Effectiveness of Training Programs in Reducing Falls in Older Adults: Systematic Review

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ARTICLE INFO

Received: January 31, 2021
Published: March 12, 2021

Citation: Alexandre S S, José Jonas de Oliveira, Geovani S A, Jenifer CS Nascimento, Anna Gabriela SV Ribeiro, et al., Effectiveness of Training Programs in Reducing Falls in Older Adults: Systematic Review. Biomed J Sci & Tech Res 34(3)-2021. BJSTR. MSID.005564.

Keywords: Risk of Falling; Older Adults; Training Program; Balance

ABSTRACT

Background: With ageing, older adults are faced with decreasing strength and balance and increasing risk for falls. A fall followed by fracture is a factor in mortality and decreased quality of life in older people. However, few systematic review studies have analyzed the effects of training programs in reducing falls in older people.

Aim: This systematic review study aimed to analyze the effects of physical training programs on the risk of falls in older people.

Methods: We used the PRISMA guidelines in conducting the systematic review. The search for eligible studies was performed using four electronic databases (PubMed, BVS Regional Portal, British Library, and Library of Congress).

Results: The results showed a decrease in the risk of falling in 21 studies. Only four studies did not show a reduction in the risk of falling after a training program.

Conclusion: Combined or multicomponent training programs, as well as isolated strength training, could decrease the risk of falling in older people.

Core Tip

Regular and systematic physical exercises can contribute in a comprehensive way to the healthy ageing process by helping increase muscle strength, bone mineral density (hip and spine), and static and dynamic balance, ultimately decreasing the risk of falling. However, controversial results have been observed, with some studies indicating no improvement, especially in the risk of falls in older adults. Thus, the characteristics of the different physical exercise programs must be investigated. Research should discern which types of exercise reduce the risk of falling in the older adults. Thus, this systematic review study aimed to analyses the effects of physical training programs on the risk of falls in older adults.

Introduction

The global projection is that by 2050, the number of older people will increase exponentially, surpassing the number of children under 14 years old [1]. As people age, changes in muscle and bone mass can be observed, as well as reduction in the capacity to produce strength, which impacts the activities of daily living. Thus, regular physical activities can delay marked physiological losses. Falls followed by fractures are recurrent among older adults, attributable to muscle instability and bone fragility [2,3]. Changes in the sensory and motor systems also become present, and these cause postural instability, which can increase the risk of falling. Falls in older people represent a major public health problem, associated with a worsening quality of life and increased mortality [4]. In Brazil, about one-third of older adults experience at least one fall per year; and the more advanced the age, the greater the risk. Women are affected in greater proportion, as they are more sensitive to changes inherent to ageing, such as hormonal changes,
which increase the incidence of sarcopenia and osteoporosis and make them more susceptible to falling [5].

Another factor associated with the risk of falling is the level of dependency of older adults, which can reach up to 14 times that of those with a high level of independence [6]. Regular and systematic physical exercises can contribute in a comprehensive way to the healthy ageing process by helping increase muscle strength, bone mineral density (hip and spine), and static and dynamic balance, ultimately decreasing the risk of falling [4,7,8].

However, controversial results have been observed, with some studies indicating no improvement, especially in the risk of falls in older adults [9-12]. Thus, the characteristics of the different physical exercise programs must be investigated. Research should discern which types of exercise reduce the risk of falling in the older adults, for example, isolated (strength, aerobic, and balance) or combined (balance/strength, aerobic/balance/strength, aerobic/balance, and aerobic/strength). Thus, this systematic review study aimed to analyses the effects of physical training programs on the risk of falls in older adults.

Materials and Methods

Search Strategy

For the review study, we adhered to the guidelines for systematic reviews (PRISMA) Moher, et al. [13]. The search for eligible studies was carried out using four electronic databases (PubMed, BVS Regional Portal, British Library, and Library of Congress) until October 2019, without language restrictions. The terms used for the search were as follows: the search strategy combined terms covering the topics of population: (resistance training OR strength training) AND (balance training) AND (older OR elderly OR older adults) AND (risk of falling). The search was carried out using combinations of the following terms linked with Boolean operators “AND” (inter-group Boolean operator) and “OR” (intra-group Boolean operator). Duplicate studies were removed. Three independent researchers analyzed titles and abstracts and then selected the articles relevant to the research.

Eligibility Criteria

Articles that met the following inclusion criteria were selected:

(1) Original study;
(2) Providing a description of the training program;
(3) Having at least one of the following tests as a method of evaluation: Balance Evaluation System Test, Timed Up and Go Test, Six Minute Walk Test, Sit To Stand Test, Falls Efficacy Scale-International, Posturografía estática BioRescue, Functional Reach Test, and Berg Balance Scale;
(4) Randomised clinical trials;
(5) Published in peer-reviewed scientific journals; and
(6) Studies evaluating the effects of training programs on the risk of falls in older adults.

The exclusion criteria were as follows:

(1) Review articles;
(2) Abstracts of unpublished conference papers and studies; and
(3) No protocol for assessing balance or risk of falling.

According to the inclusion and exclusion criteria, 19 studies were excluded. The studies were evaluated in their entirety by two reviewers. Disagreements were decided by consensus, and when necessary, with the participation of a third reviewer. Eligible study references were also analyzed to identify other relevant studies.

Data Extraction

Independently, the same two reviewers extracted the following data from each selected study: name of the first author, year of publication, research title, age group (years), balance test, type of exercise used in the training program, weekly frequency of the training program, intensity and duration of the training program, training period in months, completion of the study, and periodicals in which the studies were published.

Evaluation of Methodological Quality of Studies

The quality evaluation of the eligible studies was carried out by two independent reviewers, with doubts resolved by consensus, and with the participation of a third reviewer when no consensus could be reached. The Physiotherapy Evidence Database (PEDro) scale was used to assess randomised clinical trials. The instrument consists of 11 items, the first of which is not computed in the final score. Thus, the scale has a score from 0 to 10 [14].

Results

Study Selection

From the electronic databases (PubMed, BVS Regional Portal, British Library, and Library of Congress), 17727 studies were found. After removing the duplicates, 17610 remained. After the selection based on titles and abstracts, 44 complete articles remained. Of these, 25 were selected and used in the present work, as shown in Figure 1.
Figure 1: Organization of articles reviewing the effects of training programs on the risk of falls in the elderly. PRISMA 2009 flow diagram. Adapted from Moher, et al. [13].

Study Characteristics

Table 1 presents the general characteristics and results of studies that analyzed the effects of training programs on the risk of falls in older adults. The analyzed studies were published between 2008 and 2019, including a total of 2229 people. The studies were conducted in Australia [15], Brazil [4,10,16-18], Canada [19], China [20], Finland [21], Germany [22], Hungary [23], India [24], Iran [25], Japan [11], Portugal [7,26], Republic of Korea [27], Spain [12,28], Switzerland [29], and the United States [9,30-33]. Eight studies were identified as using a combination of balance and strength exercises [4,16,17,19,21,22,24,29]; three studies using a combination of aerobic exercises, balance, and strength [7,9,28]; six studies using strength exercises [15,20,25,27,30,33]; one study using a combination of aerobic and strength exercises [10]; one study using aerobic exercises [12]; four studies using balance exercises [11,23,31,32]; and two studies using balance and strength exercises separately [18,26]. A reduction in the risk of falling was observed in 21 studies [4,7,15-33]. In four studies, training programs did not show a reduction in the risk of falling [9-12]. To evaluate the risk of falling in the older population, 16 studies used the Timed Up and Go Test [4,7,9,11,12,15-22,25,26,29]. Some studies opted for other tests to assess the risk of falling, such as the Balance Evaluation System Test [28], Six Minute Walk Test [30,33], Sit-to-Stand [10], Falls Efficacy Scale-International [31], Posturografia estática BioRescue [27], Functional Reach Test [24], and Berg Balance Scale [23,32].
Table 1: Results of studies of training programs’ effects (n= 25) on the risk of falls in older adults.

| Nº | Author(s) | Title                                                                 | Age (y) | Method of Evaluation | Training Program (Protocol) | Weekly Frequency | Intensity and Duration | Period in Week | Conclusion Regarding Risk of Falls | Journal                      |
|----|------------|----------------------------------------------------------------------|---------|----------------------|----------------------------|------------------|------------------------|---------------|-------------------------------------|------------------------------|
| 1  | Teixeira et al. [4] | Progressive load training for the quadriceps muscle associated with proprioception exercises for the prevention of falls in postmenopausal women with osteoporosis: a randomized controlled trial | 55 - 75 | TUG                  | Combination of balance and strength exercises | -                | moderate-to-high-intensity 60 min | 4.5           | Reduced the risk of falling | Osteoporos Int                |
| 2  | Sousa et al. [7] | Combined exercise is more effective than aerobic exercise in the improvement of fall risk factors: a randomized controlled trial in community-dwelling older men | 65 - 79 | TUG                  | Combination of aerobic exercises and balance | 3                | moderate-to-high-intensity 60 min | 8             | Reduced the risk of falling | Clinical Rehabilitation      |
| 3  | Cancela et al. [9] | Effects of Three Different Chair-Based Exercise Programs on People Older Than 80 Years | >80     | TUG                  | Aerobic exercises, Balance, and Strength exercises | 3                | Low-to-moderate-intensity 60 min | 3             | Did not reduce the risk of falling | Rejuvenation Research          |
| 4  | Ansai et al. [10] | Effects of two physical exercise protocols on physical performance related to falls in the oldest old: A randomized controlled trial | >80     | Sit-to-stand        | Combination of aerobic and strength exercises | 3                | moderate-to-high-intensity 60 min | 4             | Did not reduce the risk of falling | Geriatrics Gerontology        |
| 5  | Hiyamizu et al. [11] | Effects of dual task balance training on dual task performance in elderly people: a randomized controlled trial | >65     | TUG                  | Balance exercises | 2                | Low-to-moderate-intensity 60 min | 12            | Did not reduce the risk of falling | Sage Journals - Clinical Rehabilitation |
| 6  | Varela et al. [12] | Effects of two different intensities of aerobic exercise on elderly people with mild cognitive impairment: a randomized pilot study | >79     | TUG                  | Aerobic exercises | 3                | Low-to-moderate-intensity 60 min | 12            | Did not reduce the risk of falling | Sage Journals - Clinical Rehabilitation |
| 7  | Daly et al. [15] | Effectiveness of dual-task functional power training for preventing falls in older people: study protocol for a cluster randomised controlled trial | >64     | TUG                  | Strength exercises | 2                | moderate-to-high-intensity 45-60 min | 18            | Reduced the risk of falling | BMC Research                  |
| No. | Authors et al. | Study Title | Age (yr) | Test | Training Type | Intensity | Time (min) | Results | Journal |
|-----|---------------|-------------|---------|------|---------------|----------|-----------|---------|---------|
| 8   | Bohrer et al. [16] | Multicomponent training program with high-speed movement execution of ankle muscles reduce risk of falls in older adults | >69 | TUG | Combination of balance and strength exercises | Low-to moderate-intensity | 45 | Reduced the risk of falling | Rejuvenation Reserarch |
| 9   | Pirauà et al. [17] | Effect of 24 week strength training on unstable surfaces on mobility, balance, and concern about falling in older adults | >68 | TUG | Combination of balance and strength exercises | Moderate intensity | 60 | Reduced the risk of falling | Scandinavian Journal of medicine e Science in Sports |
| 10  | Alfieri et al. [18] | Functional mobility and balance in community-dwelling elderly submitted to multisensory versus strength exercises | 60 - 75 | TUG | Balance and strength exercises separately | Moderate-to high-intensity | 60 | Reduced the risk of falling | Clin Interv Aging |
| 11  | Liu-Ambrose et al. [19] | Otago Home-Based Strength and Balance Retraining Improves Executive Functioning in Older Fallers: A Randomized Controlled Trial | >70 | TUG | Combination of balance and strength exercises | Low-to moderate-intensity | 60 | Reduced the risk of falling | Journal of the American geriatrics society |
| 12  | Yamada et al. [20] | Effect of resistance training on physical performance and fear of falling in elderly with different levels of physical well-being | >65 | TUG | Strength exercises | Moderate-to high-intensity | 60 | Reduced the risk of falling | Oxford Journal - Age and Ageing |
| 13  | Aartolahti et al. [21] | Long-term strength and balance training in prevention of decline in muscle strength and mobility in older adults | >76 | TUG | Combination of balance and strength exercises | Moderate intensity | 75 | Reduced the risk of falling | Aging Clinical and Experimental Research |
| 14  | Lacroix et al. [22] | Effects of a Supervised versus an Unsupervised Combined Balance and Strength Training Program on Balance and Muscle Power in Healthy Older Adults: A Randomized Controlled Trial | 65-80 | TUG | Combination of balance and strength exercises | Moderate-to high-intensity | 60 | Reduced the risk of falling | Gerontology |
| 15  | Miko et al. [23] | Effectiveness of balance training programme in reducing the frequency of falling in established osteoporotic women: A randomized controlled trial | >65 | Berg Balance Scale | Balance exercises | Low-to moderate-intensity | 30 | Reduced the risk of falling | Sage Journals - Clinical Rehabilitation |
| 16  | Joshua et al. [24] | Effectiveness of Progressive Resistance Strength Training Versus Traditional Balance Exercise in Improving Balance Among the Elderly - A Randomized Controlled Trial | >65 | Functional reach test | Balance, strength and combination of balance and strength exercises | Low-to moderate-intensity | 30 | Reduced the risk of falling | Journal of Clinical & Diagnostic Research |
| Study | Authors | Design | Participants | Intervention | Duration | Exercise Intensity | Outcomes | Additional Context |
|-------|---------|--------|--------------|-------------|----------|-------------------|----------|--------------------|
| 17 | Motalebi et al. [25] | Effect of low-cost resistance training on lower-limb strength and balance in institutionalized seniors | >64 | TUG | Strength exercises | 2 | Low-to-moderate intensity 50 min | 3 | Reduced the risk of falling | Experimental Aging Research |
| 18 | Marques et al. [26] | Multicomponent Training Program with Weight-Bearing Exercises: Elicits Favorable Bone Density, Muscle Strength, and Balance Adaptations in Older Women | >68 | TUG | Balance and strength exercises separately | 2 | Low-to-moderate intensity 60 min | 32 | Reduced the risk of falling | Calcified Tissue International |
| 19 | Lee et al. [27] | Balance Improvement by Strength Training for the Elderly | >69 | Posturografía estática BioRescue | Strength exercises | 2 | moderate-to-high-intensity 60 min | 12 | Reduced the risk of falling | Journal of Physical Therapy |
| 20 | Seco et al. [28] | A long-term physical activity training program increases strength and flexibility and improves balance in older adults. | >65 | Balance Evaluation Systems Test | Combination of aerobic exercises, balance, and strength exercises | 3 | Low-to-moderate intensity 50-55 min | 9 | Reduced the risk of falling | Rehabilitation Nursing Journal |
| 21 | Gschwind et al. [29] | A best practice falls prevention exercise program to improve balance, strength, power, and psychosocial health in older adults: study protocol for a randomized controlled trial | 65-80 | TUG | Combination of balance and strength exercises | 3 | Low-to-moderate intensity 30 min | 3 | Reduced the risk of falling | BMC Geriatrics |
| 22 | LaStayo et al. [30] | Eccentric versus traditional resistance exercise for older adult fallers in the community: a randomized trial within a multi-component fall reduction program | >65 | 6MW | Strength exercises | 3 | moderate-to-high-intensity 60 min | 3 | Reduced the risk of falling | BMC Geriatrics |
| 23 | Halvarsson et al. [31] | Long-term effects of new progressive group balance training for elderly people with increased risk of falling - a randomized controlled trial | >80 | Falls Efficacy Scale Internacional | Balance exercises | 3 | Low-to-moderate intensity 60 min | 12 | Reduced the risk of falling | Sage Journals - Clinical Rehabilitation |
| 24 | Jacobson et al. [32] | Independent static balance training contributes to increased stability and functional capacity in community-dwelling elderly people: a randomized controlled trial | >80 | Berg Balance Scale | Balance exercises | 3 | Low-to-moderate intensity 60 min | 12 | Reduced the risk of falling | Sage Journals - Clinical Rehabilitation |
| 25 | Sparrow et al. [33] | Increases in Muscle Strength and Balance Using a Resistance Training Program Administered Via a Telecommunications System in Older Adults | 50-94 | 6MW | Strength exercises | 3 | moderate-to-high-intensity 60 | 12 | Reduced the risk of falling | Oxford Journals |
Quality Assessment of Studies

The studies evaluated by the PEDro scale presented an average score of 8.6 points. One study scored 6 points [12], seven studies scored 7 points [4,11,16,27,28,31,32], eight studies scored 8 points [9,10,19,21,23,24,29,30], one study scored 9 points [25], and eight studies scored 10 points [7,15,17,18,20,22,26,33] (Table 2).

Table 2: Assessment Study Quality Using the PEDro Scale for Randomized Clinical Trials.

| Items | Eligibility Criteria * | Random Allocation | Concealed Allocation | Similar at Baseline | Blinding Subjects | Blinding Therapists | Blinding Assessors | Adequate Follow-up | Intention to Treat Analysis | Between-Group Statistical Comparison | Point Estimate/Measure of Variability | Score Total |
|-------|------------------------|-------------------|----------------------|---------------------|-------------------|---------------------|---------------------|---------------------|-----------------------------|--------------------------------------|---------------------------|-------------|
| Teixeira et al. [4] | Y | Y | Y | Y | Y | Y | Y | Y | Y | 07-Oct |
| Sousa et al. [7] | Y | Y | Y | Y | Y | Y | Y | Y | Y | Y | 10-Oct |
| Cancela et al. [9] | Y | Y | Y | Y | Y | Y | Y | Y | Y | 08-Oct |
| Ansai et al. [10] | Y | Y | Y | Y | Y | Y | Y | Y | Y | Y | 08-Oct |
| Hiyamizu et al. [11] | Y | Y | Y | Y | Y | Y | Y | Y | Y | 07-Oct |
| Varela et al. [12] | Y | Y | Y | Y | Y | Y | Y | Y | Y | 06-Oct |
| Daly et al. [15] | Y | Y | Y | Y | Y | Y | Y | Y | Y | 07-Oct |
| Bohrer et al. [16] | Y | Y | Y | Y | Y | Y | Y | Y | Y | 07-Oct |
| Pirauá et al. [17] | Y | Y | Y | Y | Y | Y | Y | Y | Y | 07-Oct |
| Alfieri et al. [18] | Y | Y | Y | Y | Y | Y | Y | Y | Y | 10-Oct |
| Liu-Ambrose et al. [19] | Y | Y | Y | Y | Y | Y | Y | Y | Y | 08-Oct |
| Yamada et al. [20] | Y | Y | Y | Y | Y | Y | Y | Y | Y | 10-Oct |
| Aarto-Ilhiti et al. [21] | Y | Y | Y | Y | Y | Y | Y | Y | Y | 08-Oct |
| Lacroix et al. [22] | Y | Y | Y | Y | Y | Y | Y | Y | Y | 10-Oct |
| Miko et al. [23] | Y | Y | Y | Y | Y | Y | Y | Y | Y | 08-Oct |
| Joshua et al. [24] | Y | Y | Y | Y | Y | Y | Y | Y | Y | 08-Oct |
| Motalebi et al. [25] | Y | Y | Y | Y | Y | Y | Y | Y | Y | 09-Oct |
| Marques et al. [26] | Y | Y | Y | Y | Y | Y | Y | Y | Y | 10-Oct |
| Lee et al. [27] | Y | Y | Y | Y | Y | Y | Y | Y | Y | 07-Oct |
| Seco et al. [28] | Y | Y | Y | Y | Y | Y | Y | Y | Y | 07-Oct |
| Gschwind et al. [29] | Y | Y | Y | Y | Y | Y | Y | Y | Y | 08-Oct |
| LaStayo et al. [30] | Y | Y | Y | Y | Y | Y | Y | Y | Y | 08-Oct |
| Hahvarsson et al. [31] | Y | Y | Y | Y | Y | Y | Y | Y | Y | 07-Oct |
Sparrow et al. [33] | Y | Y | Y | Y | Y | Y | Y | Y | Y | Y | Y | 07-Oct

Y: Contemplated item.

*Item 1 does not contribute to the total score.

This systematic review analyzed the effects of training programs on the risk of falling in older adults. We mainly aimed to elucidate whether the risk of falling is positively affected by isolated or combined training programs, and thus contribute to the prevention of falls and reduction in the risk of mortality. Regular exercise influenced total daily physical activity and possibly induced chronic physiological adaptations. We observed that all studies that combined strength training programs with balance exercises reduced the risk of falling [4,16-19,21,22,24,26,29]. The same was seen in isolated strength training programs [15,20,24,25,27,30,33]. According to studies by Wolfson, et al. [34], Lord, et al. [35], and Howe, et al. [36], the findings of this review can in part be attributed to improvements in neuromuscular coordination by and “training specificity” of the programs applied in the studies cited here. However, positive effects on muscle mass, strength, composition, power, and torque production, as well as changes in the mechanical properties of the tendon, must be observed to explain the significant reduction in the risk of falling [37,38]. Balance training, as well as the evaluation of this variable, is considered an essential component of fall prevention programs [39].

The loss of balance is directly related to decreases in muscle mass, strength, and proprioception. According to Teixeira, et al. [4], a strength training program for the quadriceps combined with proprioception training can decrease the risk of falling in postmenopausal women, in addition to increasing strength and static and dynamic balance. Therefore, proprioception and strength exercises are of great importance in reducing the risk of falling in older adults. Sousa, et al. [7] found a decrease in the risk of falling after the aerobic and balance training program. The risk of falling also decreases when the strength protocol integrates aerobic and balance training [28]. However, Cancela, et al. [9] observed no decrease in the risk of falling after a strength, aerobic, and balance training program. Ansai, et al. [10], who used an aerobic and strength training program, likewise found no decrease. Both studies used samples of older adults over 80 years old. This age group has less organic adaptation, and the studies justified, in a respective way, the differences attributable to the short period of intention, application of light physical activity in a sitting position, and failure to monitor falls daily.

No reduction in the risk of falling was also found in Varela, et al. [12], who used isolated aerobic training in older adults with mild cognitive impairment. According to Xu, et al. [40], aerobic activities can improve balance and generates a positive effect on the proprioception of older adults, given that aerobic exercises decrease gait instability and can decrease degenerative processes in the nervous and muscular systems. As such, aerobic exercises can contribute to decreasing the risk of falls in older adults [41]. In studies that used isolated balance exercises, Jacobson, et al.[32], Håvarsson, et al. [31], and Miko, et al. [23] reported a decrease in the risk of falling. However, these results were not observed in Hiyamizu, et al. [11]. A plausible explanation regarding the divergent results is the lack of non-standardized protocols in the experiments. According to Thomas, et al. [42], training programs that offer an approach that includes resistance exercises, aerobic components, and proprioception work can improve balance and reduce the risk of falling in older adults. Falls are multifactorial events that may be related to intrinsic and extrinsic factors. The incidence of falls increases each year in the older population worldwide, with a positive relation between age and the increase in cases of falls.

Older adults can have several complications after a fall, such as fractures and head injuries; indeed, falls account for 11% of the mortality rate in this population [43-45]. Thus, increased mortality in older adults is related to physical inactivity [46]. Moreover, Thomas, et al. [42] reported that low-intensity exercises improve the balance of older adults and contribute to decreasing the risk of falling; adherence to moderate- to high-intensity training programs is less attractive, leading to lower adherence, especially in older adults. Based on the studies above, and in recognition of the importance and relevance of reducing falling risk for maintaining the quality of life and decreasing falls-related mortality in the older population, we propose that strength and aerobic training programs with proprioception exercises be recommended when and included in designing interventions. The strengths of this systematic review are that it was based on reliable results and full-text studies and it included high-quality papers. Meanwhile, the main limitation of this study is the lack of standardized assessment instruments for the risk of falling. Nonetheless, the instruments were validated and reliable, and thus, we chose to include all instruments.

**Conclusion**

This systematic review analyzed the effects of training programs on the risk of falls in older adults. Combined or multicomponent training programs, as well as isolated strength training, could decrease the risk of falling in older people. Further studies should standardize the protocols of training programs and assessment
instruments, to enable further analysis of the aspects that brings better benefits: whether it is the training program, the modality to be worked on, or the modulation of the variables in the training.

Implications for Practice

The findings, based on the studies analyzed, demonstrated the importance and relevance of physical training programs for decreasing the risk of falling in people and older adults. Therefore, strength and aerobic training programs are recommended, along with balance exercises, for older adults.

Author Contributions

Silva A designed the research; Andrade G, Nascimento J, Ribeiro A and Barbosa C performed the research; Silva A, Silva J and Oliveira J analyzed the data; Silva A, Oliveira J wrote the paper; Silva A, Pertille A, Silva J and Oliveira J supervised the paper; all authors read and approved the final manuscript.

PRISMA 2009 Checklist

The authors have read the PRISMA 2009 Checklist, and the manuscript was prepared and revised according to the PRISMA 2009 Checklist.

Acknowledgments

The authors would like to thank the Coordenação de Aperfeiçoamento de Pessoal de Nível Superior-Brasil (CAPES) for the financial support through scholarships. Finance Code 001.

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