected studies that resulted from database searches were exported to Endnote X7.8 (Philadelphia, PA) and duplicate studies were deleted. To select the studies, the articles were analyzed by title and abstract by two independent reviewers (W.J.S. Soares and E. Nogueira). The articles selected for full reading were reexamined for eligibility criteria. A third reviewer (A.D. Lopes) was able to give his opinion at any stage of the selection process, either to arbitrate in case of disagreement or to build consensus to help us decide whether to include or exclude studies from this review. The included studies for final review were analyzed, and two authors (W.J.S. Soares and M.R. Perracini) extracted the following characteristics: the name of the first author, year of publication, country or countries where the study was conducted, sample size, sample composition according to age and gender, time of follow-up, method for monitoring fall events, instruments and measures of the level of PA, and study results (number of falls or fallers in the follow-up or risk estimates). In case of absence of data, the authors of the selected studies were contacted.

Risk of Bias Assessment

Two authors (A.D. Lopes and M.R. Perracini) independently assessed all studies for quality using the Newcastle–Ottawa Scale, which was developed jointly by the University of Newcastle and the University of Ottawa to assess the quality of cohort studies. This instrument has been used since 2004 (Margulis et al., 2014) and is available in the supplementary material part of the Cochrane Handbook for Systematic Review of Interventions (Higgins & Green, 2011). The scale is composed of questions that address the subjects’ selection and comparability and the assessment of exposure (in cohort studies). To ascertain the assessment of study quality, a star system was used, such that the highest quality studies were awarded a maximum of one star for each item within the selection and exposure/outcome categories and two stars for comparability. The final score ranged from zero up to nine stars (Stang, 2010), providing a semiquantitative assessment. The instrument provides an analysis on the quality of the reporting of the study (Higgins & Green, 2011). A score of 7 points and over was considered as the cut point for high-quality studies (Bae, 2016).

Meta-Analysis

The pooled relative risk of being a faller (one or more falls over the follow-up) and being a recurrent faller (two or more falls over the follow-up) regarding the PA level (lowest vs. highest) was generated using a random-effects model, presented by two forest plots. Within each study, we used the number of fallers or recurrent fallers in each category of PA (expressed as relative risks and 95% confidence intervals [CIs]) for risk estimates. As different studies used different exposure categories (quarters or fifths or others), we used the study-specific number of fallers for the lowest versus highest categories of PA level, retaining three categories for all studies. Study authors were contacted to provide the number of fallers in each PA level. Heterogeneity among studies was evaluated using the $\chi^2$ test based on Cochrane’s Q test and $I^2$ statistic at the p < .10 level of significance, and quantification of heterogeneity was made by the $\hat{I}^2$ metric, which describes the percentage of total variation in point estimates that is due to heterogeneity rather than chance. We considered low, moderate, and high degrees of heterogeneity to be $\hat{I}^2$ values of 25%, 50%, and 75%, respectively. All statistical analysis was conducted using Cochrane Collaboration’s Review Manager (version 5.1, London, England).

Results

Literature Search

Figure 1 shows the results of literature research and selection. We identified 15,309 articles. After we excluded duplicate records (5,884) and studies that did not fulfill the inclusion criteria (9,385), 14 articles remained for further evaluation of the full text. Of these, we excluded 10 articles as follows: Four articles used data from cohort studies, but the ascertainment of fall events was done retrospectively by asking the participants if they had fallen in the previous 12 months (Chan, Pang, Ee, Ding, & Choo, 1997; Heesch, Byles, & Brown, 2008; Jefferis et al., 2015; Mertz, Lee, Sui, Powell, & Blair, 2010). Three studies presented results based on physical performance instead of PA level (Denkinger et al., 2010; MacRae, Feltner, & Reinsch, 1994; Voukelatos et al., 2015), two studies did not involve community-dwelling older adults (Graafmans et al., 1996; Karinkanta, Kannus, Uusi-Rasi, Heinonen, & Sievänen, 2015), and one study did not present
sufficient data showing how PA was measured (Kramer et al., 2014).

Study Characteristics

The four selected studies are described in Table 1 and were published from 2007 to 2015 (Cauley et al., 2013; Chan et al., 2007; Klenk et al., 2015; Peeters et al., 2010). The study with the smallest sample had 1,214 participants (Klenk et al., 2015), and the largest one had 5,995 participants (Chan et al., 2007); all of the studies were conducted with people aged 65 years and older who lived in a community. The follow-up period ranged from 12 to 36 months. Two studies measured PA level using accelerometers (Cauley et al., 2013; Klenk et al., 2015), and two used reliable and valid questionnaires (Chan et al., 2007; Peeters et al., 2010). These questionnaires were the Longitudinal Aging Study Amsterdam (LASA; Stel et al., 2004) and the Physical Activity Scale for the Elderly (PASE; Washburn, Smith, Jette, & Janney, 1993). The PASE is a 12-item questionnaire that includes leisure, household, and occupational activities with different intensities, varying from light to heavy. Leisure activities include sport and recreational activity, exercise to improve or maintain muscle strength, and walking outside the home. Household activities comprise housework, home repair, lawn work, outdoor gardening, and caring for another person (Washburn, Smith, Jette, & Janney, 1993). The PASE score is derived from multiplying the amount of time spent in each activity (less than 1 hr, 1 hr but less than 2 hr, 2–4 hr, or more than 4 hr/day over a 7-day period) by the respective weights and summing over all activities, varying from 0 to 793, with higher scores indicating a greater PA level. The LASA is an interviewer-mediated questionnaire that includes walking outside, cycling, light and heavy household work, and a maximum of two sports (Stel et al., 2004). LASA output is the Frequency × Duration in Minutes × Metabolic Equivalents (METs) over 14 consecutive days (min/day × METs).

Of the studies with accelerometers, one used a biaxial device (Cauley et al., 2013) and the other used a uniaxial device (Klenk et al., 2015), and in both of them, the participants wore the accelerometer for 7 days. The difference between them is that one considered the total energy expenditure in kilocalories per day (Cauley et al., 2013) and the other considered the time spent lying, standing, sitting, and walking (Klenk et al., 2015).

Risk of Bias Assessment

Quality assessment was conducted using the Newcastle–Ottawa Scale. Three studies were rated 7 points (Cauley et al., 2013; Chan et al., 2007; Peeters et al., 2010), and one study was rated 8 points (Klenk et al., 2015). All studies were rated ≥7 points and were considered to be of high quality (Bae, 2016), as shown in Table 2. Although two studies used data from the Osteoporotic Fractures in Men (MrOS) Study (Cauley et al., 2013; Chan et al., 2007)
Table 1  Characteristics of the Selected Studies

<table>
<thead>
<tr>
<th>Study</th>
<th>Population characteristic</th>
<th>Follow-up time</th>
<th>Falls assessment (outcome)</th>
<th>PA assessment (exposure)</th>
<th>Results</th>
</tr>
</thead>
<tbody>
<tr>
<td>Chan et al. (2007), United States</td>
<td>MrOS 5,995 participants</td>
<td>54 months</td>
<td>Questionnaire mailed every 4 months, based on self-report</td>
<td>PASE Questionnaire (previous week)</td>
<td>Fourth quartile (more active) RR = 1.14, 95% CI [1.03, 1.25]</td>
</tr>
<tr>
<td></td>
<td>(100% males, ≥65 years)</td>
<td></td>
<td>Outcome = any fall (≥1) Falls definition not reported</td>
<td>PA outcome = score in hours per week × activities’ weight in quartiles Lowest = ≤100.0 Highest = ≥142.0</td>
<td>Increased risk for fall with ↓ level of self-reported PA ↓ leg power consistent ↑ risk of falls</td>
</tr>
<tr>
<td></td>
<td>Mean age = 73.7 years</td>
<td></td>
<td></td>
<td></td>
<td>↑ of the time to recurrent falling with ↑ in PA of 100 units (HR = 0.93, 95% CI [0.90, 0.97])</td>
</tr>
<tr>
<td></td>
<td>(SD = 5.9)</td>
<td></td>
<td></td>
<td></td>
<td>U-shaped relation between PA and fall or recurrent fall not confirmed</td>
</tr>
<tr>
<td>Peeters et al. (2010), The Netherlands</td>
<td>LASA 1,342 participants</td>
<td>36 months</td>
<td>Falls calendar collected each 3 months Outcome = any fall (occasional faller) and two or more falls within 6 months over follow-up (recurrent faller) Falls definition reported</td>
<td>LA SA PA Questionnaire, amount of PA in the last 2 weeks PA outcome = minutes spent per activity per day (min/day × METs) Lowest = ≤400 min/day × METs Highest = ≥800 up to 2,000 min/day × METs</td>
<td>≥80 years ↑ risk of falls at ↑ activity level and ↑ sedentary activity Confirmed interaction between PA and risk of falls</td>
</tr>
<tr>
<td></td>
<td>(51.3% females and 48.7% males, ≥65 years)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Mean age not reported</td>
<td></td>
<td></td>
<td></td>
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</tr>
<tr>
<td>Cauley et al. (2013), United States</td>
<td>MrOS 2,731 participants</td>
<td>12 months</td>
<td>Questionnaire mailed every 4 months Outcome = one fall (single fallers) and two or more falls (recurrent fallers) Falls definition not reported</td>
<td>Accelerometer (biaxial) used during 7 days PA outcome = total EE in kcal/day (EE) in quintiles Lowest = &lt;1975.0 kcal/day Highest = ≥2,201.6 kcal/day</td>
<td>No association between PA level and falls</td>
</tr>
<tr>
<td></td>
<td>(100% males, ≥65 years)</td>
<td></td>
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<td></td>
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</tr>
<tr>
<td></td>
<td>Mean age = 78.9 years</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>(SD = 5.1)</td>
<td></td>
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<tr>
<td>Klenk et al. (2015), Germany</td>
<td>ActiFE Ulm study 1,214 participants</td>
<td>13 months</td>
<td>Weekly falls calendar collected monthly Telephone calls to check incomplete or missing information Outcome = falls per person per year Falls definition not reported</td>
<td>Accelerometer (uniaxial) used during 7 days (5 or more complete days of data) PA outcome = time spent in lying, standing, sitting, and walking in minutes per day, categorized as: 0–59 min, 60–119 min, ≥120 min Lowest = ≤59 min/day Highest = ≥120 min/day</td>
<td>No association between PA level and falls</td>
</tr>
<tr>
<td></td>
<td>(57% females and 43% males, ≥65 years)</td>
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<tr>
<td></td>
<td>Mean age = 75.6 years</td>
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<tr>
<td></td>
<td>(SD = 6.49)</td>
<td></td>
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</tbody>
</table>

Note. MrOS = The Osteoporotic Fractures in Men Study; LASA = Longitudinal Aging Study Amsterdam; ActiFE Ulm = The Activity and Function in the Elderly in Ulm Study; PASE = Physical Activity Scale for the Elderly; CI = confidence interval; PA = physical activity; RR = risk ratio; HR = hazard ratio; EE = energy expenditure.

that included community-dwelling older adults living in six geographically and ethnically diverse sites in the United States, the sample was restricted to men, and for this reason we considered them as not being fully representative. All studies included older adults with a previous history of falls in the baseline, failing to demonstrate that the outcome of interest was not present at the start of investigation and was rated as “no” in this item. We considered that a proper design to attribute risk should exclude those people with an increased risk related to the outcome of interest. Peeters et al. (2010) did not include the history of previous fall events as a covariate, which we considered as the most important factor to be controlled, because a previous fall event increases the risk of falling and may be considered an important confounder.

PA Levels (Lowest vs. Highest) and Risk of Falling Over the Follow-Up

Four comparisons, from four studies with 7,927 participants and 1,446 events within the lowest PA category and 2,447 events within the highest category of PA, indicated that there is no association between PA level and falls (RR = 1.05; 95% CI [0.93, 1.18]). We saw moderate heterogeneity among studies ($I^2 = 70\%$, $p = .02$; Figure 2).

**PA Levels (Lowest vs. Highest) and Risk of Recurrent Falling Over the Follow-Up**

Pooled risk ratio (RR) values (Figure 3), using two comparisons, from two studies with 2,420 participants and 258 events within the lowest PA category and 248 events within the highest PA category, indicate a higher risk of recurrent falling among those older adults in the lowest PA category (RR = 1.39; 95% CI [1.17, 1.65], $p < .001$). We saw no heterogeneity among studies ($p = .43$, $I^2 = 0\%$).

**Discussion**

In this systematic review, we identified four high-quality, cohort prospective studies that explored the relationship between general PA level and the risk of falls in community-dwelling older adults. In this meta-analysis, the risk of falling recurrently was 39% higher...
### Table 2  Methodological Quality Assessment of the Studies According to the Newcastle Ottawa Scale

<table>
<thead>
<tr>
<th>Authors (year)</th>
<th>Representativeness of the exposed cohort</th>
<th>Selection of the nonexposed cohort</th>
<th>Ascertainment of exposure</th>
<th>Outcome of interest was not present at the start of study</th>
<th>Control for the most important factor</th>
<th>Control for additional factors</th>
<th>Assessment of outcome</th>
<th>Follow-up long enough</th>
<th>Adequacy of follow-up of cohorts</th>
<th>Total score</th>
</tr>
</thead>
<tbody>
<tr>
<td>Chan et al. (2007)</td>
<td>No</td>
<td>Yes</td>
<td>Yes</td>
<td>No</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>7/9</td>
</tr>
<tr>
<td>Peeters et al. (2010)</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>No</td>
<td>No</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>7/9</td>
</tr>
<tr>
<td>Cauley et al. (2013)</td>
<td>No</td>
<td>Yes</td>
<td>Yes</td>
<td>No</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>7/9</td>
</tr>
<tr>
<td>Klenk et al. (2015)</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>No</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>8/9</td>
</tr>
</tbody>
</table>
in those older adults at the lowest PA level. However, the association between any fall and PA level was inconclusive. Different instruments were used to capture the PA levels, resulting in a nonuniformity of PA units, and a dose–response analysis could not be conducted, hindering the estimation of the amount of PA needed to prevent recurrent falls. This is the first systematic review with only prospective cohort studies that investigated the association between PA level and risk of falling in community-dwelling older adults.

This review was conducted with a large number of participants from robust population-based and longitudinal studies. Although two of them were from the same MrOS cohort study (Cauley et al., 2013; Chan et al., 2007), they were conducted at different periods of time and used two distinct instruments to ascertain PA level. Nearly all key points to ascertain falls were covered in the included studies (Lamb et al., 2005). Falls were closely monitored using prospective registration systems, such as calendars, questionnaires, and telephone calls, and the follow-up period was long enough to identify those older persons who sustained falls. However, the definition of a fall was clearly reported only in one study.

Regarding PA exposure, only two studies used accelerometers that are recognized as a reliable objective measure in PA estimation in older adults (Gorman et al., 2014; Murphy, 2009). Although the correlation between questionnaires and accelerometer variables is usually around 30% in people 65 years and older (Skender et al., 2016), the fact that we compared those who were in the lowest PA level with those at the highest level lessens the possible impact of PA inconsistency between these two.

Although all studies were rated as being of high quality, we considered that they failed to demonstrate that the outcome of interest was not present at the start of the investigation. This decision may be arguable, based on the fact that a representative population of older adults generally is composed of nearly 30% of older adults who had sustained a fall in the previous year. However, we assumed that the accumulated effect of a previous fall increased significantly the risk of falling in the subsequent year. A history of at least one fall and a history of one or more falls in the year prior to baseline are associated with an increased risk of at least one fall (Likelihood ratio \( LR = 2.8 \); 95% CI \([2.1, 3.8]\)) and two or more falls (LR range \(=2.3–2.4\)) in the next year, respectively (Ganz, Bao, Shekelle, & Rubenstein, 2007). Not only a previous fall may cause mobility limitation, but the activity restriction induced by fear of falling may also contribute to a decrease in the amount of PA (Pereira, Baptista, & Infante, 2014), interfering in the estimation of risk (Navarro & Ancizu, 2009).

Over the past decades, extensive prospective studies have shown that a low PA level is associated with poor health outcomes (Perracini, Franco, Ricci, & Blake, 2017). Until now, only structured exercise programs have shown to be effective in preventing falls in community-dwelling older adults (Sherrington & Tiedemann, 2015). General light-intensity PA, such as walking, proved to be ineffective in reducing falls (Voukelatos et al., 2015). Although walking is commonly the exercise of choice for improving fitness among older adults (Voukelatos et al., 2015), its inefficacy in preventing falls suggests that it may not be challenging enough to produce balance improvement. One possible explanation is that safe mobility would be improved by walking training delivered within a task-oriented motor skill approach (VanSwearingen & Studenski, 2014), which should include supervised complex problem-solving walking exercises.

The association between PA level (lowest vs. highest) and falling (any fall) was inconclusive. We plotted the number of fallers in each category, regardless of the instrument used to capture PA level. We were particularly interested in comparing those most active with those less active regarding risk of falls. We plotted the number of fallers in each category, regardless of the instrument used to capture PA level. We were particularly interested in comparing those most active with those less active regarding risk of falls, despite PA intensity and characteristics (leisure, household, transportation, or other). This uncertain result might be explained by the fact that other factors, such as age, mobility disability, and perceived risk of falls can influence the interrelationship between PA and risk of falling. A higher risk of falling was observed in younger men.
(<80 years of age) at greater levels of activity (Cauley et al., 2013). Older adults with a low physiological risk for falling with some level of disability doing no planned PA or 4 or more hours of planned PA per week were found to be at greater risk of falls compared with those who did some exercise (<4 hr/week; Delbaere et al., 2010). Jeffersis et al. (2015) observed that for those men who did not have mobility problems and were most active, representing 10% of the study sample (>9,000 steps/day), there was a steeper increase in the number of falls. Similarly, Chan et al. (2007) observed that high levels of PA were associated with high risk of falls, even in men with good leg power. These studies suggested that older men without mobility problems would take risky behaviors and consequently would be more exposed to fall circumstances. It is also likely that because of their greater level of PA, even if the rate of risky activities undertaken were the same, they may sustain a higher number of falls. This would be the case when falls during walking is considered. A measure expressing risk related to exposure time—for instance, risk of falling per kilometer walked—would be very useful (Klenk et al., 2015). Ultimately, active older adults may present a wide spectrum of mobility skills and limitations that interplay with the relationship between risk of falling and PA level.

By contrast, older adults with lower PA levels tend to be frailer and have multiple dysfunctions that compromise the control of balance and increase substantially the risk of falling. In this meta-analysis, we observed an increased risk of recurrent falling in older adults in the lowest level of PA when compared with those at the highest level. Wijlhuizen, de Jong, and Hopman-Rock (2007) suggest that these older persons adopt a behavioral mechanism to remain in control of their balance as they experience increased difficulty in controlling balance. Lowering PA would reduce the demands on their balance control as a short-term strategy; however, in the long run, lower levels of PA would decrease neuromotor skills and increase the risk of falling (Bauman et al., 2016).

Regarding gender, in this meta-analysis, two studies included only men (Cauley et al., 2013; Chan et al., 2007) and two studies included almost equally women and men, with a slightly increased number of women (Klenk et al., 2015; Peeters et al., 2010). Globally, many more women than men experience a higher prevalence of disability that is attributable to both a higher incidence and a longer duration of disability (Hardy, Allore, Guo, & Gill, 2008), exposing women to higher rates of falls and fall-related injuries (Rubenstein, 2006; Stevens & Sogolow, 2005). Compared with men, frequent falls in women does not affect their engagement in leisure activities and household work (Stahl & Albert, 2015). However, frequent fallsers, regardless of gender, significantly decrease their walking behavior and are less engaged in vigorous activities (Stahl & Albert, 2015). Consequently, we suggest that gender might have influenced our results, but to a lesser extent, particularly for recurrent falling, since we have compared only the lowest and highest PA levels, and the study that included men and women (Peeters et al., 2010) did not observe interactions between PA and gender, or physical performance or functional limitations.

Environmental factors such as weather, season, and green space may affect both PA levels (Moran et al., 2014; Sumukadas, Witham, Struthers, & McMurd, 2009; Witham et al., 2014) and risk of falling (do Nascimento, Duarte, Lebrao, & Chiavegatto Filho, 2017; Morency, Voyer, Burrows, & Goudreau, 2012) in older adults. However, only one study included in this meta-analysis conducted an adjustment for seasonal variability by geographic site (Chan et al., 2007).

Clinical Implications of the Results

Physical activity benefits are widely recognized; however, relatively few older adults, particularly those who are frail, have high levels of PA. Moreover, physiotherapists are key clinical practitioners who should recommend general PA increases in this population. Many factors may contribute to underprescription for incrementing PA in this population, such as poor knowledge about what constitutes an effective exercise intervention, a lack of relevant training and education, or inadequate descriptions of exercise interventions in published trials and reviews (Hoffmann et al., 2016). Our results highlight the need for keeping older adults highly active to avoid recurrent falls. However, the recognition of the multifactorial etiology of falls in this population indicates the necessity of addressing other important interventions, such as psychotropic medication withdrawal, cataract surgery, customized insoles, foot and ankle exercises for disabling foot pain, and home safety interventions (Gillespie et al., 2012).

Strengths and Limitations

Compared with a previous meta-analysis (Thibaud et al., 2011) that was mostly based on cross-sectional studies, on limited measures of PA, and on retrospective methods of ascertaining fall events, the strength of our study is that we selected only prospective studies with a specific and objective measurement of PA. Although a large number of participants were included in our meta-analysis, a small number of studies were included.

In interpreting the results, several limitations of this meta-analysis should also be acknowledged. First, although we have included only cohort studies that monitored falls closely, we cannot exclude the possibility of a recall bias. Second, although the construct of lowest and highest PA levels was assumed with plausibility, the comparability between studies is restricted because different instruments were used to ascertain PA levels and different PA distributions (tertiles, quartiles, and quintiles) were used.

Conclusion

In summary, this meta-analysis suggests that the risk of falling recurrently is higher among those who are at the lowest PA levels, reinforcing the benefit of being active. The relationship between falls (any fall) and PA levels is still inconclusive. Further large cohort studies using objective PA sensors should be conducted to estimate the dose response of overall PA to prevent falls.

References


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Ganz, D.A., Bao, Y., Shekelle, P.G., & Rubenstein, L.Z. (2007). Will my study of risk factors and risk pro...


Appendix. Search Strategy for MEDLINE via PubMed Database

(1) Old (er) adult (s)
(2) Old (er) people
(3) Senior (s)
(4) Elderly
(5) Elder
(6) Aged
(7) OR/ 1–7
(8) Fall (s)
(9) Accidental Fall (s)
(10) Faller (s)
(11) Falling (s)
(12) OR/ 8–12
(13) Physical activity (ies)
(14) activity (ies) physical
(15) energy expenditure (s)
(16) expenditure (s) energy
(17) exercise
(18) physical exertion
(19) physical fitness
(20) physical endurance
(21) sports
(22) pliability
(23) exertion*
(24) exercis*
(25) sport*
(26) fitness
(27) physical endur*
(28) jog*
(29) swim*
(30) bicycli*
(31) cycle
(32) cycling
(33) walking
(34) row(s)
(35) rowing
(36) weight train
(37) muscle strength
(38) yoga
(39) tai chi
(40) ai chi
(41) vibration
(42) pilates
(43) OR/ 13–43
(44) 13/43
(45) risk factor
(46) risk factors
(47) relative risk(s)
(48) incidence
(49) exposure
(50) likelihood
(51) numerical data
(52) odds ratio
(53) inciden*
(54) rate(s)
(55) OR/ 45–54
(56) AND/ 7,12,44,55