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Case Report Paper

Effectiveness of Balance Exercise in Reducing Fall Risk Among the Elderly

Melly Anisa Putri[1*], Ahmad Nurwanto[1], Fauziyah Rezkyati[1]

[1] *Program of Applied Physiotherapy, Borneo Citra Medika Health Polytechnic. Tanah Laut, Indonesia.*

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***Corresponding Author:**
Melly Anisa Putri

Abstract: As individuals enter old age, they typically experience a decline in physical condition, characterized by reduced muscle strength that subsequently impairs bodily movement and functionality. These age-related physical changes often result in mobility impairments, limiting the elderly's ability to maintain postural stability necessary for performing daily activities, and thereby increasing the risk of falls. Balance disorders are among the primary factors contributing to the elderly's vulnerability to physical injuries from falls. This study, presented in the form of a literature review, aims to explore strategies for enhancing postural stability as a means to mitigate fall risk among older adults. Employing a scoping review methodology, this research investigates the effectiveness of balance exercise interventions in fall prevention. The literature search was conducted systematically following the PRISMA 2020 Flow Diagram guidelines and utilized three primary databases: PubMed, ScienceDirect, and SAGE Journals. The findings indicate that several exercise-based interventions, such as the Balance-Enhancing Exercise Program (BEEP), Walking Meditation, and Multi-system Physical Exercise (MPE) are effective in reducing the likelihood of falls in the elderly. It is concluded that fall risk is a significant concern among older individuals; however, this risk can be managed, particularly in those who engage in regular physical training and possess sound mental health. Among the evaluated interventions, the Self-Administered Balance-Enhancing Exercise Program (BEEP) appears to be the most effective in minimizing fall risk in elderly populations.

Keywords: Balance Training, Elderly, Exercise Balance, Fall Prevention, Risk of Falling.

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1. Introduction

Life expectancy serves as a key indicator of a population's overall health status. As life expectancy increases, so too does the proportion of individuals enter advanced age. The elderly defined as individuals over the age of 60 undergo the natural aging process, which includes physiological changes and a decline in bodily functions. One notable change is the degeneration of the musculoskeletal system, leading to decreased muscle strength and compromised balance. Balance disorders among the elderly reflect an inability to maintain postural stability while standing [1].

Data from the National Health and Nutrition Examination Survey (NHANES) in the United States reveal that, among 5,000 individuals aged over 40, approximately 19% of those aged over 49, 69% of those aged 70–79, and 85% of those aged 80 and above exhibit balance-related issues. On average, adults between 65 and 75 years of age experience notable deterioration in balance, which adversely affects their quality of life. Such changes significantly elevate the risk of falling, which is defined as the inability to maintain body stability during standing or delayed responses to postural changes [2].

According to the World Health Organization (WHO), the elderly population in the Southeast Asia region currently constitutes approximately 8% around 142 million individuals. This figure is projected to triple by 2050. In Indonesia, the elderly population accounted for approximately 5.3 million (7.4%) in 2000, rising to 24 million (9.77%) in 2010, and is projected to reach 28.8 million (11.34%) by 2020. Additionally, it is estimated that by 2020, Indonesia's total elderly population may reach approximately 80 million [3].

Individuals entering old age experience a progressive decline in physical health, marked by physiological changes such as diminished auditory and visual acuity, reduced muscle strength, and slower bodily movements [4]. These physical alterations contribute to impaired mobility, subsequently limiting the elderly's independence in performing daily tasks and significantly increasing the risk of falls [5]. Postural imbalance is identified as a leading cause of frequent falls among older adults [6].

Falls not only jeopardize the physical safety of the elderly but can also result in diverse injuries and psychological trauma. The prevalence of fall risk is reported at 49.4% among individuals over 55 years of age, and rises to 67.1% in those over 65 [6]. Annual fall incidents among elderly individuals living in the community increase from 25% at age 70 to 35% after age 75. Approximately 30% of community-dwelling adults aged 65 and above experience falls annually, and some may experience recurrent episodes [7]. Even in the absence of physical injuries, falls can have profound psychological effects, including post-fall trauma, fear of falling, heightened anxiety, loss of confidence, limitations in daily functioning, and the development of "fall phobia" [8].

Several preventive strategies have been proposed to reduce fall risk in the elderly, such as maintaining balanced nutrition, calcium supplementation, ensuring environmental safety, and engaging in balance-enhancing exercises [9]. Balance exercises are forms of physical activity aimed at improving the body's equilibrium [10]. The present case study aims to enhance postural stability and mitigate fall risk in the elderly through balance exercises, with the broader goal of improving body composition such as reducing fat, increasing muscle mass, boosting immunity, enhancing muscle strength, promoting cardiovascular health, regulating respiration, and alleviating symptoms of anxiety or depression [11].

Exercise programs for the elderly typically incorporate elements of flexibility, strength, balance, and stretching. Engaging in regular physical activity has been shown to decelerate the decline in bone density, while enhancing muscle mass and strength, including the function of cardiac muscles [12]. A range of physical activities such as walking has been proven effective in significantly improving postural balance [13]. In a study involving 113 elderly individuals with a history of falls, those who participated in a structured exercise regimen twice weekly for five weeks demonstrated a 46% reduction in fall incidence. Further research revealed that elderly participants who engaged in balance exercises three times per week for six weeks exhibited significantly better outcomes than their non-exercising counterparts, particularly in terms of improved stability [14].

Findings from a case study involving three elderly participants aged between 60–74 years confirmed that aging is associated with diminished physiological functions, notably affecting postural control. The decline in muscle strength among the elderly is primarily due to reduced protein levels [15], while neurological changes, especially in motor neurons, also contribute to impaired reflexes and balance regulation [16]. Environmental assessments of the participants' homes indicated safety concerns, particularly the absence of supportive handrails in critical areas such as bathrooms, thereby elevating fall risks. Notably, fall risks in older adults are influenced not only by intrinsic physiological

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factors but also by extrinsic environmental hazards, such as slippery or uneven flooring, inadequate lighting, stairs, and the lack of safety supports [17].

Evaluations of the three participants post-intervention showed measurable improvements in balance following implementation of balance exercises four times within a week. This was evident in the increase in their respective Berg Balance Scale (BBS) scores: the first participant averaged 39.25, the second 31.5, and the third 36.75, indicating enhanced postural stability after the intervention.

Balance exercises stimulate the body's postural and movement response systems. Movements such as Single Limb Stance, Tandem Stance, 3-Way Hip Kick, Lateral Stepping, Standing Marching, Mini Lunge, Calf Stretch, Heel Raises, Hamstring Stretch, and Foot Taps to Step elicit sensory feedback by activating receptors in the joints, muscles, and nervous system, which subsequently transmit signals to the brain. Within the somatosensory system, this input is processed and relayed to the motor system, initiating muscular contractions in response to balance challenges. The resulting feedback involves coordinated actions among muscles, tendons, and cutaneous receptors, producing adaptive motor responses. Through regular balance exercise, muscle strength is enhanced, thereby improving postural stability during movement. Additionally, the body's automatic postural adjustments become more efficient during such training [18].

The case study findings demonstrate that balance exercises significantly contribute to reducing fall risks while enhancing postural control in the elderly. These findings align with those of Ida's research, which reported that four sessions of balance training were sufficient to produce measurable improvements in elderly balance performance [19]. Furthermore, balance training has been associated with improvements in both static and dynamic stability, motor system function, sensory integration, and postural control. Supporting evidence from related studies indicates notable differences in fall risk assessments before and after the implementation of balance training protocols [20].

2. Method

This literature review was conducted using a systematic online search strategy following the PRISMA Flow Diagram 2020 guidelines. The search process targeted three academic databases: PubMed, ScienceDirect, and Sage Journals. The review adopted the scoping review methodology, which offers a structured framework for exploring and mapping existing literature relevant to a defined research question [21]. The scoping review process was executed through five sequential stages: (1) identifying the core research question, (2) conducting a systematic literature search to locate sources aligned with the question, (3) selecting eligible studies, (4) synthesizing and presenting data from the selected literature, and (5) drawing conclusions, proposing recommendations, and reporting the overall analytical findings [22].

An initial search across the three databases yielded a total of 610 articles. Article selection was guided by the PICO framework—Population: elderly individuals; Intervention: physical exercise; Comparison: not specified; Outcome: reduced risk of falls. Inclusion criteria for this review encompassed: (1) free full-text availability, (2) publication date within the last decade (2011–2021), (3) use of randomized controlled trial (RCT) or quasi-experimental designs, (4) English language, and (5) a minimum of 30 participants per group in studies with at least two comparison groups.

The search utilized the following keywords: ("Aged" OR "Elderly" OR "Frail elderly") AND ("Physical exercise" OR "Physical activity" OR "Physical training" OR "Exercise training") AND ("Fall risk reduction" OR "Balance").

3. Finding and Discussion

The findings of the author's analysis indicate that various forms of physical exercise can effectively mitigate the risk of falls among elderly individuals. Among the most notable interventions identified are the Balance-Enhancing Exercise Program (BEEP)**,** Walking Meditation Physical Therapy, and Multi-System Physical Exercise (MPE)**.** These exercise modalities demonstrated measurable improvements in postural stability, muscular strength, and motor coordination in older adults, as supported by empirical evidence drawn from the analyzed journal articles.

To present the review findings in a systematic manner, the extracted data are organized into a comprehensive table. This table outlines the intervention types, study authors and publication years, research designs, methodologies, and the respective outcomes of each study. From the literature search, three primary journal articles were identified, each offering distinct approaches but consistently confirming the efficacy of physical exercise interventions in reducing fall risk among the elderly. These findings are detailed in the subsequent table presentation.

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Table 1. Exercise Interventions to Reduce Fall Risk in the Elderly

Article	Research Design	Sample	Variables and Instruments	Results	Research Strengths and Weaknesses
[15]	Randomized Controlled Trial	Adults aged ≥ 65 years living in outpatient community settings	*Research Framework Overview* Independent Variable: Self-Administered Balance-Enhancing Exercise Program (BEEP) Dependent Variable: • Motor control and coordination • Muscle strength • Position and movement detection • Gaze stability • Balance control both • Sensory eweighting process Instrument: Balance ability Specific balance tests (e.g., Timed Up and Go, One-Leg Stance, BBS) Self-Perceived Dizziness: Activity-Specific Balance Confidence (ABC) Scale Physical Fitness Level / Energy Expenditure: *Human Activity Profile (HAP)* questionnaire (maximum score: 94)	Key Results from BEEP Intervention Study One-Leg Standing Time Improvements: • +32% with Eyes Open (EO) on compact surfaces • +206% with Eyes Closed (EC) on compact surfaces • +54% with EO on suitable (less stable) surfaces • Statistical Significance: $P < .001$ Posturography Findings • Confirmed improved balance under disturbances on solid surfaces • Improvements observed with both EO and EC conditions • Statistical Significance: $P = .033$	*Strengths of BEEP Intervention* • Vision-Impaired Balance Training: Exercises are specifically designed to train balance when vision is poor (e.g., eyes closed). • High Challenge Level: Balancing with eyes closed (EC) is notably difficult, making it an effective challenge for relatively healthy elderly individual Weaknesses / Study Limitation Participant Recruitment: Participants may have been more health-conscious or already aware of balance-related issues prior to the study, potentially biasing the outcomes.

Article	Research Design	Sample	Variables and Instruments	Results	Research Strengths and Weaknesses
[9]	Randomized Controlled Trial	Participant Information • Total Participants Enrolled: 60 women (elderly) • Random AssignmentControl Group: 30 participants • WM Group (Walking Meditation or other intervention group): 30 participants • Randomization method: Random draw of lot numbers • Dropouts: 1 participant moved to another province and 1 participant fell ill • Group: 29 participants • WM Group: 29 participants	Variable Independent: Walking meditation (WM) physical therapy. Dependent Variable: • Balance control • Reposisi ankle Instruments: Main effects of WM and training time on studied parameters analyzed with two mixed model ANOVA direction and by Bonferroni, except BBS. BBS data was analyzed using non-parametric statistics, because the data was not normally distributed. Wilcoxon and Mann-Whitneykamutes signed rank tests were used to compare, both within and between groups, BBS parameters. Statistical significance was set at $p < 0.05$.	WM improving ankle proprioception and balance performance of elderly women. The characteristics of WM, as a slow form of walking along with attention to leg and foot movements, provide longer single-leg stance periods and improve control neuromuscular. Therefore, WM is a form of gentle and balanced exercise with mind-body exercises that promote proprioception and balance performance among elders. In addition, the results also support that balance performance and ankle proprioception are associated with age-related decline among older people, who are not involved in physical training whatever.	*Strength*: Apart from being physically beneficial, Walking Meditation practice provides mental exercise. In addition, current medical science findings have revealed that calm or peaceful conditions can encourage nerve regeneration. And slow gait activity during WM can be classified as light exercise for the elderly. *Weaknesses*: This study only involved older people with moderate levels of physical activity. Thus, the results of this research cannot refer to elderly people with high or low levels of physical activity. Also, this study did not examine brain functional changes during WM training. Therefore, the improvements in ankle proprioception in this study may not be clearly related to improvements in brain processing of meditation or attention mechanisms.

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Article	Research Design	Sample	Variables and Instruments	Results	Research Strengths and Weaknesses
[10]	Randomized Controlled Trial	72 participants randomly selected and then randomly assigned to groups *Multi-system Physical Exercise* (MPE) (n = 36) and controls (n = 36) using n block randomization	Variable Independent: *Multi-system Physical Exercise (MPE)* Dependent Variable: • Propriocept ion • Muscle strength • Reaction time balance and posture Instruments: The risk of falling is measured by use Physiological Profile Assessment (PPA) which identify pre-weakness and measure fall risk score light and currently. Meanwhile, taste afraid of falling measured with use Efficacy Scale Fall Thailand—questionnaire International, which has alpha coefficient Cronbach of 0.95. Depression was assessed use Depression Scale Thai Geriatrics (TGDS), which own alpha coefficient Cronbach 0,85. HRQOL was assessed use survey questionnaire Health Short Form 36- Item (SF-36) Thai version.	Intervention consists of proprioception , muscle strengthening, reaction time, and balance training and is performed three days per week for 12 weeks. The primary outcome was fall risk assessed using PPA at 12 weeks post-baseline and on 24 weeks follow-up. Difference significant found on Improvement risk of falling, proprioception, strength muscle, time reaction and wobble postural, and fear score fell on group AND compared to with control on week 12 and 24 ($P < 0.001$ and $P < 0.05$). Besides that is, HRQOL has been increased regularly significant on group AND compared to with group control (on 12th week $p<0,05$). Program ALSO regularly significant increase muscle strength and increase proprioception, reaction time, and sway postural ones leads on Fall risk reduction in older adults with pre-frailty. Therefore, the MPE program recommended for use in daily primary care practice pre-frail population.	*Strenth*: The study results were consistent with pre-vious studies, which showed that exercise interventions had beneficial effects on improving physical perfor mance and redu-cing the risk of falls in frail and pre-frail elderly living in the com-munity. *Weaknesses*: This study has several limitations which should be noted. *First*, training program this research designed as group exercise, which is not allows for set intensity appro-priate training for each individual. Practice groups often generate level more euphoria higher than training individual. In studies next, fitness everyone's physique must be assessed and subject should be set to in groups with ability the same do. *Second*, this program designed as training program center based, so it's difficult subject to appear on House. There fore that is, program based the house must be designed for use sustainable and effective on elderly.

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3.2. Discussion

1) Balance-Enhancing Exercise Program

A study by Anna Hafström and colleagues in 2016, titled "Improved Balance Confidence and Stability for Elderly After 6 Weeks of a Multimodal Self-Administered Balance-Enhancing Exercise Program: A Randomized Single Arm Crossover Study," demonstrated a significant improvement in balance. The results showed a 32% increase in one-leg standing time with eyes open (EO), a 26% increase with eyes closed (EC) on a solid surface, and a 54% increase with EO on a compliant surface (P < .001). Posturography confirmed these balance improvements during perturbations on a solid surface, with EO and EC results showing a correlation (P .033). Additionally, performance in walking, bench stepping, and the Timed Up and Go test improved (P .001), as did scores in the Berg Balance Scale and balance confidence scale (P .018). The participants in this study underwent a Balance-Enhancing Exercise Program (BEEP) for 6 weeks, which was designed to be simple, safe, and suitable for home use. To reduce the risk of orthostatic hypotension and syncope, the program began with a 3-minute warm-up, allowing participants to focus mentally on the exercises [15]. The program included activities that promoted sensory reweighting, addressing the degenerative effects of aging on the sensory systems responsible for detecting position and movement. BEEP exercises were performed on both solid (floor) and compliant surfaces (double-fold exercise mat), with and without eyes open. Although participants were instructed to train daily, they averaged 16 minutes of training four times per week. No adverse incidents or side effects were reported by the participants [23].

2) Walking Meditation

A study by Apsornsawan Chatutain, Jindarut Pattana, Tunyakarn Parinsarum, and Saitida Lapanantasin in 2018, titled "Walking Meditation Promotes Ankle Proprioception and Balance Performance Among Elderly Women," revealed that Walking Meditation (WM) enhances ankle proprioception and balance in elderly women. WM, characterized by slow walking with a focus on leg and foot movements, leads to longer single-leg stance durations and improves neuromuscular control. Thus, WM serves as a gentle form of exercise and balance training that enhances proprioception and balance among older adults. The study also found that balance and ankle proprioception performance decline with age in individuals who do not engage in physical training. The WM group participated in training for 8 weeks, three days a week, while the control group continued their regular daily activities. The WM sessions were guided by a Buddhist monk with over 5 years of experience in the practice. During the training, participants focused their attention on their leg and foot movements while walking slowly back and forth, taking 8 to 12 steps for 30 minutes daily. Ankle proprioception, specifically the right ankle joint, and balance performance were assessed at baseline, after 4 weeks, and at the end of the 8-week training. The same assessor conducted all evaluations throughout the study and was blinded to group randomization [24].

3) Multi-System Physical Exercise

In a study by Jiraporn Chittrakul, Penprapa Siviroj, Somporn Sungkarat, and Ratana Sapbamre in 2020, the Multi-System Physical Exercise (MPE) intervention was shown to reduce the risk of falls in older adults with pre-frailty. The MPE program was designed based on components from a falls risk assessment, specifically the Physiological Profile Assessment (PPA), and existing literature on exercise interventions for fall prevention. The program consisted of four main components: proprioception training, muscle strength training, reaction time training using auditory cues, and postural balance training [25].

The intervention was carried out for 12 weeks, with the participants in the intervention group engaging in the program three times a week, for a total of 36 sessions. To ensure safety and proper execution, participants exercised in supervised sub-groups of twelve. Each session lasted 60 minutes, starting with a 10-minute warm-up and concluding with a 5-minute cool-down. Initially, all participants began at the beginner level, progressing through intermediate and advanced levels as a group, since they all had comparable abilities at the start. The program was designed to allow participants to successfully advance through each level. Each exercise component was performed in three sets of 15 repetitions, with participants holding the contraction for 10 seconds, followed by a 10-second rest between sets. The program was taught by a physiotherapist with experience in exercise instruction. The control group, on the other hand, participated in flexibility training three times a week and met with a researcher once a week during the 12-week study period to discuss their health experiences [26].

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Based on the explanations of each intervention, it was found that all three interventions effectively reduce the risk of falls by improving balance, muscle strength, and movement coordination. However, among these, the Self-Administered Balance-Enhancing Exercise Program (BEEP) stands out as one of the most effective physical exercises to address fall risk in the elderly. Aging represents the final stage of life, where maintaining health becomes crucial due to the decline in physiological, psychological, cognitive, and functional capabilities. These physical changes often lead to impaired mobility, limiting independence and increasing the risk of falls among the elderly [27].

The analysis of the three journal articles revealed the positive impact of physical exercise interventions on reducing the risk of falls in older adults, which aligns with research conducted by Quanjer. According to Quanjer, structured physical exercise can significantly enhance the fitness of the elderly. Regular physical activity improves strength and dexterity, helps prevent falls, and supports independence in daily activities. It also slows down bone density loss and increases both muscle mass and strength, including that of the heart muscle [28].

Various forms of exercise, including walking, have been proven to significantly improve balance. Several interventions, such as Balance-Enhancing Exercise Program (BEEP), walking meditation therapy, and Multi-System Physical Exercise (MPE), have been widely applied to reduce fall risk in the elderly [29]. Researchers who analyzed these interventions found that all three significantly improved balance in elderly participants. However, as previously mentioned, the Balance-Enhancing Exercise Program (BEEP) is considered the most effective and easiest intervention for elderly individuals to follow in reducing the risk of falls [30].

The Balance-Enhancing Exercise Program (BEEP) intervention resulted in increased balance, especially when disturbed on a solid surface, and improvements were observed with both eyes open and eyes closed [31]. Additionally, walking, bench stepping, and the Timed Up and Go (TUG) test all showed improvements in terms of speed and performance. After the intervention, the participants demonstrated enhanced walking speed (30 meters), better scores on the modified bench step test, and higher results on the Berg Balance Scale (BBS). Participants reported feeling that their balance had improved, making it easier for them to walk, especially while wearing socks [32].

One of the key advantages of BEEP is its potential to be implemented before balance dysfunction becomes too severe [33]. This preemptive approach could effectively reduce the risk of falls in the long term by improving balance and overall health. The program can help maintain the functional ability and mobility of seniors living in communities with a relatively low fall risk, which aligns with research suggesting that after six weeks of intervention, participants' ability to balance on one leg with visual information improved by more than 30% [34].

This improvement is particularly significant for preventing fall-related fractures, as balance measurements like those from the BBS have been validated to predict hip laxity and fractures in elderly populations [35]. A notable strength of this intervention is that it includes exercises to train balance even when vision is compromised, an aspect that sets it apart from many other balance training programs [36]. Unlike other interventions, which often involve health professionals and are delivered either individually or in group sessions (typically several times a week and at higher costs), BEEP is a home-based program. It allows participants to adjust the exercises based on their personal progress and challenges their postural control system, fostering effective learning processes [37].

However, despite the many advantages of BEEP, the program does have some limitations [38]. High scores in the BBS, HAP, ABC, and Mattiasson-Nilo questionnaires indicate that the elderly participants in the study may not have had a high risk of falls to begin with. Therefore, it can be concluded that elderly individuals at high risk of falls may not benefit as much from BEEP and should consider other interventions better suited to their needs [39].

4. Conclusion

The risk of falling is a common concern among elderly individuals. However, this risk can be effectively addressed, particularly in older adults who engage in regular physical activity and maintain good cognitive function. Several non-pharmacological interventions have been identified to help reduce fall risk, including the Self-Administered Balance-Enhancing Exercise Program (BEEP), Walking Meditation, and Multi-System Physical Exercise (MPE). Based on a review of the literature, the Self-Administered Balance-Enhancing Exercise Program (BEEP) emerges as one of the most effective physical exercise interventions for preventing falls in the elderly. Research indicates that consistent participation in the BEEP program significantly reduces the risk of falls among older

adults. In clinical nursing practice, this suggests that nurses should consider implementing the BEEP intervention as part of fall-prevention strategies for patients identified as being at risk.

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