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Review Article

Examining the Effect of Exercise Interventions on Balance and Fall Prevention in the Elderly: A Systematic Review

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Abstract

Background and purpose: With the growing elderly population worldwide, their associated problems are also increasing. Falls and their consequent outcomes are considered major health issues for the elderly, and imbalance is undoubtedly recognized as the primary cause of falls among the elderly.

Materials and methods: The aim of this study was to search for articles published in scientific and research journals from 2000 to 2020 and to review studies related to physical and exercise interventions aimed at improving balance and reducing the risk of falls in the elderly. Keywords such as elderly, older adults, aging, exercise, and falling were used to review the literature in electronic databases such as PubMed, Embase, Medline, SID, Scopus, and Google Scholar.

Results: A total of 190 articles were identified through the preliminary database search. One hundred studies were selected through title screening, and 90 of these records were excluded after abstract analysis. Of the remaining 50 articles, whose full texts were analyzed, 40 were excluded due to non-compliance with the inclusion criteria. Finally, 7 studies were identified as potentially relevant and met all the considered criteria.

Conclusion: It appears that the use of various exercise methods specifically designed for the elderly, such as home-based protocols like Otago, vestibular exercises such as Cawthorne and Cooksey, fall-proof exercises, and other similar exercises mentioned in the present study, which specifically challenge balance in the elderly, can enhance their abilities and consequently reduce the risk of falls.

Keywords: Balance; Falls Accidental,; Aged; Exercise Interventions; Prevention

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Introduction

Aging is likely the most significant demographic phenomenon of the 21st century, with definitions indicating that the onset of aging begins at the age of 65. The aging process is accompanied by a decline in the functioning of various bodily systems, with anatomical and physiological changes in the sensory-motor systems of the elderly leading to increased vulnerability and the occurrence of injuries. Given the growth of the elderly population worldwide, the associated problems are also on the rise, with falls and their consequences being major health issues for older adults. Imbalance is undoubtedly recognized as the primary factor contributing to falls among the elderly.

The most common cause of injuries in individuals over the age of 65 is falls at the same level or ground-level falls. Ground-level falls, defined as sudden events, are a common issue in the elderly population, leading to increased mortality, immobility, reduced functionality, hospitalization, and elevated societal costs. Annually, 28-35% of individuals over 64 years of age experience falls, with the frequency of falls increasing with age and fragility, reaching up to 50% in those over 80 years old. This represents a serious public health issue due to the high demand for healthcare services and the associated costs, significantly impacting each elderly individual. Falls result in consequences such as trauma, pain, functional deficits, and decreased confidence in performing daily activities, leading to reduced independence and even death. Factors associated with falls in the elderly include decreased self-efficacy, increased fear of falling, reduced mobility, and poor balance.

Various factors contribute to falls among the elderly. External factors account for 30% and internal factors for 35.5%. Poor lighting, uneven surfaces, and inappropriate footwear are environmental factors that increase the risk of falling. Additionally, 40-60% of falls among the elderly occur in the absence of a witness. Therefore, if various interventions (pharmaceutical, visual, exercise, etc.) can reverse or mitigate these disorders, the risk of falling and its irreparable consequences can be reduced. Several meta-analyses and review studies have shown that among all available interventions, exercise programs hold the greatest importance in terms of effectiveness and generalizability to larger groups of elderly individuals for fall prevention.

There are various types of exercise interventions, the most commonly used of which include balance exercises, resistance training, yoga, Pilates, sensory-motor exercises, aquatic exercises, and training on various stable and unstable surfaces, each designed and

implemented with specific goals in mind. Some researchers have focused on resistance and aerobic exercises to enhance balance and reduce fall risk among the elderly, while others emphasize balance training aimed at engaging various sensory resources, including proprioceptors, the vestibular system, and visual input.

Ambrose et al. (2013) conducted a review study examining the risk factors influencing falls among the elderly. Their findings indicated that falls can result from environmental factors (poor lighting, uneven surfaces, stairs, and inappropriate footwear), physical illnesses, decreased alertness, seizures, sudden strokes, muscular weakness, a history of falls, gait difficulties, lack of balance, visual impairments, movement disorders, fear of falling, and other factors. These factors can also serve as tools for assessing fall risk among the elderly, allowing for the identification of individuals at risk of falling. Furthermore, Ambrose et al. concluded that the most significant risk factor or best tool for identifying elderly individuals at risk of falling is balance tests and kinetic and kinematic parameters of gait. Therefore, examining factors influencing balance and the kinetic and kinematic parameters of walking is of great importance.

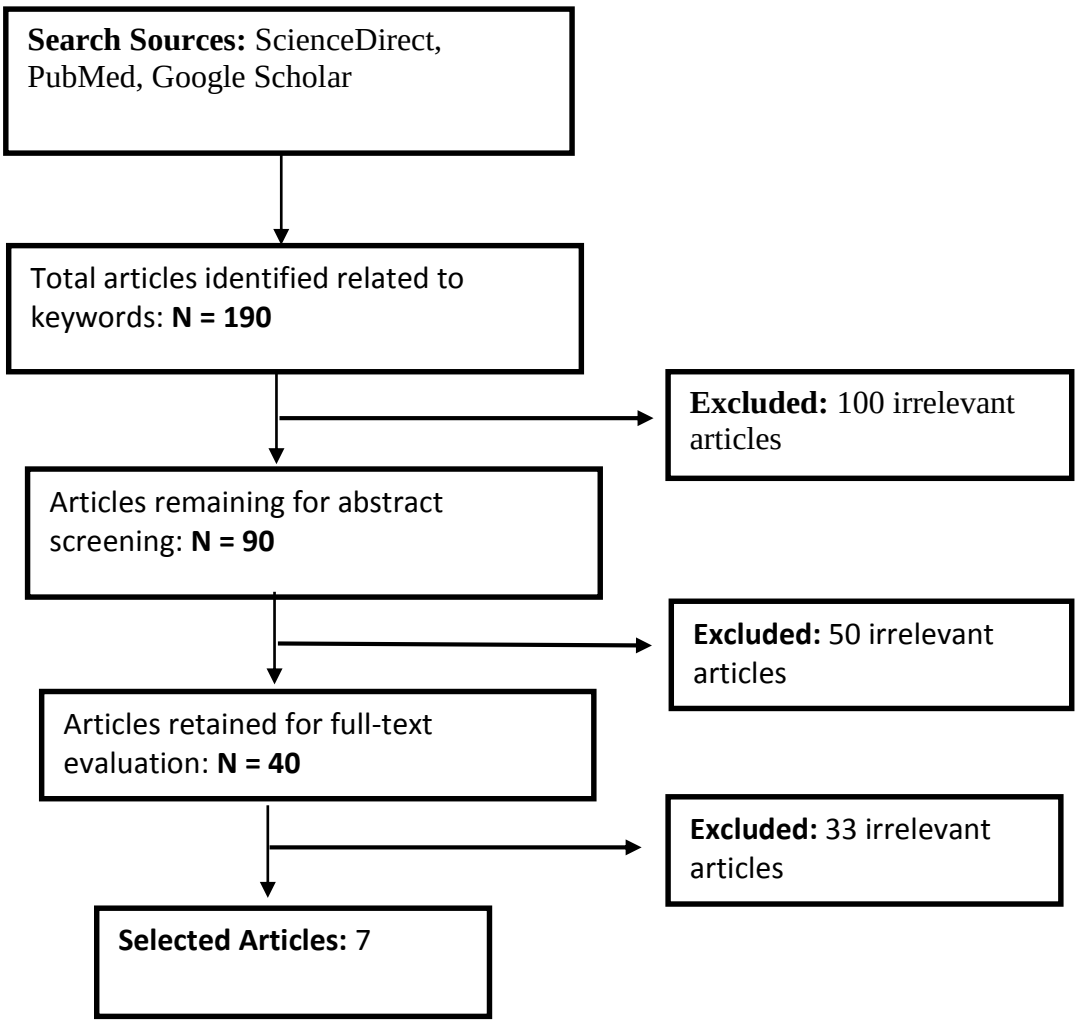
Physical activity plays a crucial role not only in preventing age-related physical decline but also in reducing cardiovascular diseases and musculoskeletal degenerative conditions such as osteoporosis and arthritis. Many studies have proposed physical activity as a means to improve fitness and reduce physical fatigue. Some articles have investigated the effects of strength, endurance, aerobic, balance, and flexibility exercises, while others have explored the combined effects of these interventions, noting both their efficacy and ineffectiveness in fall prevention.

Attention to the phenomenon of aging, changes in bodily systems, falls and their consequences, and ultimately finding methods to slow aging and prevent falls have been focal points for researchers. On the other hand, selecting exercises that can be effective for the elderly in a short time with minimal resources has been the ultimate goal of researchers. Therefore, the aim of this review study is to examine the various exercise interventions used to enhance balance and to understand which of these can strengthen the abilities of older adults and support fall prevention.

Materials and Methods

The aim of this study was to explore published articles in scientific and research journals from 2000 to 2020, focusing on studies related to physical and exercise interventions aimed at improving balance and reducing the risk of falls among the elderly. The keywords **elderly, older adults, aging, exercise, falling** were used to search the literature in electronic databases such as PubMed, Embase, Medline, SID, Scopus, and Google Scholar. In the first stage, the screening of abstracts and titles was conducted, concentrating on various exercise interventions related to balance and fall risk in the elderly population, with publications available in both Persian and English. The researcher independently reviewed the abstracts of the articles, and in the second stage, a full-text screening was performed based on specific publication criteria (focusing on specific exercise programs) and clearly defined target populations. Descriptive information was collected and verified by the researcher. A standard sample table was utilized to extract information regarding the target population, balance measurement tools, fall risk levels, and their outcomes (Table 1). Exclusion criteria for the study included articles that did not pertain to healthy elderly individuals (those examining balance and fall risk in elderly patients with Parkinson's disease, Alzheimer's disease, orthopedic problems, stroke, spinal canal injuries, multiple sclerosis, motor neuron diseases, or peripheral nerve diseases). A total of 190 articles were identified through preliminary searches of the database. One hundred studies were selected through title screening, and 90 of these records were eliminated after abstract analysis. From the remaining 50 articles, which underwent full-text analysis, 40 were excluded due to non-compliance with the inclusion criteria, leaving 7 potential studies that met all the established criteria (Figure 1).

Image number one: Overview of the selection of articles



The articles included in this review study, based on the established inclusion and exclusion criteria, were evaluated using a questionnaire (Table 1) that examines key factors of the studies. This questionnaire comprised 9 questions and was used to score the articles.

- Scoring System:
- Articles scoring 0 to 49% were classified as weak studies.
- Articles scoring 50 to 89% were classified as moderate studies.
- Articles scoring over 90% were classified as good studies.

This scoring system allowed for a systematic assessment of the quality of the included studies, ensuring that only relevant and methodologically sound research contributed to the findings of the review.

Table 1 (Study Quality Assessment)

Score **Study Reference**
How was allocation to the intervention group done? 2 = random 1 = cluster random 0 = historical comparison/volunteer or convenience group
Was the assigned intervention concealed before allocation? 2 = adequate 1 = unclear 0 = inadequate/impossible
Were the outcomes of participants who withdrew described and included in the analysis (intention to treat/effect of compliance)? 2 = withdrawals well described and accounted for in analysis 1 = withdrawals described and analysis not possible 0 = no mention, inadequate mention, or obvious differences and no adjustment
Were the outcome assessors blinded to treatment status? 2 = effective action taken to blind assessors 1 = small or moderate chance of unblinding of assessors 0 = not mentioned or not possible
Were the inclusion and exclusion criteria (age, previous injury, sport) clearly defined? 2 = clearly defined 1 = inadequately defined 0 = not defined
Were the intervention and control group comparable at entry? 2 = good comparability of groups, or confounding adjusted for in analysis 1 = confounding small; mentioned but not adjusted for 0 = large potential for confounding, or not discussed
Were the interventions clearly defined? 2 = clearly defined interventions are applied 1 = clearly defined interventions are applied but the application is not standardised 0 = intervention and/or application are poorly or not defined
Were the outcome measures used clearly defined?(injury: selfreported injury/medically confirmed/severity defined) 2 = clearly defined 1 = adequately defined/recorded 0 = not adequately defined/recorded

Was the surveillance period active and of clinically appropriate duration? 2 = active surveillance and appropriate duration 1 = active surveillance, but inadequate duration 0 = surveillance not active or not defined
Total score (18=%100)

Results

The participants in the studies included elderly men and women aged 60 years and older. The minimum number of participants was 30, while the maximum reached 405. In most studies, in addition to assessing balance and fall risk, factors such as strength, range of motion, performance, quality of life, and psychological factors like anxiety and depression were addressed over different time periods (40, 41). As indicated by the results of the studies, the duration of the exercise protocol ranged from 8 to 12 weeks.

The variables examined in the current study included balance variables, which comprised static and dynamic balance as well as functional balance. Static balance was assessed through one-leg standing tests (stork test), while dynamic balance was evaluated using the Timed Up and Go (TUG) test, as this test requires not only mobility but also good dynamic ability, making it a simple test with high reliability and validity for assessing dynamic balance (42). Functional balance was measured using the Berg Balance Scale and the Fullerton Advanced Balance Scale (43). A summary of the research process, number of participants, methodology, and results of these studies is presented in Table 1.

Article Title	Study Design and Sample Size	Measured Variables	Evaluation Tools	Score	Main Findings
Effects of three home-based exercise programmes regarding falls, quality of life and exercise adherence in older adults at risk of falling (Anne-Gabrielle Mittaz Hager et al., 2019)	Clinical trial; 405 participants (aged 65+), divided into three training groups: Otago (162), T&E (162), Helsana (81).	Balance, falls, and quality of life	Timed Up and Go Test (TUG), Functional Sit-to-Stand Test (FTSTS), Functional Reach Test (FR), Six-Meter Walk Test (SMWT), OPQOL-35 Questionnaire	14	After six months of follow-up, all three exercise protocols had positive effects on fall prevention in older adults.
Effects of a falls prevention exercise programme on health-related quality of life in	Clinical trial; 150 participants divided into two groups: Otago exercises and	Static balance and risk of falling	30-Second Sit-to-Stand Test, Berg Balance Scale, Four-Meter Walk	13	Otago fall prevention exercises significantly improved balance

older home care recipients (Bjerk, Maria et al., 2019)	control (functional exercises) over 12 weeks		Test, SF-36 Questionnaire		and quality of life in older adults receiving home care.
Effectiveness of Lafiska exercise on risk of fall, balance, and health status in the elderly (Dwi Nurviyandari et al., 2018)	Prospective study; 80 older adults in two groups: control (40) and Lafiska exercises (40) for 10 weeks	Risk of falling, balance, and health status	Berg Balance Scale, SF-12 Questionnaire	15	Lafiska exercises significantly reduced fall risk and improved balance and health status in older adults.
The effects of eyeball exercise on balance ability and falls efficacy of the elderly who have experienced a fall (Park, Jh et al., 2017)	Clinical trial; 61 participants divided into eyeball exercise group (30) and functional exercise group (31) for 10 weeks	Static balance, dynamic balance, and risk of falling	TUG Test, Modified Falls Efficacy Scale (MFES) Questionnaire	13	Eyeball exercises were more effective than functional exercises in improving balance and reducing falls in older adults.
The effect of selected FallProof exercises on static and dynamic balance in older adults (Hossein Khazanin Hassan Daneshmandi, 2019)	Semi-experimental study; 24 older adults (60-74 years), divided into experimental and control groups for 8 weeks	Static and dynamic balance	Sharpened Romberg Test (eyes open and closed), TUG Test	14	Selected FallProof exercises significantly improved static balance (eyes open and closed) and dynamic balance in the experimental group compared to controls.
Effect of Cawthorne and Cooksey Exercise Program on Balance and Likelihood of fall in Older Women (Prajakta D. Zambare et al., 2015)	Clinical trial; 60 older women (60-69 years), divided into two groups of 30, for 9 weeks (3 days/week, 60 minutes/session)	Balance and risk of falling	Dynamic Gait Index (DGI), Berg Balance Scale, Fall Efficacy Scale	13	Significant improvement in Berg Balance Scale and Fall Efficacy Scale results in the Cawthorne and Cooksey group compared to the control group.
Effectiveness of FallProof home-based DVD program in improving balance, select functional fitness parameters, and balance-related confidence among community-dwelling older adults at moderate to high risk of falls (Kelly Ward et al., 2011)	38 participants divided into FallProof home-based exercise group (23) and non-exercise control group (15) for 12 weeks	Balance in older adults at high risk of falling	Fullerton Advanced Balance Scale, Balance Efficacy Scale	13	Significant improvements in the exercise group, while the control group showed no improvements.

Conclusion

In this study, seven international case research articles published between 2011 and 2019, along with one domestic article published in (2019), were utilized. Each of these studies holds a high level of credibility in the field of balance and fall prevention among the elderly. Two of the articles employed Otago exercises, which are specialized balance exercises aimed at preventing falls in older adults (42, 44). The Otago exercise program includes muscle strengthening and balance recovery activities conducted at home by a trained instructor (50, 49). The rationale behind this exercise program is that muscular strength, flexibility, balance, and reaction time are critical risk factors for falls among the elderly (49). This program is unique due to its clearly defined protocol and its feasibility for implementation within the elderly community; consequently, it is widely used in New Zealand and other parts of the world (49, 51).

Another exercise program that has gained attention among the elderly is the Fall Proof exercise protocol, developed by Rose and colleagues in 2011. The primary goal of this balance and movement program is to enhance functional independence and improve risk factors that contribute to falls among older adults. This is achieved through four program components: voluntary and involuntary center of gravity control, sensory perception and skill integration, selection and scaling of postural strategies, and development of walking pattern flexibility. Overall, the structure of the Fall Proof program follows the principles and theories of the Woollacott & Shumway-Cook motor control system. This theory posits that multiple systems collaborate to control orientation and movement. According to their framework, in addition to the sensory-motor systems that form the basis of postural control, musculoskeletal and cognitive systems enable an individual to achieve specific actions. Thus, it can be stated that the components integrated into the Fall Proof program—including sensory, vestibular, and strength components, as well as center of gravity maintenance and control strategies—can impact the movement control system (52). Therefore, a possible reason for the association between Rose's program and this theory may be the presence of such components in the Fall Proof fall prevention program. In the study by Khazinin and Daneshmandi, an exercise program based on postural control systems and related factors affecting balance in the elderly was selected (47).

According to Makias and colleagues, vestibular rehabilitation is one of the most crucial exercises for improving balance disorders (53). The Cawthorne and Cooksey exercises are

part of vestibular rehabilitation that engages balance control centers such as vision, proprioception, and the vestibular system (54). Visual impairment is considered the primary cause of balance deficits and increased fall risk among the elderly, and the aforementioned exercises can enhance their balance. Based on the available articles and the conducted reviews, it can be concluded that Cawthorne and Cooksey exercises likely improve balance in older adults (48).

Duy and colleagues (2018) examined the effects of Lafisca exercises on fall risk, balance, and health status among the elderly. The results indicated that Lafisca exercises had a significant impact on reducing fall risk and enhancing balance and health in older adults (45).

Discussion

The aim of this study was to review the scientific literature to identify exercise programs capable of enhancing balance in older adults. It appears that focusing on the development of specific aspects of movement control in intervention programs may contribute to their effectiveness. As mentioned, the decline in neuromuscular, musculoskeletal, and sensory systems with aging leads to difficulties for older adults in maintaining postural control.

Muscle strength is a key component of balance and walking ability, which, along with other degenerative changes in bodily systems, tends to decrease with age. The reduction in muscle mass and the weakening of sensory systems (visual, proprioceptive, and vestibular) contribute to decreased balance and instability during walking and daily activities. Recent research has also indicated that improper weight transfer is a primary cause of falls in older adults. Stable standing is achieved when the center of mass is within the base of support. The location of the center of mass is determined by changes in the center of pressure. To maintain balance during daily activities, individuals must control the position of their center of mass through weight transfer. Typically, older adults require more movement adjustments to achieve the target point during voluntary weight transfer and often fail to reach it. This is likely due to their reduced ability to perform proper weight transfer movements necessary for maintaining balance. Given that balance is a variable and adaptable factor, it seems that exercise interventions for older adults should focus on multiple training components (55, 56, 57, 58).

Final Conclusion

It appears that the use of various specialized exercise methods for older adults, such as home-based protocols like Otago, vestibular exercises such as Cawthorne and Cooksey, the Fall Proof program, and similar exercises mentioned in this study, can enhance the capabilities of older adults and reduce the risk of falls.

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