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The effect of strengthening and balance programs on preventing falls in the elderly: A systematic review

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Abstract
Falls can occur at any age, however, older adults are more prone to falls because of the physiological changes which occur due to aging, but also because of delayed recovery caused by age. The purpose of this systematic review is to study the effectiveness of strengthening and balance improvement programs as well as the importance of these programs in the quality of life of the elderly.
Methods: The international databases PubMed, Springer Link, PEDro and Medline were searched with keywords in the English language: Strengthening AND balance exercises AND Elderly falls prevention. Clinical studies published in the last 9 years were selected.
Results: Six clinical studies were included in the review, applying a total of 524 elderly people. Most studies concluded that balance and strengthening programs have significant effects in preventing falls in the elderly, although one found that while there was an improvement in the musculature and combating musculoskeletal problems, no improvement in fall prevention was observed.
Discussion-Conclusions: From the results of this review it appears that the implementation of programs with strengthening and balance exercises has significant effects in reducing falls in the elderly. It was also observed that there is a considerable improvement in the quality of life and assistance in the independent living of the elderly. Therefore, strengthening and balance programs for the elderly are a safe and effective solution not only for preventing falls but also for recovery after a fall.

Keywords: Falls, elderly, strengthening, balance, physical therapy

Introduction
It stands to reason that falls can occur at any age; however, older adults are more prone to falls because of the physiological changes which occur due to aging, but also because of delayed recovery caused by age [1]. The scientific community is focusing on aging and more specifically on successful aging. The decline in fitness and cognitive abilities of the elderly causes a gradual decline in muscle strength, coordination and balance, increasing the likelihood of falling [2]. Balance is a complex variable related to postural control and the person's ability to maintain their posture, e.g., to sit or stand, to change positions in space and, most importantly, to perform basic daily activities [3].
Falls in the elderly are a global concern for health organizations because they dramatically reduce quality of life and significantly increase healthcare costs. A total of 28% to 35% of people over the age of 64 experience one or more falls a year. Globally, falls are the second leading cause of death connected to unintentional injuries [4]. The World Health Organization reports that 80% of fall-related deaths occur in low-to middle-income countries, with Western Pacific and Southeast Asian countries being responsible for 60% of fall-related deaths [4].
Physiotherapy has been proven to contribute to the reduction of falls and also to the decrease of the negative results that may arise from them [4-7]. Many interventions have been shown to reduce the fear of falling with multifactorial interventions including physical activities with strengthening and balance exercises but also behavioral interventions being more effective [8]. Behavioral interventions usually address strategies to free older adults from destructive thoughts and avoidant behaviors due to fear of falling, while physical activities aim to strengthen muscles and improve balance. However, multifactorial interventions are not always feasible or not always preferred by the elderly. Exercise interventions are perhaps the

most promising method as a unit as there is evidence of them reducing falls, improving gait and balance, but also increasing the ability to get up from a fall, while also improving mood. Through these mechanisms, exercise may reduce the fear of falling and allow more daily activities to be performed without falling, leading to a more positive assessment of the ability to maintain balance [9].

The purpose of this systematic review is to study the effectiveness of strengthening and balance improvement programs as well as the importance of these programs in the quality of life of the elderly.

Methods

The international databases PubMed, Springer Link, PEDro and Medline were searched. For the research of the articles, different combinations (Boolean operators) were used with the following keywords in the English language: Strengthening AND balance exercises AND Elderly falls prevention. The search was conducted from February to March 2022. Clinical studies published in the last 9 years (from 2013 onwards) were selected.

Results

From all the sources that appeared in our search, the titles and abstracts of the articles were initially evaluated, and then a thorough evaluation of the full texts was carried out. Six clinical studies were included in the review, applying a total of 524 elderly people. The study selection flow diagram is shown in Figure 1. Most studies concluded that balance and strengthening programs have significant effects in preventing falls in the elderly, although one found that while there was an improvement in the musculature and combating musculoskeletal problems, no improvement in fall prevention was observed. The characteristics of the sources included in this review are listed below while Table 1 summarizes the findings of each research.

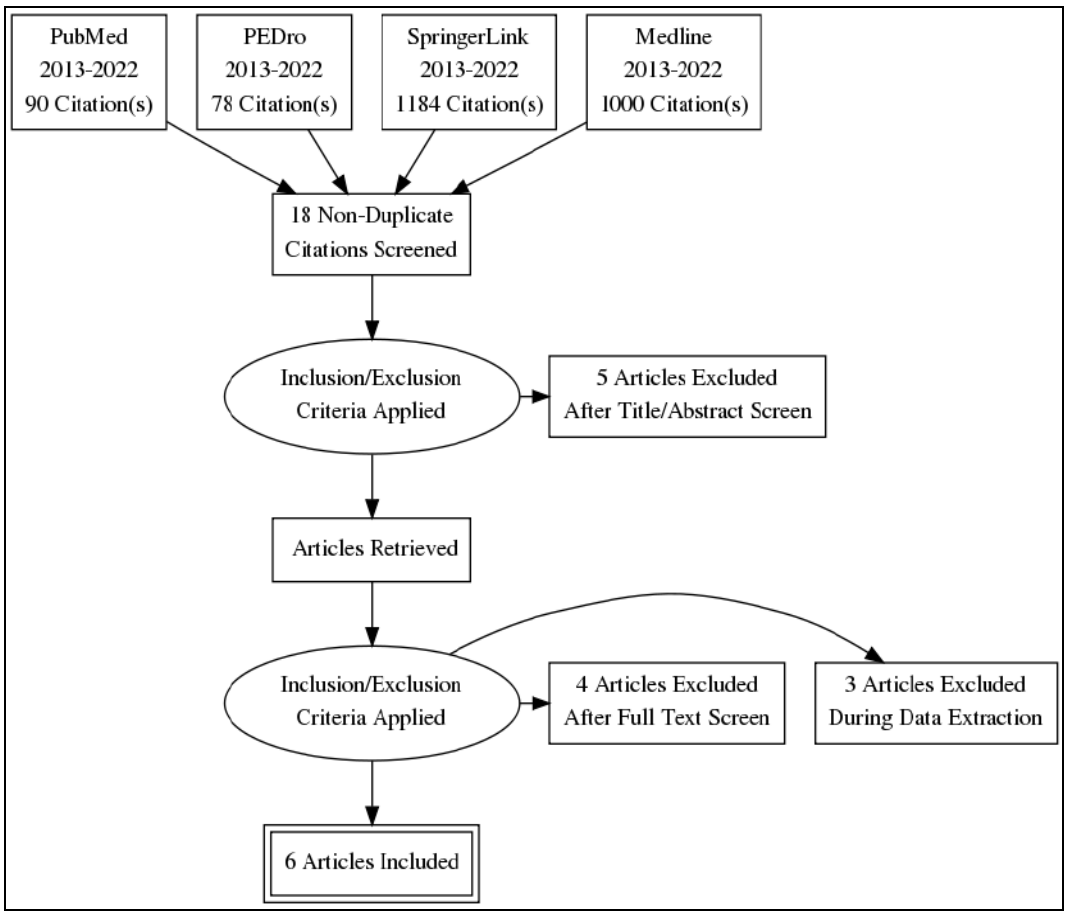

Fig 1: Identification of studies via databases

Table 1: Details of the included studies

Author, Year	Number of participants	Intervention time	Intervention	Outcome measures	Conclusions
Eckardt (2016)	75	10 weeks	1st group: resistance training with machines on stable surface 2nd group: with machines on an unstable surface 3rd group: with free weights on an unstable surface	• Falls efficacy scale-international • Muscle strength Isometric leg extension • Hand grip strength • Chair rise test • Chair rise test AIREX® • Stair ascent time • Stair descent time • Stair ascent power • Stair descent power • Proactive balance	Regardless of the training surface, all groups had significant lower extremity strengthening and balance improvement with the third group (F-URT) having the most effective program for preventing falls in the elderly.

				• Timed up and go test • Functional reach test • Functional reach test AIREX® • Dynamic steady-state balance • Stride velocity • Stride velocity CV • Stride length • Stride length CV • Stride width • Stride width CV • Double support • Double support CV Reactive balance	
Ansai *et al*. (2016)	69	16 weeks	1st: Control group 2nd: Multi-exercise program 3rd: Program of strengthening and resistance exercises	• Sit-to-stand • One-leg standing (right support) • One-leg standing (left support) • Tandem • TUGT-motor Time • Loss of water No. steps Report	This study shows that training with the multi-exercise program was more effective and reduced the chances of falling in the elderly.
Patti *et al*. (2017)	92	13 weeks	1st: Lower limb strengthening exercises and balance exercises 2nd: Control group, did not carry any program.	• Berg Balance Scale (BBS) • Oswestry Disability Index	The 13-week non-equipment program applied to the elderly was effective in improving balance and pain perception in order to reduce falls.
Chittrakul *et al*. (2020)	72	12 weeks	1st: MPE group muscle strengthening, reflexes, balance and posture correction exercises 2nd: Control group	• Fall risk index score • Edge-contrast sensitivity • Proprioception • Knee extension strength • Hand reaction time • Sway path • Depression Score • Overall Health-Related Quality of Life (HRQOL)	The multisystem physical exercise (MPE) program is recommended for muscle strengthening and balance improvement, but also for fall prevention in the elderly.
Rohmani, Fuady and Anindyarini (2013) [14].	54	12 weeks	1st: Strengthening and balance exercises. 2nd: Control group.	• Clock drawing test (CDT). • Falls efficacy scale-international version (FES-I) • World health organisation quality of life assessment-bref (WHOQOL-Bref) • Freiburg questionnaire of physical activity (FQoPA) • Tuning fork test • Romberg Test • Functional Reach Test (FRT) • Timed up and Go Test (TUG) • Chair Stand Test • Stair Climb Power Test (SCP)	An important finding of the study was that even after 12 weeks after the end of the program the fall factors were significantly reduced in both groups but mainly in the experimental group.
Gianoudis *et al*. (2014)	162	12 months	1st: Strengthening program with resistance exercises, exercises with weights and balance exercises 2nd: Control group	• Leg muscle strength (kg). • Back muscle strength (kg). • Muscle function. • Functional muscle power. • 30 Second Sit-to-Stand (number of stands). • Four Square Step Test (seconds). • Dual task Timed Up and Go.	The program followed by the experimental group represents an effective approach to improving musculoskeletal and functional problems in the elderly, however, this doesn't equate to a reduction in the rate of falls, and according to the researchers, further studies with a larger sample should be carried out.

Literature review

The study by Eckardt [10] examined strength and balance training on unstable surfaces in elderly people. The study involved 75 healthy seniors aged 65-80, who were divided into 3 groups. The first group performed resistance training with machines on stable terrain (M-RST), the second one with machines on an unstable surface (M-URT) and the third one with free weights on an unstable surface (F-URT). Over a period of 10 weeks, all participants performed the programs 2 times per week with a duration of 60 minutes per session. The measurements were performed before and after the end of the study where the Muscle strength of the lower limbs was measured with maximal isometric exercises, the strength with the Chair rise test and the balance with the Functional Reach Test (FRT). In addition, maximum seat tests were performed and evaluated during

the last week of the program. Maximum Sitting Tests were significantly reduced in the third group (F-URT) compared to the other 2 groups. However, lower extremity strengthening exercises had significant improvements in strength and balance in all groups. The second group (M-URT) had the best results in lower limb strengthening and the third group (F-URT) had the greatest improvement in the Chair rise test and FRT. From the results of the present study, it appears that regardless of the training surface, all groups had significant lower limb strengthening and balance improvement with the third group (F-URT) having the most effective program for preventing falls in the elderly.

In the study by Ansai *et al*. [11] a multi-exercise program was compared with a strength and resistance exercise program. The study involved 69 elderly people, aged 80 and over, who were divided into 3 groups. The first group was the control group, the second performed a multi-exercise program and the third a strength and resistance exercise program. The program was performed for 16 weeks, followed by 6 weeks of detraining. The control group did not perform any form of exercise, the group that executed a multi-exercise program performed warm-up, aerobic exercise, strength and balance exercises with the sessions having graded difficulty. The group that performed the strength and resistance program performed exercises on 6 different machines. Each session lasted 1 hour. For the measurements, the 5-repetition test from standing to sitting position and the one-legged support test were used. In conclusion, this study shows that training with the multi-exercise program was more effective and it reduces the chances of falling in the elderly.

In the study by Patti *et al*. [12] the association of a strength and balance program in the elderly with fall prevention was studied. The study involved 92 elderly people from a rural area of Italy, who were randomly assigned to 2 intervention groups. The experimental group with 49 people and the control group with 43 people. The program was performed under the supervision of trained gymnasts in the experimental group where lower extremity strengthening exercises and balance exercises were performed, while the control group did not perform any program. Berg Balance Scale (BBS) and Oswestry Disability Index (ODI) were used for measurements. Measurements were performed before and after the end of the program. The results showed significant improvements in the balance of the experimental group as well as the perception of pain. Accordingly, in the control group no significant changes were observed in any of the 2 measurements performed. In conclusion, it appears that the 13-week non-equipment program applied to the elderly was effective in improving balance and pain perception in order to reduce falls.

In the study by Chittrakul *et al*. [13] a Multisystem Physical Exercise (MPE) program to improve quality of life and reduce falls in the elderly with weakness was implemented. The study involved 72 elderly people, aged 65 and over, who according to the Pathophysiological Profile Assessment (PPA) are considered to have a higher probability of falling. Participants were randomly assigned to 2 groups, the control group (36 individuals) and the MPE group (36 individuals). The MPE group received mainly muscle strengthening, reflexes, balance and postural correction exercises. The program was performed 3 times per week for 12 weeks. The measurements were made with the PPA immediately after the end of the program, i.e., at the end of 12 weeks, followed by a repeat measurement after 12 weeks. The results showed significant differences in muscle strength, balance and fall probability between the 2 groups, both at week 12 and at week 24. In addition, the MPE group's quality of life increased significantly compared to the control group. In conclusion, the Multisystem Physical Exercise (MPE) program is recommended for muscle strengthening and balance improvement, but also for the prevention of falls in the elderly.

In the study by Rohmani *et al*. [14] the benefits of a program developed by an interdisciplinary team to improve balance, strength, posture and psychosocial well-being were examined. The study involved 54 healthy seniors aged 65 to 80 years. The research protocol includes tests to assess static and dynamic balance (Romberg test, gait analysis, Timed up and Go test, Functional Reach Test, disturbance test during standing on two legs, Push and Release test), the assessment of strength (Hand grip Strength Test, Chair Stand Test, Stair Climb Power Test, counter movement jump). Additional questionnaires for the assessment of psychosocial well-being (World Health Organization Quality of Life Assessment-Bref), cognitive level (Mini Mental State Examination) and factors of falls (Falls Effectiveness Scale) were used. The participants were randomly divided into 2 intervention groups, the experimental and the control group. After baseline measurements, participants began a 12-week program of strength and balance exercises, with 3 sessions per week, each session lasting 30 minutes. One group will do the program with supervision, while the control group will do a short version of it at home, which will be checked weekly through the phone. Measurements were taken after 12 weeks, and again 12 weeks after the end of the program. As expected, the group that performed the supervised program had greater improvements in strength and balance than the control group. An important finding of the study was that even after 12 weeks after the end of the program the fall factors were significantly reduced in both groups but mainly in the experimental group.

In the randomized controlled 12-month study by Gianoudis *et al*. [15] the aim was to evaluate the effectiveness and feasibility of a multimodal exercise program incorporating high-velocity resistance and strength training (HV)-PRT, combined with an education and behavior change program, regarding bone mineral density (BMD), composition body mass, muscle strength and functional muscle performance in older adults. A total of 162 adults aged 60 and over who had a significant fall risk and low bone density participated in the study. They were divided into 2 groups, the experimental group with 81 people and the control group with 81 people. The experimental group followed a strengthening program with resistance exercises, exercises with weights and balance exercises, which were performed 3 times a week. After 12 months the program showed significant improvements in muscle strength, functional muscle strength (Timed Stair Climbing Test), control-related dynamic balance and control-related dynamic balance (4-square step test). However, no reduction in the percentage of falls was observed. Therefore, the program followed by the experimental group represents an effective approach to improving musculoskeletal and functional problems in the elderly, however, this doesn't equate to a reduction in the rate of falls, and according to the researchers, further studies with a larger sample should be carried out.

Discussion and Conclusions

The results of this review show that the implementation of programs with strengthening and balance exercises have significant effects in reducing falls in the elderly. It was also observed that there is a significant improvement in the quality of life and help in the independent living of the elderly, as seen after the completion of the studies by Rohmani *et al*. [14] and Chittrakul *et al*. [13], while there is a significant improvement in mobility according to the studies of Patti *et al*. [12] and Gianoudis *et al*. [15]. The results of the present systematic review coincide with the results of a similar review carried out by Kumar *et al*. [9] where different programs were studied with the aim of reducing fear of falling in elderly people over 65 years of age. Moreover, in the review by Thomas *et al*. [16] where various balance and strength programs were reviewed to improve balance and prevent falls, with each review having its limitations and problems. However, there were also systematic studies that proposed different approaches such as the study by Weber *et al*. [8] where he suggested that functional exercise programs are very effective in mortality and quality of life in the elderly. In addition, in the present review according to the study by Gianoudis *et al*. [15] where they applied an exercise program incorporating high-velocity resistance and strength training, combined with an education and behavior change program, regarding bone mineral density (BMD), body composition, muscle strength and functional muscle performance in older adults, it appeared that while there was an improvement in the musculoskeletal problems of the elderly participants, no reduction in the rate of falls was observed. The problems of the present systematic review are initially the duration of the programs implemented in each study since for example in the study of Eckardt [10] the duration of the program was 10 weeks, while in the case of Gianoudis *et al*. [15] it was 12 months. Duration is a factor that can affect the results of a study. There was also a small inconsistency regarding the ages of the participants in the studies since in the study by Ansai *et al*. [11] the participants were from 80 years and older while in the study by Rohmani *et al*. [14] were from 65 to 80. All the above age ranges may indicate elderly people, however, the results of each research may be different.

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