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The effect of the otago exercise program (OEP) on motor function in elderly people with osteoporosis

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Abstract

Background: The number of elderly people in Indonesia continues to increase, with the proportion of the elderly population reaching 11.75% in 2023, up from 10.48% in the previous year. This increase in the elderly population is directly proportional to the prevalence of osteoporosis, which not only impacts individuals but also places a burden on families and the health system.

Purpose: To analyze the effect of physical therapy on the balance of elderly people with osteoporosis, to assess changes in muscle strength after undergoing physical therapy and to identify the impact of physical therapy on the risk of falls in elderly people with osteoporosis.

Method: This study employed a quantitative, quasi-experimental design with a pre-test and post-test design. Accidental sampling was used, and univariate analysis was used to determine the frequency distribution of each variable. Bivariate analysis used the Wilcoxon mean difference test for each group and the Mann-Whitney test to determine differences in post-test results between the two groups.

Results: The majority of participants were aged ≥ 66 years, more female participants than male, most participants had jobs. • The average increase in BBS scores in the OEP group (2.67). The average decrease in TUG scores in the OEP group (0.87) was lower than the control group (2.00), p value = 0.0005. Both results are supported by a highly significant p value (<0.001) and a large effect size (>1), which means that the OEP intervention had a strong and real impact on elderly participants.

Conclusion: Statistical analysis results indicate that the Otago Exercise Program (OEP) has a significant and significant impact on improving balance in older adults (BBS score), mobility, and reducing fall risk (TUG score). Therefore, the OEP is recommended as an effective physical exercise program to improve the quality of life in older adults and reduce the risk of falls.

Suggestions: Involve a larger number of participants Extend the duration of the intervention program and conduct long-term follow-up, Include additional variables such as quality of life, actual fall risk, and the impact of the intervention on daily independence.

Keywords: Elderly; Osteoporosis; Otago Exercise Program (OEP).

INTRODUCTION

Osteoporosis is a degenerative disease characterized by decreased bone density and quality, which increases the risk of fractures, especially in the elderly. Osteoporosis is one of the most common diseases of the skeletal system associated with an increased risk of fractures and causes many complications for patients (Patel &

Saxena, 2025). With increasing age, the prevalence of this disease increases, making it a serious problem among the elderly. In this study, the prevalence of osteoporosis among the elderly worldwide was examined to gain an understanding of its prevalence patterns (Salari, Darvishi, Bartina, Larti, Kiaei, Hemmati, Shohaimi, & Mohammadi, 2021).

According to data from the World Health Organization (WHO), osteoporosis is one of the main health problems among the elderly population worldwide. In Indonesia, the prevalence of osteoporosis was recorded at 19.7% according to the Indonesian Osteoporosis Association (Perosi), while the Ministry of Health stated the figure was around 10.3%. This indicates that 2 in 5 Indonesians are at risk of osteoporosis (Ministry of Health of Republic of Indonesia, 2023). With increasing age, decreased bone density can cause impaired motor function and balance, as well as increase the risk of falls that can be fatal. Age-related bone loss is influenced by various factors, including hormonal, metabolic, genetic, and environmental factors (Conti, Russomanno, Corbi, Toro, Simeon, Filippelli, Ferrara, Grimaldi, D'Argenio, Maffulli, & Filippelli, 2015). This makes older adults more susceptible to serious injuries that can lead to permanent disability or even death (Yang, Wang, Liu, Qu, Wang, Chen, Zhang, & Luo, 2022). With increasing life expectancy, the prevalence of osteoporosis and its impact on quality of life for older adults has become a major concern in the healthcare world. One recommended method for managing the impact of osteoporosis is physical therapy, which aims to improve muscle strength, balance, and flexibility to reduce the risk of falls and increase the independence of older adults in carrying out daily activities (Hertz & Santy-Tomlinson, 2024).

The number of elderly people in Indonesia continues to increase, with the proportion of the elderly population reaching 11.75% in 2023, up from 10.48% in the previous year (Gustiyan, & Sutantri, 2023). This increase in the elderly population is directly proportional to the prevalence of osteoporosis, which not only impacts individuals but also places a burden on families and the healthcare system (Pramadita, Wati, Muhartomo, Kognitif, & Romberg, 2019). When an elderly person experiences a fracture due to osteoporosis, the recovery process can be very long and often requires intensive medical care. Serious injuries such as hip fractures can result in loss of independence and dependence on others, which reduces quality of life and increases the economic and social burden on families and healthcare facilities.

Physical therapy has long been used as a rehabilitation method to help elderly people maintain

and improve their motor function (Pujiastuti & Utomo, 2003). However, many elderly people avoid physical activity for fear of falling or further injury. In fact, lack of physical activity actually accelerates functional decline. Muscle and balance problems, making them more susceptible to falls and fractures. Therefore, this research is important to demonstrate that physical therapy is not only safe but also effective in improving balance and muscle strength, and reducing the risk of falls in older adults with osteoporosis.

Balance training is crucial for older adults to increase muscle strength and maintain body stability, enabling them to perform normal activities and prevent falls. Some effective exercises for reducing fall risk in older adults include Otago exercises, square step exercises, muscle strengthening exercises, and similar exercises (Martins, Guia, Saraiva, & Pereira, 2020). Group-based Otago exercises significantly improved mobility, functional balance, single-leg balance, and lower-limb strength compared to a control group. Although several studies have discussed the benefits of physical therapy for the elderly, more specific scientific evidence is needed regarding its effects on older adults with osteoporosis (Benavent-Caballer, Rosado-Calatayud, Segura-Ortí, Amer-Cuenca, & Lisón, 2016). This study is expected to provide stronger and more accurate data regarding the effectiveness of physical therapy as a rehabilitation strategy and prevention of osteoporosis complications. With this research, medical personnel and physiotherapists will have a clearer scientific basis for designing more optimal therapy programs for older adults. From a public health perspective, if physical therapy proves effective in improving motor function and preventing falls in older adults with osteoporosis, the results of this study can be used as a basis for developing better health policies. Physical therapy-based rehabilitation programs can be prioritized in health services for older adults, whether in hospitals, nursing homes, or in the community.

It is a misconception that those with osteoporosis need to limit physical activity to prevent physical impairments such as fractures. In fact, the right type of activity can help strengthen muscles, which provides better protection for bones. Several studies have shown that structured physical exercise can help increase bone density and improve motor

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function in older adults with osteoporosis (Paddiansyah, Nisa, & Faddiasya, 2023). Good exercises for people with osteoporosis include weight training, resistance training, and balance training. These exercises can help slow bone loss. However, there are not many studies specifically examining the effectiveness of physical therapy on motor function in older adults with osteoporosis in Indonesia. Therefore, this study aims to evaluate the effect of physical therapy on motor function in older adults with osteoporosis.

RESEARCH METHOD

This quantitative study used a quasi-experimental design using a pretest–posttest approach with a control group. The study was conducted at the Medical Rehabilitation Unit of Bhakti Husada Hospital, Cikarang, from June to September 2025, after obtaining ethical approval from the Health Research Ethics Committee of Bhakti Husada Cikarang Health College, with the following letter: No. 332C B/STIKes-BHC/LPPM/VII/2025.

The study population was elderly people with osteoporosis undergoing therapy at the Medical Rehabilitation Unit of Bhakti Husada Hospital, Cikarang. The sample was obtained using simple random sampling based on predetermined inclusion and exclusion criteria, then divided into an intervention group and a control group. Inclusion criteria included elderly people aged ≥60 years with

a diagnosis of osteoporosis and able to follow exercise instructions. Exclusion criteria included medical conditions or cognitive impairments that could hinder participation in the exercise program.

The intervention group received the Otago Exercise Program (OEP), while the control group received standard hospital physical therapy without OEP exercises. The Otago Exercise Program was conducted over 12 sessions, twice weekly, for approximately 15 minutes each session, tailored to the physical condition of the elderly. The program consisted of 17 movements, including lower extremity muscle strengthening exercises, static and dynamic balance exercises, and walking exercises, and was conducted under the supervision of a physiotherapist.

The research instruments used were the Berg Balance Scale (BBS) to assess balance and the Timed Up and Go Test (TUG) to assess functional mobility. Measurements were taken before the intervention (pretest) and after all intervention sessions were completed (posttest).

Data were analyzed using univariate analysis to describe participants characteristics and bivariate analysis. The Wilcoxon test was used to analyze differences in pretest and posttest scores within each group, while the Mann–Whitney test was used to analyze differences in posttest results between the intervention and control groups. The significance level was set at $p < 0.05$.

RESEARCH RESULTS

Table 1. Characteristics of Participants (N=30)

Variable	Group	
	Intervention (n=15)	Control (n=15)
Age (Mean±SD)(Range)(Year)	(68.00 ± 6.23)(60–81)	(66.13 ± 6.19)(60–83)
Age (n/%)		
<66 Years	6/40.0	9/60.0
≥66 Years	9/60.0	6/40.0
Gender (n/%)		
Male	3/20.0	3/20.0
Female	12/80.0	12/80.0
Employment (n/%)		
Employee	8/53.3	10/66.7
Unemployment	7/46.7	5/33.3

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Participant characteristics showed that the intervention group was dominated by elderly people aged ≥ 66 years (60%) with a mean and standard deviation of 68.00 ± 6.23 and an age range of 60 to 81 years, while the control group was dominated by people aged <66 years (60%) with a mean and standard deviation of 66.13 ± 6.19 and an age range of 60 to 83 years. Gender distribution in both groups was similar and predominantly female (80%), reflecting the high prevalence of osteoporosis in elderly women. Most participants in both groups were still working, with a higher proportion in the control group (66.7%) than in the intervention group (53.3%). In general, baseline characteristics between the two groups were relatively comparable, although there were differences in age distribution that need to be considered in interpreting intervention results.

Table 2. T-test to Compare

Variable	Group		P	Effect Size
	Intervention (n=15)	Control (n=15)		
Berg Balance Scale (Mean$\pm$SD)	(2.67 $\pm$ 0.53)	(0.33 $\pm$ 0.12)	0.0002	1.56
Time Up Go Test (Mean$\pm$SD)	(0.87 $\pm$ 0.51)	(2.00 $\pm$ 0.41)	0.0005	-1.42

Table 2 shows that the mean BBS before and after treatment (mean of the OEP group = 2.67; SD = 0.53) was higher than the control group (mean = 0.33; SD = 0.12). This difference was statistically significant ($p = 0.0002$). The magnitude of the difference between the control and OEP groups was measured using an effect size of 1.56, indicating a significant effect.

The mean TUG before and after treatment (Mean of the OEP group = 0.87; SD = 0.51) was lower than the control group (Mean = 2.00; SD = 0.41). And the difference was statistically significant ($p = 0.0005$). The magnitude of the difference between the control and OEP groups was measured using the effect size, which resulted in -1.42, meaning a large effect.

DISCUSSION

Based on the study results, participants characteristics (Table 1) show that in the intervention group, the majority of participants were aged ≥ 66 years (60%), while in the control group, the majority were aged <66 years (60%). The gender distribution in both groups was similar, with women dominating (80%), who are the group most susceptible to osteoporosis. Osteoporosis is characterized by decreased bone mass and density, resulting in brittle bones and an increased risk of fractures (Kanis, Burlet, Cooper, Delmas, Reginster, Borgstrom, Rizzoli, & European Society for Clinical and Economic Aspects of Osteoporosis and Osteoarthritis (ESCEO), 2008). This condition is often accompanied by sarcopenia—a decrease in muscle mass and strength—which significantly

affects balance and mobility (Rantanen, Guralnik, Sakari-Rantala, Leveille, Simonsick, Ling, & Fried, 1999). Most were still working (76.67%). Participants who were still actively working tended to have higher levels of physical activity, making them more responsive to the OEP exercise program. Physical activity accelerates neuromuscular and musculoskeletal adaptations, contributing to improved BBS scores and decreased TUG times (Seidler, Bernard, Burutolu, Fling, Gordon, Gwin, Kwak, & Lipps, 2021; Cadore, Casas-Herrero, Zambom-Ferraresi, Idoate, Millor, Gómez, Rodríguez-Mañas, & Izquierdo, 2022). In older adults, particularly women, aging is accompanied by a decline in muscle mass, strength, and bone density, which increases balance disorders and the risk of falls (Cruz-Jentoft, Bahat, Bauer, Boirie, Bruyère, Cederholm, Cooper, Landi, Rolland, Sayer, Schneider, Sieber, Topinková, Vandewoude, Visser, & Zamboni, 2021; Kanis, Cooper, Rizzoli, Reginster, & Scientific Advisory Board of the European Society for Clinical and Economic Aspects of Osteoporosis (ESCEO) and the Committees of Scientific Advisors and National Societies of the International Osteoporosis Foundation (IOF), 2019; Yoo, Ha, Kwon, Lee, Koo, & Park, 2022).

Decreased musculoskeletal function in older adults with osteoporosis leads to poor postural control and limitations in performing functional activities, reflected in low BBS scores and prolonged TUG times in the non-intervention group. According to neuromuscular adaptation theory, structured exercise can improve motor unit recruitment, muscle

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coordination efficiency, and reflex responses, which play a role in postural control and functional movement (Horak, 2006). In older adults with osteoporosis, Otago Exercise Program (OEP) training stimulates increased muscle strength and sensory function, resulting in improved balance ability and a reduction in the time required to complete mobility tasks such as TUG. Furthermore, weight-bearing muscle training can stimulate osteogenesis, indirectly increasing bone strength, which supports improved motor performance (Kohrt, Bloomfield, Little, Nelson, & Yingling, 2004).

In a t-test analysis (Table 2), Berg Balance Scale (BBS) scores showed a significant increase in the treatment group (OEP) compared to the control group. This indicates that the Otago Exercise Program (OEP) is effective in improving balance ability in older adults. This finding is consistent with the theory that the OEP, consisting of leg muscle strengthening exercises, balance training, and walking, can improve postural stability and reduce the risk of falls.

Older adults, especially women, tend to experience decreased muscle mass (sarcopenia), decreased proprioceptive function, and changes in the vestibular system, which collectively affect balance and stability (Horak, 2006). An OEP exercise program that systematically emphasizes leg muscle strengthening, balance training, and coordination can activate neuromuscular adaptation processes, thereby improving postural ability and resulting in a significant increase in BBS scores in the OEP group.

Additionally, older women tend to be more responsive to structured exercise programs because they typically have lower levels of physical activity than men. Therefore, exercise interventions produce more significant changes in this group. Routine daily activity can also facilitate the success of OEP exercises because the body is already in a state of adaptation. The additional exercise from an OEP program improves muscle strength and sensorimotor function, ultimately improving balance ability.

Neuroplasticity theory states that the nervous system is capable of adapting and reshaping neural pathways in response to repeated, targeted exercise (Kleim & Jones, 2008). The Otago Exercise Program (OEP), which involves regular balance training and leg muscle strengthening, provides sufficient

stimulation to trigger positive adaptations in the sensorimotor system. These adaptations include improved motor control and integration of sensory input from the vestibular, visual, and proprioceptive systems, which collectively improve balance. Consequently, the OEP group experienced significantly greater improvements in BBS scores compared to the control group that did not receive the exercise intervention.

A t-test analysis showed a significant decrease in the Get Up and Go (TUG) Test time in the treatment group (OEP) compared to the control group. This indicates that the Otago Exercise Program (OTA) is effective in improving mobility and motor function in older adults.

The characteristics of the participants, who were mostly older adults with osteoporosis, lead to decreased muscle strength and impaired balance, which results in decreased mobility (Kanis et al., 2008). The OEP exercises, which focused on strengthening leg muscles and balance training, helped improve neuromuscular control and enhance functional abilities such as standing, walking, and changing positions more quickly and stably.

Neuromuscular adaptation theory explains that repeated practice stimulates increased motor unit recruitment and muscle coordination, which contributes to increased movement efficiency and reduced time on the TUG test (Enoka, 1997). Consequently, the OEP group was able to complete mobility tasks in a shorter time than the control group.

In older adults with osteoporosis, pain, fear of falling, and muscle weakness often hinder walking ability. Consistently performing 12 sessions of the Otago Exercise Program (OEP) twice a week has been shown to improve leg muscle strength and pelvic stability, resulting in improved mobility and shorter completion times on the Timed Up and Go (TUG) Test.

Although the exercises are quite strenuous, the frequency is tailored to the elderly's abilities. The OEP is effective in improving balance, gait stability, and postural control, significantly reducing the risk of falls. Although it does not directly strengthen bones, the OEP helps prevent fall-related injuries in people with osteoporosis (Skelton & Mavroedidi, 2018).

The results of this study confirm previous findings that the OEP provides significant benefits in

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improving motor function, strengthening leg muscles, and reducing the risk of falls in older adults with musculoskeletal disorders and aging-related physiological decline.

In addition to improving balance and mobility, the success of the Otago Exercise Program (OEP) in this study can also be explained by its multicomponent training approach that targets multiple body systems simultaneously. Recent literature suggests that exercise interventions combining muscle strengthening, balance training, and gait training have a greater effect on reducing fall risk than either exercise alone, particularly in older adults with osteoporosis (Sherrington, Fairhall, Wallbank, Tiedemann, Michaleff, Howard, Clemson, & Lamb, 2022; Cadore et al., 2022; Granacher, Muehlbauer, Gollhofer, Kressig, & Zahner, 2021).

OEP exercises consistently stimulate anticipatory and reactive postural control, which is crucial for preventing falls during sudden balance disturbances (Horak, 2006; Seidler et al., 2021). This improvement contributes to older adults' ability to maintain stability during positional transitions, such as standing from sitting or turning, which are key components of the TUG test (Thomas, Battaglia, Patti, Brusa, Leonardi, Palma, & Bellafiore, 2021; Liu, Shiroy, Jones, & Clark, 2021).

Furthermore, repeated exercises in OEP can improve balance confidence and reduce fear of falling, which is often a major mobility barrier in older adults with osteoporosis (Yoo et al., 2022; Giné-Garriga, Roqué-Figuls, Coll-Planas, Sitjà-Rabert, & Salvà, 2021). A reduced fear of falling allows older adults to move more freely and efficiently, positively impacting functional performance (Hopewell, Adedire, Copsey, Boniface, Sherrington, Clemson, Close, & Lamb, 2023).

From a clinical perspective, the relatively short duration of OEP exercises (approximately 15 minutes per session) performed regularly offers advantages in terms of adherence. Studies show that exercise adherence is a key factor in the success of fall prevention programs in older adults (Skelton & Mavroedidi, 2018; Sherrington et al., 2022).

These research findings reinforce the recommendation that OEP is feasible to implement as a facility-based and community-based rehabilitation program, particularly for older adults

with osteoporosis and mobility limitations (Zhao, Feng, Wang, & Liu, 2023; Compston, McClung, & Leslie, 2022). Integrating OEP into routine physiotherapy services has the potential to reduce the burden on the healthcare system from falls, fractures, and loss of independence in older adults (Kanis et al., 2019).

Thus, the results of this study not only support the effectiveness of OEP in improving BBS scores and reducing TUG times, but also confirm its role as a comprehensive intervention that impacts the physical, neuromuscular, and psychological aspects of older adults with osteoporosis (Kleim & Jones, 2008; Levin, Kleim, & Wolf, 2021).

CONCLUSION

The Otago Exercise Program (OEP) for older adults, particularly those at risk for osteoporosis, has been shown to be effective in improving balance and functional mobility. This is evidenced by a significant increase in Berg Balance Scale (BBS) scores, indicating improved balance ability, and a decrease in the Time Up and Go Test (TUG) time, reflecting improved mobility and the ability to perform functional activities. Neuromuscular adaptations that occur in response to the muscle-strengthening and balance training in the OEP are the primary mechanism for improving motor function in older adults. Therefore, the OEP can be recommended as an effective intervention for fall prevention and motor function in older adults with osteoporosis. Balance can be improved at any age and at any baseline level. The key is repetition and practice. Maintaining balance is crucial, especially as we age. Having good balance helps prevent falls and injuries, and facilitates daily activities.

SUGGESTION

Although the results were significant, there were several limitations to this study, including: The sample size was relatively small ($n = 30$), so the results cannot be generalized to a wider population. The duration of the intervention was not described in detail (in this manuscript), so the length of the OEP program could have influenced the results. Other factors such as nutritional status, comorbidities, or daily activity levels, which also influence balance and mobility, were not analyzed.

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Future research is recommended to: Involve a larger number of participants; Extend the duration of the intervention program and conduct long-term follow-up; Include additional variables such as quality of life, actual fall risk, and the impact of the intervention on daily independence.

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