Managing Fall Prevention through Exercise in Older Adults Afflicted by Cognitive and Strength Impairment

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Keywords

Geriatrics · Physical activity · Exercise · Prevention · Rehabilitation · Risk assessment

Abstract

Introduction: A growing trend in medicine is older adults and increased need for geriatric services. Falls contribute heavily to hospitalizations and worsening of overall health in this frail demographic. There are numerous biological and physical culprits which, if targeted, can prevent falls. The objective was to review benefits of different types of exercises for fall prevention for older persons who are community-dwelling or living in long-term care facilities. **Methods:** A systematic review was conducted to determine the different types of exercises for fall prevention. Data extraction via a standardized protocol was performed to assess study design, outcomes, limitations, and author's conclusions. Corroborative themes were identified and the authors responsible for the contributing research were cited as they came up. Nineteen randomized controlled trials were identified, between 1990 and 2018, using MEDLINE, PubMed, Cochrane, CINAHL, and Web of Science databases. Studies involving adults greater than age 60 in high-risk community or nursing

home populations in the English language with a duration longer than or equal to 6 weeks with focuses on either low-risk balance, strength, or combination of both and whole-body vibration. **Results:** Balance exercise training increased balance at 6 and 12-month intervals involving balance, strength, and cognitive training. **Discussion:** Insignificant results were seen in whole-body vibration and differing results existed for Tai Chi. It is important to recognize that although exercises help reduce the risk of falling and play a significant role in improving mobility safely, there will always be a risk of falls.

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Introduction

Over the years, the population of older adults has steadily increased. With that in mind, certain occurrences tend to happen more frequently with consequences arising as a result. One of these increasingly prominent issues is falling. As one can imagine, falls especially in an older population, can lead to poor outcomes and can significantly alter quality of life due to their fragility. This article had the purpose of providing a one-stop look at

various interventions to prevent falls from occurring in the first place. By implementing the strategies below, falls can be reduced significantly and therefore prolong the quality of life older adults can have and/or avoid further complications given their respective conditions. An important topic affecting a growing population and therefore requires further analysis to provide clarity as to what to do.

Falls are the leading cause of hospitalizations for fatal and nonfatal injuries, increasing with age in both probability and injury severity. Approximately one-half of people over the age of 80 fall annually [1]. Despite the chances of falling doubling after a previous fall, less than half report the falls to their doctor [2, 3]. An estimated 2.8 million older adults are rushed to emergency for fall injuries and 800,000 are hospitalized [4]. In one-fifths of falls, further complications include serious fractures, head traumas, and ensuing traumatic brain injuries [5, 6]. Many of those who have fallen previously develop an FOF which often leads to inactivity and muscle weakness [7]. By 2030, a report by the United Nations projects that about 1.4 billion people will be 60 or older, highlighting the urgency to find solutions [8]. Research determined multiple risk factors which increase the probability of falling, namely, lower body weakness, vitamin D deficiency, difficulties with walking and balance, polypharmacy, environmental hazards (broken steps or uneven ground), and inadequate footwear [9, 10].

This review aims to provide a comprehensive overall picture as previous studies on fall risks and prevention have focused on individual exercise regimens or targeted interventions. This consolidation to prevent falls of multifactorial origin in this frail population will increase knowledge translation and reduce ambiguity. This review concentrates on low-risk exercises, determining their benefits to fall prevention, justifying their merits in management and need for future research. These exercises included balance, strength, whole-body vibration, Tai Chi, and a combination of physical and cognitive exercises.

Methods

We searched MEDLINE, PubMed, Cochrane, CINAHL, and Web of Science databases on the literature dated from January 1990 to December 2018, with ongoing surveillance through March 2019 that focused on the role and type of exercises that can be used in fall prevention using the following keywords: Geriatrics, Fall Prevention, Exercise, Balance, and Whole-Body Vibration. For the purpose of this review, fall prevention is defined as studies using exercises with emphasis placed on mitigating muscle weakness, cognitive deficits, or cerebral impairments (i.e., dizziness) which

Fig. 1. PRISMA flowchart.

can cause instability from sustained postural positions above floor/ground level to falls causing end position at ground level in community-dwelling older adults. Additional sources were added to the literature search by way of being referenced. Studies that were deemed useful to the objective at hand had an inclusion criterion comprising being in the English language, being equal to or longer than 6 weeks in duration, statistically significant with a p value of <0.05 , involving low-risk exercises in a high-risk population over 60 years old in either a community or NH setting, patients with a history of falls or cognitive impairment and patients with outcome measures in fall prevention. Studies in the non-English language, studies lacking statistical significance ($p > 0.05$), patients under the age of 60, high-risk exercises and studies dated before January 1990 were excluded. Nineteen studies were selected for review, which can be found in Figure 1.

Data from each study were extracted using a standardized protocol to assess study design, outcomes, limitations, and author's conclusions. Corroborative themes were identified and the authors responsible for the contributing research were cited as they came up.

The method used to choose and synthesize the studies aimed to be unbiased, consistent, and accurate, so bias related to study length, population sizes, demographics, and reported outcome could be minimized. There was no ethical approval required for this systematic review. The two reviewers, Helen Senderovich and Basile Montagnese, were not blinded to the study hypotheses.

Results

The balance exercise training was found efficient in improving balancing and fall prevention at 6 and 12 months of intervention resulted in the improvement in

Table 1. Summary of studies [11–22, 24–26, 30, 34, 39]

Author	Study design	Intervention description	Demographic involved	Authors' conclusions	CI/p value (if included in the study)	Level of evidence (sackett)
Kovacs et al. [11]	RCT	Eighty-six participants were randomized to an exercise group providing multimodal exercise program for 12 months or a control group which did not participate in any exercise program. Sessions were held twice weekly, beginning with a 5 min warm-up, 3 sets of 10 repetitions of strength/balance training followed by 5 min of cooling down	Cognitively impaired individuals aged over 60 years. Gender not specified	12-month multimodal exercise program can improve the balance in cognitively impaired older adults	Improvement in balance-related items of POMA scale in the exercise group both at 6 months and 12 months ($p < 0.0001$, $p = 0.002$, respectively). Increase in gait-related items of the POMA scale and Tinetti POMA-G score at 12 months ($p < 0.0001$) in cognitively impaired elderly participants	1b
Dadgari et al. [12]	RCT	160 total OEP participants were engaged in 45–60 min of exercise 3 times per week. Each OEP session consisted of: 1. 5–10 min of warm-up 2. 30–40 min of strength training 3. 5–10 min of cool-down training	Older community dwellers greater than 60 years old. Gender not specified	OEP as a home-based exercise is effective for the reduction of the incidence of falls among senior citizens with a history of falls	Improved physical performance through strengthening upper and lower extremities ($p > 0.00$, $p > 0.017$), as well as functional capacity ($p > 0.025$), which correlates with improved balancing ability	1b
Park and Chang [13]	Prospective cohort	8 subjects performing the OEP for 50 min, 3 times per week, for 8 weeks	Patients with a diagnosis of stroke without cognitive impairments greater than the age of 65. Gender not specified	OEP significantly improved fall efficacy but did not significantly improve activities of daily living and QoL	Improved fall efficacy in exercising patients whose FES scores significantly improved from 36.1 ± 11.7 to 50.6 ± 9.0 ($p < 0.05$)	2b
Voukelatos et al. [14]	RCT	702 community-dwelling aged adults were randomized to a 16-week, 1 h/week, Tai Chi program or a no-intervention control	702 community-dwelling people aged 60 and older (mean age 69). Gender not specified	Participation in once per week Tai Chi classes for 16 weeks can prevent falls in relatively healthy community-dwelling older people	The participants in the Tai Chi group had fewer falls after 24-weeks ($p = 0.03$) and better scores on balance assessments at the end of the program ($p = 0.02$)	1b
Li et al. [15]	RCT	256 community-dwelling aged adults were randomized into Tai Chi or a stretching program. Participants of both programs received 1-h training three times a week	256 physically inactive, community-dwelling adults aged 70 to 92 (mean age, 77.48 years; standard deviation, 4.95 years). Gender not specified	A 3 times per week, 6-month Tai Chi program is effective in decreasing the number of falls, the risk for falling, and the fear of falling, and it improves functional balance and physical performance in physically inactive persons aged 70 years or older	The risk for multiple falls in the Tai Chi group was 55% lower than that of the stretching control group (RR, 0.45; 95% CI, 0.30–0.70). Compared with the stretching control participants, the Tai Chi participants showed significant improvements ($p < 0.001$)	1b

Table 1 (continued)

Author	Study design	Intervention description	Demographic involved	Authors' conclusions	CI/p value (if included in the study)	Level of evidence (sackett)
Wolf et al. [16]	RCT	311 aged adults were randomized to an intense Tai Chi exercise program or an education intervention. Tai Chi exercises took place twice weekly lasting 60–90 min. The education intervention was once weekly for an hour. It focused on falls prevention, exercise, nutrition, stress, depression, and life changes	291 women and 20 men aged 70–97	Tai Chi did not reduce the RR of falling in transitionally frail, older adults, but positive findings seen previously in more-robust older adults, suggests that Tai Chi may be clinically important and should be evaluated further in this high-risk population	The RR of falling was not statistically different in the Tai Chi group and the wellness education group (RR = 0.75, 95% CI = 0.52–1.08), $p = 0.13$	2a
Nowalk et al. [17]	RCT	Tai Chi was combined with behavioral interventions to reduce falls and FOF in 120 LTC residents. Exercises occurred 3 times per week throughout the 12-month study. Intensity was not specified	110 participants whose average age were 84 and who were capable of ambulating with or without assistive devices and could follow simple directions. 70 participants were female and 40 were male	No significant differences in falls among the two exercise groups and the control group	Time to first fall, time to death, number of days hospitalized, and incidence of falls did not differ among the treatment and control groups ($p > 0.05$)	2a
Faber et al. [30]	Multi-center RCT	A Tai Chi balance program was compared to a daily mobility program in 278 aged LTC residents after a 20-week intervention. Both programs had identical duration and frequency of training sessions 1. 60 min of exercise 2. 30 min of group socialization 3. 1 session per week for the first 4 weeks, 2 sessions per week for the following 16 weeks 4. 52 week follow-up post-participation in program	278 men and women (mean age $\pm$ standard deviation, 85 ± 6 y)	Fall-preventive moderate intensity group-exercise programs have positive effects on falling and physical performance in pre-frail, but not in frail elderly	Fall incidence rate was higher in the daily mobility group (3.3 falls/y) than the Tai Chi balance group (2.4 falls/y) and control (2.5 falls/y) groups, but not statistically significant The risk of becoming a faller in participants who were classified as being frail (HR = 2.95; 95% CI, 1.64–5.32) For participants who were classified as being pre-frail, the risk of becoming a faller decreased; this effect became significant after 11 weeks of training (HR = 0.39; 95% CI, 0.18–0.88). Participants in both exercise groups showed a small, but significant improvement in their POMA and physical performance scores	1b

Table 1 (continued)

Author	Study design	Intervention description	Demographic involved	Authors' conclusions	CI/p value (if included in the study)	Level of evidence (sackett)
L Tomas-Vega et al. [18]	Systematic review and meta-analysis	Examination of 10 RCTs that compared Tai Chi to other interventions. Sessions lasted 1 h and occurred 1–3 times a week for 12–26 weeks	Older adult population and at-risk adults. Aged 56–98. Gender not specified	In at-risk older adults, Tai Chi practice may reduce the rate of falls and injury-related falls over the short term (<12 months) by approximately 43 and 50%, respectively. Tai Chi practice may not influence time to first fall and due to the low quality of evidence, more studies investigating the effects of tai chi on injurious falls and time to first fall are required	Medium protective effect for fall incidence over the short term (IRR = 0.57; 95% CI = 0.46, 0.70) and a small protective effect over the long term (IRR = 0.87; 95% CI = 0.77, 0.98). Regarding injurious falls, medium protective effect over the short term (IRR = 0.50; 95% CI = 0.33, 0.74) and a small effect over the long term (IRR = 0.72; 95% CI = 0.54, 0.95)	1a
Bautmans et al. [19]	RCT	24 NH residents exercised 3 times/week for 6 weeks Regimen included 10 min of physical therapy and 4 series of 1 min on the vibration platform per session on a frequency of 30–50 Hz and an excursion of 2–5 mm	24 NH residents (15 female, 9 males; mean age 77.5±11.0 years)	Six weeks static whole-body vibration exercise is feasible and is beneficial for balance and mobility. The supplementary benefit of whole-body vibration on muscle performance compared to classic exercise remains to be explored further	Training-induced changes in timed up-and-go and Tinetti test were better for the whole-body vibration group than the control group ($p = 0.029$ for timed up-and-go, $p = 0.001$, and $p = 0.002$ for Tinetti body balance and total score, respectively)	1b
Bruyere et al. [20]	RCT	Physical therapist led exercise program of the following exercises: gait and balance exercises, training in transfer skill, strengthening exercises with resistive mobilization of the lower limbs Sessions were 10 min long, 3 times/weeks for 6 weeks. Whole-body vibration group had an additional 4 series of 60 s of vibration alternating with 90 s of rest on a vertical vibrating platform at frequencies of 10 Hz and 26 Hz at amplitudes of 3 and 7 mm, respectively	42 volunteer NH residents aged 63–98 years. Gender not specified	Controlled whole-body vibration can improve elements of fall risk and health-related quality of life in older adults	Improvements in gait and balance for the study group ($p = 0.029$, $p = 0.002$) 6 weeks after training	1b
Alvarez-Barbosa et al. [34]	RCT	29 LCT residents followed 8-week whole-body vibration program	29 volunteer NH residents aged 80–95 years old Gender not specified	An 8-week whole-body vibration-based intervention in a nursing home setting is effective in reducing fall risk factors and quality of life in nursing home residents aged 80+	At the 8-week follow-up, timed up and go test ($p < 0.001$), 30 s chair-sit-to-stand ($p = 0.006$), and Barthel index to assess functional dependence ($p = 0.003$) improved in the whole-body vibration intervention group when compared to the control group	1b

Table 1 (continued)

Author	Study design	Intervention description	Demographic involved	Authors' conclusions	CI/p value (if included in the study)	Level of evidence (sackett)
Sitjā-Rabert et al. [21]	Randomized parallel assessor-blinded clinical trial	159 LTC residents executing the same static/dynamic exercises-balance and strength training, while the intervention group performed these exercises on a vibrating platform. The frequency of platform vibration was set to 30–35 Hz and the amplitude was set to 2–4 mm	159 participants from 10 centers were included: 81 in the whole-body vibration plus exercise group and 78 in the control group. Mean age was 82 years, and 67.29% were women	Exercise program on a vibratory platform provides benefits similar to those with exercise program on a stationary surface in relation to body balance, gait, functional mobility, and muscle strength in institutionalized older people. Longer studies in larger samples are needed to assess falls	The Tinetti test score showed improvement in both groups ($p < 0.001$). No significant differences were found between groups at week 6 ($p = 0.890$) or month 6 ($p = 0.718$). The Timed up and go test did not improve ($p = 0.599$) in either group over time, and no significant differences were found between groups at week 6 ($p = 0.757$) or month 6 ($p = 0.959$). Muscle performance results from the 5 sit-To-stand tests improved significantly across time ($p = 0.001$), but no statistically significant differences were found between groups at week 6 ($p = 0.709$) or month 6 ($p = 0.841$). A total of 57 falls (35.8%) were recorded during the follow-up period, with no differences between groups ($p = 0.406$)	1b
Bogaerts et al. [22]	RCT	6-Month long RCT conducted on 113 institutionalized older women, measuring the effects of whole-body vibration exercises on fall risk. Sessions happened 3 times a week lasting 15 min including warm-up and cool down	113 women (mean age: 79.6)	No additional benefit of whole-body vibration training could be detected on fall risk and postural control, although sway velocity and maximal isometric knee extension strength improved only in the whole-body vibration group	Not available	4
Beaudart et al. [24]	RCT	Patients were randomized into two groups: Whole-body vibration group which received 3 training sessions every week composed of 5 series of only 15 s of vibrations at 30 Hz frequency and a control group with normal daily life for the whole study period. All were assessed blindly by 3 tests: the Tinetti Test, the Timed up and go test and a quantitative evaluation of a 10 s walk performed with a tri-axial accelerometer	62 subjects (47 women and 15 men; mean age 83.2±7.99 years)	The whole-body vibration training performed with the exposition settings such as those used in this research was feasible but seems to have no impact on the risk of falls among NH residents. Further investigations, in which, for example, the exposure parameters would be changed, seem necessary	No significant change in the studied parameters was observed between the treated ($n = 31$) and the control group ($n = 31$) after 3 months of training by controlled whole-body vibration. Tinetti test increase of $+0.93 \pm 3.14$ points in the treated group against $+0.88 \pm 2.33$ points in the control group ($p = 0.89$ when adjusted)	1b

Table 1 (continued)

Author	Study design	Intervention description	Demographic involved	Authors' conclusions	CI/p value (if included in the study)	Level of evidence (sackett)
Buckinx et al. 2014 [39]	Randomized Control single-blind	Patients were randomized into two groups: whole-body vibration group which received 3 training sessions every week composed of 5 series of only 15 s of vibrations at 30 Hz frequency and a control group with normal daily life for the whole study period. All were assessed blindly by 3 tests: the Tinetti Test, the timed up and go test and a quantitative evaluation of a 10 s walk performed with a tri-axial accelerometer	62 subjects (47 women and 15 men; mean age 83.2±7.99 years)	This study failed to establish the effectiveness of low doses of whole-body vibration, under the conditions used in our study, on functional and motor abilities of institutionalized older patients. However, given the positive results of other studies, further investigations, with modified therapeutic protocols, seem necessary to clarify the effects of whole-body vibration in older adults	There was no significant difference between the two groups regarding the Tinetti test ($p = 0.75$), the "Timed up and go" test ($p = 0.19$) and the Locomotrix (°) test, except for the step length, measured by dual task ($p < 0.01$). No significant inter-group difference in the frequency of falls was observed during the 12 months of research	2a
Huang et al. [25]	Prospective RCT	75 high-risk residents at 6 different NH who were split into 3 equal groups – a control group, a CB strategy group with exercise, and a CB strategy group without exercise. Both CB strategy groups met weekly to discuss and educate prevalent topics pertaining to falling and those CB groups who also had exercise met for an additional session weekly. Exercises related to upper and lower limb strength and endurance	Age and gender not specified	Combination intervention helped older residents manage their fear of falling and falls, decrease their depressive inclination, and enhance their mobility and muscle strength	$p < 0.05$	5
Reve and Bruin [26]	Randomized parallel clinical trial	159 residents from older homes and 23 community-dwelling older populations were randomized into SB training group or a SBC training group Program lasted 12 weeks, exercising twice weekly on age-adapted resistance machines for 30 min and 10 min balance training The SBC group did additional computerized cognitive training weekly aimed at improving participants' alertness, selective attention, and divided attention	82 participants (mean age± SD: 81.5±7.3 years)	Strength-balance training improves executive functions and reduces falls	Combination of both physical and cognitive training improves dual task costs of walking ($p = 0.002$), gait initiation ($p = 0.003$), and divided attention ($p < 0.001$)	1b
CI, confidence interval; HR, hazard ratio; RR, relative risk; SB, strength-balance; SBC, strength-balance-cognitive.						

the balance aspects of the POMA scale ($p < 0.0001$) and an increase in gait-related items of the POMA scale and Tinetti POMA – Gait Portion (POMA-G) score at 12 months ($p < 0.0001$) in cognitively impaired elderly participants [11]. Similarly, Dadgari et al. [12] showed that the OEP as a home-based exercise improved physical performance through strengthening upper and lower extremities ($p > 0.00$, $p > 0.017$), as well as functional capacity ($p > 0.025$), which correlates with improved balancing ability. Finally, Park and Chang [13] demonstrated the improved fall efficacy in exercising patients whose FES scores significantly improved from 36.1 ± 11.7 to 50.6 ± 9.0 ($p < 0.05$).

Studies exploring the efficiency of Tai Chi, a training program aimed at improving the balance, on fall prevention reported contradictory results. While Voukelatos et al. [14] reported Tai Chi group having fewer falls after 24-weeks ($p = 0.03$) and better scores on balance assessments at the end of the program ($p = 0.02$). Li et al. [15] supported the positive effect of Tai Chi, Wolf et al. [16], and Nowalk et al. [17] found no significant differences between with regard to fall risk after 2 years. Additionally, Lomas-Vega et al. [18] concluded that Tai Chi practice may reduce the rate of falls in the aged population in the short term (<12 months), but it does not influence time to first fall.

The benefit of whole-body vibration exercises for fall prevention was revealed to be inconsistent between studies. Bautmans et al. [19] determined that training-induced changes in timed up-and-go and Tinetti test were better for the whole-body vibration group than the control group ($p = 0.029$ for timed up-and-go, $p = 0.001$, and $p = 0.002$ for Tinetti body balance and total score, respectively) [19]. Similarly, Bruyere et al. [20] reported improvements in gait and balance for the study group ($p = 0.029$, $p = 0.002$) 6 weeks after training. Yet, other sources have failed to capture differences in fall frequency and incidence between whole-body vibration and regular physical training groups [21–24].

The recent studies present the promising effects of combined physical and cognitive training. As such, Huang et al. [25] determined that after 5 months of training, combination group improved the most compared to the other two with respect to FOF, depressive inclination, mobility, and muscle strength ($p < 0.05$), which are the direct contributors to the reduced incidents in falls that were recorded in the combination group. Furthermore, a combination of both physical and cognitive training improves dual task costs of walking ($p = 0.002$), gait initia-

tion ($p = 0.003$), and divided attention ($p < 0.001$) [26]. The results of the individual studies have been summarized in Table 1.

Discussion

Balance and strength are both essential functions a person must have in order to prevent themselves from falling, but, in many cases, the falls might also be caused by the underlying cognitive limitations of older persons. Therefore, a combination of physical and cognitive exercise might be an extremely beneficial method of fall prevention. The merits with descriptions of the individual exercises (i.e., Balance exercises and whole-body vibration) and combination therapy, and cognitive behavioral with exercise programs, are discussed below.

Balance Exercises

The ability to balance weakens with age and is a major risk for causing a fall [11]. It is estimated that approximately 17% of falls in the elderly are a consequence of balance and gait disorders [1]. Kovacs et al. [11] demonstrated the importance via 12 months of a multimodal Otago Exercise Program (OEP), which included both balance exercise (walking backward, tandem, heel, and sideways) and gait-related exercises (moderate-intensity strength training of 30-min daily walks and the other repetition-based strengthening exercises). Despite the positive impact of the multimodal exercise program with regards to balance, there was no noteworthy difference between the exercise group and the control group in fall prevention. However, another randomized controlled trial that also followed the OEP found a reduction in the incidence of falls after the exercises [12]. This exercise training improved patients' balancing ability through physical performance and functional capacity. This finding was supported by another study, which concluded that the balance training received over this time period (i.e., knee bends, backward walk, walk and turn, sideways walk, heel-toe stand, heel-toe walk, one leg stand, heel walk, toe walk, heel-toe backward walk, STS, and stair walk) decreased fall frequency [13]. This improvement was an impressive indicator of the effectiveness of OEP because FOF has been proven to be one of the major causes of falls [27]. Although OEP suggested a correlation between balance exercises and fall prevention, it included a combination of other forms of exercise, like strength and gait to further minimize the likelihood of falls.

A review of Tai Chi exercises, which combine mindful movement with dynamic balance, is necessary for the effect of balance exercises to be objectively demonstrated. Tai chi exercise has previously been reported as an effective training to prevent falls [28]. In a randomized controlled trial conducted in 2007, the study demonstrated both the improved balancing ability of the participants in the experimental group as well as a decrease in fall incidence [29]. This was corroborated by Li and colleagues where the Tai Chi group had fewer FOF, falls, fall-related injuries with improved functional balance, and physical performance versus the stretching participants [15]. However, some studies found little or no benefit to Tai Chi interventions for fall prevention with Wolf et al. [16] being one of them. In Nowalk et al. [17] randomized controlled trial, no effects were also found on the rate of falls or time to first fall compared to the control group. In a study by Faber et al. [30] no significant differences with regard to fall incidence were recorded for participants in both exercise groups had improved mobility and physical performance. A recent systematic review and meta-analysis by Lomas-Vega et al. [18] found Tai Chi training provides short-term benefits but is not able to affect the time to first fall.

Falling as a result of poor balance is a top risk factor for the vulnerable older population and improving balance and gait plays a vital role in reducing the severity and quantity of falls. Despite contrasting findings, it is necessary to recognize that any unstable person will encounter a fall at some point and by doing balance and gait exercises, which were proven to help even for only 4–12 months, they are able to minimize the risk of falling [31].

Whole-Body Vibration Exercise

Whole-body vibration exercises are a type of physical exercise that typically consists of static and/or dynamic exercises being done on a vibrating platform [19]. This type of exercising is gaining popularity with the older population due to its less taxing influence on the musculoskeletal, cardiovascular, and respiratory systems than other types of exercises (Álvarez-Barbosa et al. [32]). This discovery is encouraging because multiple studies have been demonstrated that whole-body vibration exercise can be beneficial for balance, muscle strength, walking gait, and capacity in the older population [33, 34]. However, in the institutionalized older population, fewer studies have been conducted to show long-term effects of whole-body vibration exercise.

A randomized controlled trial was conducted by Bautmans et al. [19] found whole-body vibration had im-

proved body balance than the control group, demonstrating its feasibility in NH and positive impact on balance and mobility, potentially decreasing fall risk. Another study showed improvements in motor capacity and gait and balance for the study group using whole-body vibration [20]. This highlights the potential of whole-body vibration as fall prevention therapy. Several other studies on short-term exercising interventions also suggested similar improvements in stability and mobility [32].

Despite multiple clinical trials suggesting positive implications of whole-body vibration exercising, there exists evidence which contradicts the efficiency of whole-body vibration training by the Physiological Profile Assessment [22]. Among the measured parameters, only the sway velocity and maximal isometric knee extension strength tests results improved individually for the whole-body vibration group. Other randomized controlled trials conducted further demonstrated the similarity of the efficiency of normal exercise programs and whole-body vibration exercise programs [21, 24]. While exercises remain a safe intervention for the institutionalized older population, whole-body vibration does not have a significant impact on fall frequency.

Combination Exercise

A journal article in *Aging and Mental Health* commented on a brief study that was used to evaluate the effectiveness of a cognitive-behavioral and exercise program in reducing the occurrence of falls. Follow-up revealed that the combination group experienced a reduction in fall incidence, FOF, decreasing depressive inclination and enhancing mobility and muscle strength in older population [25]. This finding further revealed the importance of a combination of physical and cognitive exercise in fall prevention.

In 2014, a study published in *BioMed Central Geriatrics* compared the efficiency of regular strength-balance exercise program and a strength-balance-cognitive training program [26]. The outcomes of this research study showed the positive effect of combinational training on dual task costs of walking, gait initiation, and divided attention; emphasizing adding cognitive exercises further aid to fall reductions to strength-balance training [26].

Rationale for the Inclusion/Exclusion Criteria

One of the most important inclusion criteria was the length of the investigated therapeutic intervention. The minimal length of the training regimen was 6 months which allowed the participants to adapt to the exercise regimen and benefit from it by increasing muscle strength

and/or improving balance. It was allowing researchers to reliably evaluate the exercises' effect on the patients' health. Additionally, the study aimed to determine the benefit of exercises in older patients, including those with a history of falls or cognitive impairments as a source of the valuable data. This review focused on the impact of the low-risk training programs containing balance, strength, combination of physical and cognitive tasks, and whole-body vibration exercise. These trainings were considered low risk as the elderly patients were not expected to receive injuries during the training due to the nature of the exercises, which was not associated with any straining and did not require the special preparation; in addition, it was conducted under supervision of the professional trainer. This is not true for the majority of the exercises placed in the high-risk category, whose potential to detriment elderly patient's health greatly outweighs their usefulness for fall prevention. Some of those exercises, such as lifting weights, crunches, and sit-ups, are dangerous to the elderly due to the risk associated with improper technique and age-related impairment of musculoskeletal system, while the running/high intensity yoga might inflict too much cardiovascular load on the elderly, increasing the risk of severe cardiovascular complications [35, 36].

Limitations

This review attempted its best to be unbiased, consistent, and accurate; however, there are some limitations that detract from the research. First, in this study, many randomized controlled trials consisted of only 6–8 week trials which reported no data on lasting effects. As well, the statistical significance was affected by variable sample sizes of the selected randomized controlled trials. Furthermore, this study included both institutionalized and community-dwelling elders, which may reduce the statistical significance due to the large differences in the environments and capability of the elders between the groups. Last, there may also be unknown errors that have skewed the results.

Implications

As cognitive and motor skills degrade with age, the risk of fall of older adults would continuously grow. Yet, exercise is one aspect of health that can combat this process. Still, in order to effectively and safely implement physical and cognitive training into the patients' treatment, further studies might focus more closely on the long-term impact of exercise. Clinical trials that would have both longer intervention and follow-up period are required to

further analyze and determine the longstanding effects of the exercise and prove its statistical significance. At the same time, when determining the efficiency of exercise in fall prevention, studies with similar sample sizes should be reviewed to ensure equal statistical significance. Last, studies focusing on specific living arrangements for the aging population, for example, isolating NH residents, should be conducted to ensure the feasibility of an exercise regimen in this environment.

Regiments that were beneficial and should be considered for use by care providers include 4 months, 1 h/week of Tai Chi, or 6–12 months following the OEP (50 min 3 times/week, knee bends, backward walk, walk and turn, sideways walk, heel-toe stand, heel-toe walk, one leg stand, heel walk, toe walk, heel-toe backward walk, STS, and stair walk) to improve balance. Last, a combination exercise lasting 2–4 months, with 2 times/week strength and resistance exercise, and 1 time/week discussion about falling were found to be beneficial in decreasing FOF and preventing falls.

Although physical activity requires effort and perseverance, the benefits of doing balance exercises, strength exercises, or a combination of both physical and cognitive exercises may help reduce and prevent falls even in a high-risk population. All the studies that were focused on determining the effect of exercising revealed improvement in the ability of the participants to walk and stand whether from increased stability, increased lower body strength, or even a decreased FOF. Exercises, however, need to be done on a consistent basis because the improvements disappear in absence of regular training, and the resulting deterioration will once again impact the quality of one's life [37]. The evidence shows that approximately 50 h is imperative to reduce the number of falls in the aged population and since most of the programs mentioned in this review utilized hour-long workout sessions and were over a 12-month span, the described exercise should be done, minimum, on a weekly basis [38].

It is important to recognize that although exercises help reduce the risk of falling and play a significant role in improving mobility safely, there will always be a risk of falls. Exercises simply help reduce that risk in the aged population. This review focused on the type of exercises in fall prevention, emphasizing the benefits of a nonpharmacological approach to this matter. As falls are multifactorial, single intervention may not be sufficient and frequently multiple interventions may be required to combat the issue, but this is out of the scope of the article.

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Statement of Ethics

This research did not need approval according to the World Medical Association Declaration of Helsinki or ICMJE Recommendations for the conduct, reporting, editing, and publication of Scholarly Work in Medical Journals.

Conflict of Interest Statement

The authors have no conflicts of interest to declare.

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Author Contributions

Helen Senderovich was responsible for the conception, design, drafting, critical revisions, final approval of version to be published, and accountable for all aspects of the published work. Basile Montagnese was responsible for the analysis and interpretation of data, drafting of article, and critical revisions. Nadiya Bayeva was responsible for the collection and interpretation of data and drafting of article. Akash Yendamuri was responsible for the collection and interpretation of data, drafting of article, and critical revisions.

Data Availability Statement

All data generated or analyzed during this study are included in this article. Further inquiries can be directed to the corresponding author.

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