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Effectiveness of the Otago Exercise Program in Reducing Fall Risk Among Community-Dwelling Older Adults in Sidoarjo, Indonesia: A Pre-Experimental Study

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ABSTRACT The aging process is associated with progressive degenerative changes that increase the risk of falls among older adults. Declining physiological functions, including reduced muscle strength, impaired coordination, postural instability, and decreased balance, contribute significantly to fall incidents, which may lead to physical injury, reduced independence, and decreased quality of life. Therefore, effective interventions are needed to minimize fall risk and improve functional mobility in the elderly population. This study aimed to determine the effect of the Otago Exercise Program on fall risk among older adults in Gelang Village, Sidoarjo Regency. This study employed a pre-experimental design using a one-group pretest–posttest approach. A total of 30 older adults were recruited through purposive sampling. The intervention consisted of the Otago Exercise Program administered over 12 sessions within four weeks. Fall risk was assessed using the Timed Up and Go (TUG) test before and after the intervention. Data were analyzed using the Wilcoxon signed-rank test to evaluate differences in fall risk scores between pretest and posttest measurements. The findings demonstrated a statistically significant reduction in fall risk following the intervention. The Wilcoxon test revealed a p-value of 0.000 ($p < 0.05$), indicating that the Otago Exercise Program effectively improved balance and mobility among the participants. Post-intervention observations showed that participants experienced better functional movement and a lower risk of falling compared to their baseline condition. In conclusion, the Otago Exercise Program has a significant positive effect on reducing fall risk among older adults in Gelang Village, Sidoarjo Regency. These findings suggest that the program can be considered an effective non-pharmacological intervention to enhance balance and prevent falls in the elderly population. Future studies are recommended to include additional variables, such as muscle strength, dynamic balance, and quality of life, to provide more comprehensive findings.

INDEX TERMS Older adults, Otago Exercise Program, Fall risk, Balance improvement, Timed Up and Go Test.

I. INTRODUCTION

Falls among older adults remain a major public health concern because they contribute significantly to morbidity, disability, reduced quality of life, and mortality worldwide [1], [2]. Aging is associated with progressive physiological degeneration, including decreased muscle strength, impaired postural stability, reduced joint flexibility, and diminished neuromuscular coordination, all of which increase susceptibility to falls [3], [4]. In addition, chronic illnesses commonly experienced by older adults, such as hypertension, diabetes mellitus, and musculoskeletal disorders, further exacerbate balance impairment and mobility limitations [5], [6]. Falls may result in bruises, fractures, fear of movement, loss of independence, prolonged hospitalization, and psychological distress, thereby increasing the burden on healthcare systems and caregivers [7], [8]. Consequently, fall prevention has become an essential component of geriatric nursing and community health programs.

Indonesia is currently experiencing a demographic transition characterized by a rapidly increasing older adult population. Data from the Central Bureau of Statistics reported that older adults accounted for 11.75% of the Indonesian population in 2023, with East Java ranking among the provinces with the highest proportion of older adults [9]. Globally, a comprehensive meta-analysis involving more than 36 million participants demonstrated that the prevalence of falls among older adults reached 26.5% [10]. Previous studies in Indonesia also revealed that approximately one-third of older adults aged over 65 years experience falls annually, with recurrent falls occurring frequently among high-risk populations [11]. Preliminary observations conducted in Gelang Village, Tulangan District, Sidoarjo Regency, further indicated that several older adults had experienced falls within

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Vol. 6 No.3, pp. 250-261, June 2026

the previous six months. This condition emphasizes the urgent need for effective and evidence-based fall prevention strategies at the community level.

Risk factors for falls in older adults can generally be categorized into intrinsic and extrinsic factors. Intrinsic factors include advanced age, impaired mobility, decreased balance, chronic diseases, muscle weakness, and dependency in activities of daily living [12], [13]. Meanwhile, extrinsic factors involve environmental hazards such as slippery floors, poor lighting, inappropriate footwear, and unsafe home environments [14]. Therefore, interventions addressing both physical capacity and environmental safety are required to minimize fall risk among older adults.

Several interventions have been developed to reduce fall risk, including multifactorial interventions, environmental modifications, vitamin D supplementation, educational programs, and physical exercise [15]. Among these approaches, exercise-based interventions have consistently demonstrated the greatest effectiveness in improving balance, muscle strength, gait performance, and functional mobility [16], [17]. One widely implemented exercise intervention is the Otago Exercise Program (OEP), which was specifically designed to enhance strength and balance among older adults through structured and progressive exercises [18]. Previous studies reported that the OEP significantly reduced fall incidence and improved physical performance among community-dwelling older adults and nursing home residents [19]–[21]. Moreover, modified and technology-assisted Otago programs have recently shown promising outcomes in improving balance confidence and adherence to exercise programs [22].

Despite the growing body of evidence regarding the effectiveness of the Otago Exercise Program, most studies have been conducted in developed countries or institutional settings with different environmental, socioeconomic, and cultural characteristics from rural Indonesian communities. Research investigating the implementation of the Otago Exercise Program among community-dwelling older adults in rural areas of Indonesia remains limited. Furthermore, few studies specifically evaluate the effectiveness of the program in reducing fall risk among older adults living independently within village-based community settings.

Therefore, this study aims to analyze the effect of the Otago Exercise Program on fall risk among older adults in Gelang Village, Sidoarjo Regency. The contributions of this study are as follows:

1. Providing empirical evidence regarding the effectiveness of the Otago Exercise Program in reducing fall risk among community-dwelling older adults.
2. Enriching geriatric nursing literature related to exercise-based fall prevention interventions in rural Indonesian settings.
3. Offering practical recommendations for implementing community-based exercise programs as preventive strategies for older adults.

This paper is organized as follows: Section II presents the related literature and theoretical framework; Section III explains the research methodology; Section IV discusses the findings and analysis; and Section V concludes the study along with recommendations for future research.

II. METHOD

A. STUDY DESIGN AND RATIONALE

This study employed a pre-experimental research design using a one-group pretest-posttest approach to evaluate the effectiveness of the Otago Exercise Program in reducing fall risk among older adults. A pre-experimental design was selected because the study aimed to determine changes in participants' fall risk before and after the intervention without the inclusion of a control group. This design enables researchers to assess within-subject differences following the intervention and is commonly utilized in community-based nursing research where randomization and controlled conditions are difficult to implement [23].

The one-group pretest-posttest design involved conducting baseline measurements prior to the intervention and comparing them with measurements obtained after completion of the intervention period. Although this design has limitations in establishing strong causal relationships due to the absence of randomization and a comparison group, it remains appropriate for preliminary investigations evaluating the feasibility and effectiveness of exercise-based interventions among community-dwelling older adults [24]. The design also allows practical implementation within rural community settings while minimizing disruption to participants' daily activities

B. STUDY SETTING

The study was conducted in RT 1, RT 2, and RT 3 of RW 4, Gelang Village, Tulangan District, Sidoarjo Regency, East Java, Indonesia. The selected location was considered appropriate because the area has a relatively high proportion of older adults and several reported incidents of falls among community-dwelling older adults. In addition, the village health cadres and local community leaders actively supported health promotion programs targeting older adults, thereby facilitating the implementation of the intervention.

The research was conducted from January to December 2025, which included proposal preparation, ethical approval, coordination with community stakeholders, participant recruitment, data collection, data analysis, and manuscript preparation. The intervention and primary data collection were specifically carried out over four weeks between September and October 2025.

C. PARTICIPANTS AND SAMPLING METHOD

The target population consisted of all older adults residing in RT 1, RT 2, and RT 3 of RW 4, Gelang Village, totaling 73 individuals. The sample included 30 older adults who met the inclusion criteria established by the researchers. Participants were selected using a non-probability purposive sampling technique. This sampling method was chosen because it enabled the researchers to recruit respondents who fulfilled specific characteristics relevant to the objectives of the study [25].

The inclusion criteria comprised older adults aged 60 years and above, able to communicate effectively, capable of performing light physical activity, willing to participate throughout the intervention period, and identified as having a risk of falls based on initial screening. Meanwhile, the exclusion criteria included older adults with severe cognitive impairment, severe musculoskeletal disorders, acute illness,

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Vol. 6 No.3, pp. 250-261, June 2026

uncontrolled cardiovascular disease, or conditions limiting safe participation in physical exercise.

Prior to data collection, all eligible participants received explanations regarding the study objectives, intervention procedures, benefits, and potential risks. Participants who agreed to participate were required to sign informed consent forms before enrollment in the study.

D. MATERIALS AND INTERVENTION

The intervention administered in this study was the Otago Exercise Program (OEP), which is a structured exercise program specifically designed to improve muscle strength, balance, and mobility among older adults [26]. The program consisted of lower-extremity strengthening exercises, balance retraining activities, walking exercises, and flexibility movements aimed at reducing fall risk and improving functional independence.

The intervention was conducted for approximately 35 minutes per session, three times per week, over a four-week period, resulting in a total of 12 exercise sessions. Each session included warm-up exercises, strengthening activities for lower limb muscles, balance exercises, walking practice, and cool-down movements. Rest days were provided between sessions to prevent excessive fatigue and ensure participant safety.

To improve adherence and consistency, participants were provided with exercise guide sheets and monitoring checklists. Weekly home visits and telephone reminders were conducted by the researchers to ensure proper implementation of the exercises. Family members were also encouraged to supervise participants during independent exercise sessions conducted at home. Previous studies demonstrated that adherence monitoring and family involvement can significantly improve compliance with exercise-based fall prevention programs among older adults [27], [28].

E. DATA COLLECTION INSTRUMENTS AND PROCEDURE

Data collection began with the administration of respondent characteristic questionnaires, including age, gender, body mass index (BMI), history of falls, medical history, medication use, and environmental risk factors within the home setting. Participants who experienced difficulties in reading or understanding the questionnaire received assistance from the researchers while maintaining ethical standards and participant autonomy.

The primary outcome variable, fall risk, was measured using the Timed Up and Go (TUG) test. The TUG test is a standardized performance-based assessment widely used to evaluate mobility, balance, and fall risk among older adults [29]. During the test, participants were instructed to stand up from a chair, walk three meters, turn around, return to the chair, and sit down again. The time required to complete the activity was recorded using a stopwatch and documented on an observation sheet prepared by the researchers.

Before implementation of the intervention, a pretest assessment was conducted to determine baseline fall risk. Following completion of the four-week Otago Exercise Program, participants underwent a posttest assessment using the same TUG procedure to identify changes in mobility performance and fall risk.

F. DATA ANALYSIS

The collected data were analyzed using Statistical Package for the Social Sciences (SPSS) version 26.0. Data analysis consisted of univariate and bivariate analyses.

1. UNIVARIATE ANALYSIS

Univariate analysis was performed to describe the characteristics of the respondents and summarize the distribution of variables included in the study. Descriptive statistical measures such as frequency, percentage, mean, and standard deviation were utilized to present demographic characteristics, internal risk factors, environmental conditions, and pretest-posttest TUG scores [30].

2. BIVARIATE ANALYSIS

Bivariate analysis was conducted to compare differences between pretest and posttest fall risk scores following the intervention. Prior to inferential testing, normality analysis was performed using the Shapiro-Wilk test because the sample size was fewer than 50 respondents. Since the data were not normally distributed, the Wilcoxon signed-rank test was employed to analyze differences between paired observations [31]. A p-value of less than 0.05 was considered statistically significant, indicating that the Otago Exercise Program had a significant effect on fall risk among older adults.

G. ETHICAL CONSIDERATIONS

This study received ethical approval from the Health Research Ethics Committee (KEPK) of Poltekkes Kemenkes Surabaya under approval number No. EA/3854/KEPK-Poltekkes_Sby/V/2025, issued on September 9, 2025. Prior to participation, respondents received both verbal and written explanations regarding the study procedures, objectives, benefits, and risks. Written informed consent was obtained from all participants before data collection commenced.

The study adhered to ethical principles involving human participants, including autonomy, confidentiality, beneficence, and justice [32]. Participants' personal information was kept confidential and used solely for research purposes. Furthermore, respondents were informed of their right to withdraw from the study at any stage without any consequences or penalties.

III. RESULTS

TABLE 1
Distribution of Older Adults Characteristics Based on Demographics in Gelang Village, Sidoarjo Regency, October 2025 (n=30)

Age	*f*	%
Elderly (60−74 years)	28	93,3
Eldery old (75−90 years)	2	6,7
Total	30	100
Gender	***f***	**%**
Male	6	20
Female	24	80
Total	30	100

Gelang Village is one of 22 villages located in the Tulangan District, Sidoarjo Regency, East Java. Gelang Village has four posyandu facilities that regularly hold posyandu activities for toddlers, the older adults, and people of productive age every month, with assistance and schedules coordinated by Puskesmas Kepadangan. At the research site itself, the existing health facilities include 1 posyandu. Activities that have been held for the older adults population in the area include posyandu, hypertension exercises, and older adults exercises, which are held once a month.

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Vol. 6 No.3, pp. 250-261, June 2026

Based on TABLE 1 above, it can be seen that almost all of them were elderly, consisting of 28 people (93.3%). It is also known that almost all of them (80%) were female.

TABLE 2
Distribution of Older Adults Characteristics Based on Health Conditions in Gelang Village, Sidoarjo Regency, October 2025 (n=30)

Body Mass Index (BMI)	*f*	%
Underweight (<18.5 kg/m²)	4	13,3
Normal weight (18.5–22.9 kg/m²)	7	23,3
Overweight (23.0–24.9 kg/m²)	7	23,3
Obesity Class I (25.0–29.9 kg/m²)	8	26,7
Obesity Class II (≥30.0 kg/m²)	4	13,3
Total	30	100
History of Falls in the Last 6 Months	*f*	%
History of falls	11	36,7
No history of falls	19	63,3
Total	30	100
History of fainting	*f*	%
History of fainting	4	13,3
No history of fainting	26	86,7
Total	30	100
History of illness	*f*	%
No history of illness	14	46,7
History of disease (hypertension)	11	36,7
History of disease (gout)	3	10
History of disease (hypertension and diabetes mellitus)	2	6,7
Total	30	100
Medication consumption	*f*	%
Not currently taking medication for specific diseases	14	46,7
Currently taking medication (antihypertensive and antidiabetic)	11	36,7
Currently taking medication (antihypertensive)	3	10
Currently taking medication (antihyperuricemic)	2	6,7
Total	30	100
Weakness in the Legs when Walking	*f*	%
Complaints of weakness in the legs when walking	13	43,3
No complaints of weakness in the legs when walking	17	56,7
Total	30	100
Decreased Balance when Walking	*f*	%
There is a decrease in balance when walking	12	60
There is no decrease in balance when walking	18	80
Total	30	100
Joint Stiffness	*f*	%
There are complaints of joint stiffness	21	70
There are no complaints of joint stiffness	9	30
Total	30	100

Based on the data distribution in in TABLE 2, the findings from the analysis of body mass index (BMI) measurements classified according to the Asia-Pacific BMI guidelines show that the highest prevalence is held by older adults in the class I obesity category, with a number of almost half, namely 8 people (26.7%). Based on fall history, it was found that nearly half, or 11 out of a total of 30 older adults individuals (36.7%), had a history of falling in the past six months. Only a small proportion of older adults (13.3%) had a history of fainting, while almost all older adults (86.7%) had no history of fainting. Based on medical history, it was found that most older adults (53.3%) had no history of specific diseases, followed by nearly half of the older adults (46.7%) who had a history of specific diseases. Older adults with a history of hypertension had the highest prevalence compared to other medical histories, with nearly half of them, or 13 people (43.3%). Based on medication history, it was found that most older adults (53.3%) were taking medication for specific diseases, and most (68.8%) of those taking medication were taking antihypertensive drugs.

Based on the TABLE 2, most older adults (56.7%) did not complain of leg weakness when walking, but nearly half (43.3%) still complained of weakness. Impaired balance when walking was reported by most older adults (60%), but complaints of joint stiffness were quite high, with most (70%) older adults experiencing this.

TABLE 3
Distribution of Older adults Characteristics Based on Environmental Conditions in Gelang Village, Sidoarjo Regency, October 2025 (n=30)

Lighting in the Home	*f*	%
The lighting in the home is bright enough	30	100
Total	30	100
Condition of Floors in the Home	*f*	%
There are slippery or uneven floors	20	66,7
There are no slippery or uneven floors	10	33,3
Total	30	100
Furniture Conditions in the Home	*f*	%
Furniture in the home is neatly arranged and does not obstruct passageways	25	83,3
Furniture in the home is not neatly arranged and obstructs passageways	5	16,7
Total	30	100
Handrails on the Walls of the House	*f*	%
There are handrails on the walls of the house, especially in the bathroom	6	20
There are no handrails on the walls of the house, especially in the bathroom	24	80
Total	30	100
Condition of Beds in the House	*f*	%
There are high beds	18	60
There are no high beds	12	40
Total	30	100
Type of Toilet in the House	*f*	%
Has a squat toilet	24	80
Has a sitting toilet	6	20
Total	30	100

According to the information presented in TABLE 3, all older adults homes have good lighting (100%) and almost all older adults have neatly arranged furniture (83.3%). However, most older adults (66.7%) still have homes with slippery or uneven floors, and only a small proportion (20%) of homes are equipped with wall handrails, especially in bathrooms. Most older adults (60%) have high beds and almost all of them (80%) use squat toilets.

TABLE 4
Distribution of Older adults Fall Risk Before Intervention with the Otago Exercise Program in Gelang Village, Sidoarjo Regency, October 2025 (n=30)

Fall Risk	Mean ± SD	Median	IQR	Min – Max
Pre-test	15,70 ± 2,588	15,00	4	12 – 21

Fall Risk	*f*	%
Low Fall Risk (10 – <20 seconds)	27	90
Moderate Fall Risk (20-29 seconds)	3	10
Total	30	100

Based on TABLE 4, it can be seen that the 30 older adults involved in this study before being given the Otago Exercise Program intervention had an average pre-test score of 15,70 ± 2,588 seconds and median score of 15.14 seconds. The minimum pre-test score was 12 seconds and the maximum score was 21 seconds.

These pre-test scores were then categorized to describe the risk of falls among the older adults. The older adults's time taken to complete the TUG test was used to categorize their

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Vol. 6 No.3, pp. 250-261, June 2026

fall risk. According to the pre-test results, the average score was in the low fall risk category. The minimum score was in the low fall risk category, while the maximum score was in the moderate fall risk category.

It is evident through the information which is shown in TABLE 4 that the 30 older adults involved in this study before being given the Otago Exercise Program intervention, 27 people (90%) had a low risk of falling and 3 people (10%) had a moderate risk of falling.

TABLE 5
Distribution of Older adults Fall Risk After Intervention with the Otago Exercise Program in Gelang Village, Sidoarjo Regency, October 2025 (n=30)

Fall Risk	Mean ± SD	Median	IQR	Min – Max
Post-test	14,50 ± 2,316	14,50	4	11 – 18
Fall Risk			*f*	%
Low Fall Risk (10 – <20 seconds)			30	100
		Total	30	100
Difference (Δ = Pre – Post)			*f*	%
Decrease in value (positive rank)			25	83,3
Increase in value (negative rank)			5	16,7
		Total	30	100

TABLE 6
Distribution of Older adults Demographic Characteristics by Fall Risk in Gelang Village, Sidoarjo Regency, October 2025 (n = 30)

	Fall Risk (*Pre-test*)						p-value
	Low Fall Risk		Moderate Fall Risk		Total		
Age	*f*	%	F	%	*f*	%	
Elderly (60–74 years)	26	92,9	2	7,1	28	100	0,053
Eldery old (75–90 years)	1	50	1	50	2	100	
Total	27	90	3	10	30	100	
Gender	*f*	%	F	%	*f*	%	
Male	6	100	0	0	6	100	0,369
Female	21	87,5	3	12,5	24	100	
Total	27	90	3	10	30	100	

According to the data shown in TABLE 5, it can be seen that 30 older adults involved in this study after being given the Otago Exercise Program intervention had an average pre-test score of 14,50 ± 2,316 and a median score of 14,50 seconds. The minimum pre-test score was 11 seconds and the maximum score was 18 seconds. Based on the post-test results, the average score was in the low fall risk category. The minimum and maximum score was in the low fall risk category.

It is evident from the data presented in TABLE 5 that the 30 older adults involved in this study, after being given the Otago Exercise Program intervention, all (100%) had a low risk of falling. All participants were categorized as having a low risk of falls after the intervention. This lack of variability prevented further correlation analysis between post-test fall risk and participant characteristics. It is possible that the TUG cut-off became less sensitive after the intervention, which may have masked smaller variations in improvement.

There were no longer any individuals who had a moderate risk of falling, as was the case before the Otago Exercise Program intervention was administered.

Based on the data presented in TABLE 5, it was also found that almost all older adults individuals (83,3%) experienced a decrease in their scores, as indicated by a positive difference (Δ = pre–post), showing that the post-test scores were lower than the pre-test scores. A small proportion of

TABLE 7
Distribution of Older Adults's Health Conditions by Fall Risk in Gelang Village, Sidoarjo Regency, October 2025 (n = 30)

	Fall Risk (*Pre-test*)						p-value
	Low Fall Risk		Moderate Fall Risk		Total		
Body Mass Index (BMI)	*f*	%	*f*	%	*f*	%	
Underweight (<18.5 kg/m²)	4	100	0	0	4	100	0,017
Normal weight (18.5–22.9 kg/m²)	7	100	0	0	7	100	
Overweight (23.0–24.9 kg/m²)	7	100	0	0	7	100	
Obesity Class I (25.0–29.9 kg/m²)	7	87,5	1	12,5	8	100	
Obesity Class II (≥30.0 kg/m²)	2	50	2	50	4	100	
Total	27	90	3	10	30	100	
History of Falls in the Last 6 Months	*f*	%	*f*	%	*f*	%	
History of falls	8	72,7	3	27,3	11	100	0,018
No history of falls	19	100	0	0	19	100	
Total	27	90	3	10	30	100	
History of fainting	*f*	%	*f*	%	*f*	%	
History of fainting	2	50	2	50	4	100	0,005
No history of fainting	25	96,2	1	3,8	26	100	
Total	27	90	3	10	30	100	
History of illness	*f*	%	*f*	%	*f*	%	
No history of illness	13	92,9	1	7,1	14	100	0,694
History of disease (hypertension)	9	81,8	2	18,2	11	100	
History of disease (gout)	3	100	0	0	3	100	0,694
History of disease (hypertension and diabetes mellitus)	2	100	0	0	2	100	
Total	27	90	3	10	30	100	
Medication consumption	*f*	%	*f*	%	*f*	%	
Not currently taking medication for specific diseases	13	92,9	1	7,1	14	100	0,694
Currently taking medication (antihypertensive and antidiabetic)	9	81,8	2	18,2	11	100	
Currently taking medication (antihypertensive)	3	100	0	0	3	100	
Currently taking medication (antihyperuricemic)	2	100	0	0	2	100	
Total	27	90	3	10	30	100	
Weakness in the Legs when Walking	*f*	%	*f*	%	*f*	%	
Complaints of weakness in the legs when walking	16	94,1	1	5,9	17	100	0,398
No complaints of weakness in the legs when walking	11	84,6	2	15,4	13	100	
Total	27	90	3	10	30	100	
Decreased Balance when Walking	*f*	%	*f*	%	*f*	%	
There is a decrease in balance when walking	17	94,4	1	5,6	18	100	0,329
Decreased Balance when Walking	*f*	%	*f*	%	*f*	%	
There is no decrease in balance when walking	10	83,3	2	16,7	12	100	
Total	27	90	3	10	30	100	
Joint Stiffness	*f*	%	*f*	%	*f*	%	
There are complaints of joint stiffness	8	88,9	1	11,1	9	100	0,896
There are no complaints of joint stiffness	19	90,5	2	9,5	21	100	
Total	27	90	3	10	30	100	

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Vol. 6 No.3, pp. 250-261, June 2026

older adults individuals (16,7%) showed an increase in scores, indicated by a negative difference score (Δ = pre–post). This points out that the post-test score was higher than the pre-test score.

As shown in TABLE 6, most older adults (92.9%) were aged 60–74 years and had a low fall risk, while 7.1% had a moderate fall risk before the intervention. Spearman's rank correlation showed no significant correlation between age and fall risk before the Otago Exercise Program.

All male participants (100%) had a low fall risk, whereas most female participants also had a low fall risk (87.5%), with 12.5% classified as moderate risk. The Mann–Whitney U test indicated no significant correlation between gender and fall risk before the intervention (p = 0.369).

Based on TABLE 7, all older adults with underweight, normal weight, and overweight BMI were classified as having a low fall risk. Moderate fall risk was observed among those with obesity class I (12.5%) and increased in obesity class II, where 50% were classified as moderate risk. Spearman's rank correlation showed a significant correlation between BMI and fall risk before the intervention.

Older adults with a history of falls during the previous six months showed a higher proportion of moderate fall risk (27.3%), whereas all participants without a fall history had a low fall risk. The Mann–Whitney U test indicated a significant difference in fall risk between these groups (p = 0.018).

Participants with a history of syncope showed equal proportions of low and moderate fall risk (50% each), while nearly all participants without syncope had a low fall risk (96.2%). The Mann–Whitney U test demonstrated a significant correlation between syncope history and fall risk (p = 0.005).

Moderate fall risk was most frequently observed among participants with hypertension (18.2%). However, the Kruskal–Wallis test showed no significant correlation between comorbidity history and fall risk before the intervention (p = 0.694).

Participants using antihypertensive medication had a higher proportion of moderate fall risk (18.2%) than those not using specific medications (7.1%), although no significant correlation was found between medication use and fall risk (Kruskal–Wallis, (p = 0.694).

A higher proportion of moderate fall risk was observed among participants reporting lower-limb weakness (15.4%) compared with those without such complaints (5.9%), but Spearman's rank analysis showed no significant correlation. Similar patterns were observed for balance impairment during walking and joint stiffness, with no significant correlations identified before the intervention.

Based on TABLE 8, most older adults with adequate home lighting were classified as having a low fall risk (90%), with only 10% categorized as moderate risk. Regarding floor conditions, almost all participants had a low fall risk regardless of whether floors were slippery or uneven (90% in both groups), although moderate fall risk was observed among those with slippery or uneven floors (10%). The Mann–Whitney U test indicated no significant link in fall risk based on floor condition before the intervention. Environmental factors such as floor conditions and furniture arrangement did not show significant associations with fall risk before the intervention. This may be due to the relatively homogeneous living conditions of participants or the small sample size, which limited statistical power. Nevertheless, maintaining a safe home environment remains important, as

TABLE 8
The Effect of the Otago Exercise Program on the Risk of Falls Among Older adults in Gelang Village, Sidoarjo Regency, October 2025 (n=30)

	Fall Risk (*Pre-test*)						p-value
	Low Fall Risk		Moderate Fall Risk		Total		
Lighting in the Home	***f***	**%**	***f***	**%**	***f***	**%**	
The lighting in the home is bright enough	27	90	3	10	30	100	
Total	27	90	3	10	30	100	
Condition of Floors in the Home	***f***	**%**	***f***	**%**	***f***	**%**	
There are slippery or uneven floors	9	90	1	10	10	100	1,000
There are no slippery or uneven floors	18	90	2	10	20	100	
Total	27	90	3	10	30	100	
Furniture Conditions in the Home	***f***	**%**	***f***	**%**	***f***	**%**	
Furniture in the home is neatly arranged and does not obstruct passageways	4	80	1	20	5	100	0,422
Furniture in the home is not neatly arranged and obstructs passageways	23	92	2	8	25	100	
Total	27	90	3	10	30	100	
Handrails on the Walls of the House	***f***	**%**	***f***	**%**	***f***	**%**	
There are handrails on the walls of the house, especially in the bathroom	21	87,5	3	12,5	24	100	0,369
There are no handrails on the walls of the house, especially in the bathroom	6	100	0	0	6	100	
Total	27	90	3	10	30	100	
Condition of Beds in the House	***f***	**%**	***f***	**%**	***f***	**%**	
There are high beds	6	85,7	1	14,3	7	100	0,329
There are no high beds	21	91,3	2	8,7	23	100	
Total	27	90	3	10	30	100	
Type of Toilet in the House	***f***	**%**	***f***	**%**	***f***	**%**	
Has a squat toilet	16	94,1	1	5,9	17	100	0,550
Has a sitting toilet	11	84,6	2	15,4	13	100	
Total	27	90	3	10	30	100	

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Vol. 6 No.3, pp. 250-261, June 2026

environmental hazards may contribute to fall incidents when combined with other risk factors such as impaired balance, muscle weakness, or cognitive decline.

Participants whose household furniture was poorly arranged and obstructed walkways showed a higher proportion of moderate fall risk (20%) compared with those whose furniture was well arranged (8%); however, the Mann–Whitney U test showed no significant correlation. All participants with handrails had a low fall risk (100%), whereas moderate fall risk was observed among those without handrails (12.5%), with no significant correlation identified.

Moderate fall risk was more common among participants with high beds (14.3%) than among those without high beds (8.7%), although this difference was not statistically significant. Similarly, most participants using squat toilets had a low fall risk (94.1%), while a higher proportion of moderate fall risk was observed among those using seated toilets (15.4%). The Mann–Whitney U test indicated no significant correlation between toilet type and fall risk before the intervention.

Post-test assessment showed that all older adults in this study were classified as having a low fall risk (100%) after the Otago Exercise Program intervention. No variability in fall risk categories was observed, particularly the absence of moderate fall risk, which had been present at the pre-test stage. As a result, post-test fall risk data were homogeneous and lacked between-group variation. Consequently, correlation analysis between post-test fall risk and participant characteristics could not be performed, as such analyses require variability in the variables examined.

In contrast, pre-test fall risk data demonstrated variability across categories, including low and moderate fall risk, allowing correlation analyses with older adults' characteristics. Therefore, the inability to conduct correlation analysis on post-test data was not due to methodological limitations but rather to the uniform reduction in fall risk achieved after the Otago Exercise Program intervention.

TABLE 9
The Effect of the Otago Exercise Program on the Risk of Falls Among Older adults in Gelang Village, Sidoarjo Regency, October 2025 (n=30)

Fall Risk	Mean ± SD	Median	IQR	Min – Max	p-value
Pre-test	15,70 ± 2,588	15,00	4,32	12 – 21	0,000
Post-test	14,50 ± 2,316	14,50	4	11 – 18	
		N	Mean Rank		Z
Negative ranks		25	16,80		-3,961
Positive ranks		5	9,00		
Ties		0			
Total		30			

Based on the data presented in TABLE 9, Based on Table 5.9 above, it shows that the average fall risk score in the older adults before intervention (pre-test) was 15,70 ± 2,588, while after intervention (post-test) the average fall risk score decreased to 14,50 ± 2,316. This decrease in the average score indicates a downward trend in fall risk after the intervention, with relatively homogeneous variation in fall risk scores at both measurement times.

Based on the data presented in TABLE 9, the median pre-test time was 15,00 seconds with an IQR of 4 and a minimum-maximum range of 12–21 seconds. After the intervention, the median post-test time decreased to 14,50 seconds with an IQR of 4 and a range of 11–18 seconds. These results indicate that the intervention did not alter data homogeneity, despite changes in the mean and median values, suggesting that the level of variability or dispersion among participants remained relatively stable before and after the intervention.

Based on the data presented in TABLE 9, statistical analysis using the Wilcoxon test was performed to determine whether the Otago Exercise Program had an effect on the risk of falling in the older adults. The results of the Wilcoxon test showed that the Timed Up and Go (TUG) scores before and after the implementation of the Otago Exercise Program produced a p-value of p=0.000 (p<0.05), which means that H_0 was rejected and H_1 was accepted. This indicates that the Otago Exercise Program has an effect on the risk of falls in the older adults.

The data in the table reveal, because the p-value shows p=0.000 (p<0.001), the Wilcoxon test findings indicate a difference of statistical significance throughout the pre- and post-tests. This implies that the possibility of these results occurring by chance is very small (<0.1%), so it can be believed that the Otago Exercise Program intervention has an effect on the risk of falls in the older adults.

Based on the results in the table, a decrease in scores (pre-test > post-test) occurred in almost all older adults participants (83.3%), totaling 25 people, while an increase in scores (pre-test < post-test) occurred in a small number of older adults participants (16.7%), totaling 5 people. These results show a greater decrease in scores than an increase in scores, which means that the change towards a negative direction (decrease in scores) is stronger or more dominant than the increase in scores that occurred.

The Wilcoxon Signed Rank Test resulted in a Z value of -3.961. The negative sign on the Z value shows that the post-test value is less than the pre-test value. It implies that the risk of falling decreased following the Otago Exercise Program intervention in this study.

IV. DISCUSSION

A. FALL RISK AMONG OLDER ADULTS IN GELANG VILLAGE, SIDOARJO REGENCY, BEFORE THE OTAGO EXERCISE PROGRAM INTERVENTION

The baseline evaluation of community-dwelling older adults in Gelang Village, Sidoarjo Regency, revealed that prior to the implementation of the Otago Exercise Program (OEP), an overwhelming majority of the participants (90%) exhibited a low risk of falling, while only a minor cohort presented with a moderate risk. This baseline distribution slightly diverges from prevailing geriatric literature, which typically documents a higher prevalence of moderate-to-high fall risks within suburban community settings. For instance, contemporary investigations by Nugroho *et al.* [33] utilizing performance-based balance instruments on cohorts with independent mobility reported that a dominant proportion of community-dwelling seniors actually fell into moderate-to-high risk stratifications due to undetected gait variances. This discrepancy implies that the specific population under study in Gelang Village retained a relatively well-preserved state of physiological mobility, vestibular balance, and neuromuscular coordination at the outset.

The baseline low-risk profile identified in the majority of participants is strongly coupled with specific socio-

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Vol. 6 No.3, pp. 250-261, June 2026

demographic and intrinsic protective factors. Gerontological models by Martinez *et al.* [34] emphasize that "young-old" populations (predominantly aged 60–74 years) maintain significantly higher functional reserves, musculoskeletal elasticity, and metabolic capacities compared to "old-old" cohorts. This age-graded resilience aligns with findings from Choi *et al.* [35], which demonstrate that fall incidences and balance degradation accelerate exponentially after the seventh decade of life due to the progressive decline of multi-sensory feedback integration.

Furthermore, the baseline low-risk group was characterized by an absence of syncope history and stable lower-extremity strength. In contrast, clinical literature establishes that intrinsic pathologies such as syncope characterized by a transient reduction in cerebral blood flow serve as prominent triggers for sudden postural instability [36]. Cardiovascular impairments, including orthostatic hypotension, cardiac arrhythmias, and carotid sinus hypersensitivity, frequently manifest as dizziness or blurred vision, which severely disrupt anticipatory postural adjustments [37]. O'Connor *et al.* [38] observe that normal senescent alterations in the visual, vestibular, and somatosensory systems lead to gait variations; however, the low-risk cohort in this study exhibited adequate compensatory motor control. This biological stability was further reinforced by optimized extrinsic factors, such as adequate domestic illumination and ergonomically arranged living environments that minimized spatial hazards, thereby validating established ecological safety models in senior health.

Conversely, the minor cohort presenting with a baseline moderate fall risk highlights the multi-factorial nature of geriatric instability. Intrinsic analysis points toward an elevated Body Mass Index (BMI), gender-specific physiological vulnerabilities, and musculoskeletal comorbidities. A high BMI modifies postural biomechanics by displacing the body's center of mass, increasing postural sway, and placing atypical mechanical stress on the plantar arch structure [39]. Gender disparities also emerge prominently; senescent females exhibit accelerated degradation of musculoskeletal integrity and postural stability due to post-menopausal estrogen depletion, which compromises bone mineral density and induces sarcopenic changes [40].

Furthermore, a documented history of falls creates a cyclical degradation of mobility; the psychological fear of recurrent falls prompts voluntary physical restriction, which paradoxically accelerates disuse muscle atrophy, joint stiffness, and joint proprioceptor failure [41]. This is frequently compounded by systemic chronic conditions such as hypertension, where the pathological process itself or the secondary effects of polypharmacy induce orthostatic hypotension, transient cerebral hypoperfusion, and diminished alertness [42]. Musculoskeletal stiffness and decreased physical activity further impair static and dynamic balance parameters [43]. When these intrinsic vulnerabilities interact with extrinsic environmental hazards such as slippery flooring, a lack of grab-rails in bathrooms, improper bed heights, and the physiological strain associated with traditional squat toilets—the risk transitions from low to moderate [44].

B. FALL RISK AMONG OLDER ADULTS IN GELANG VILLAGE, SIDOARJO REGENCY, AFTER THE OTAGO EXERCISE PROGRAM INTERVENTION

Following the completion of the 4-week Otago Exercise Program, post-test metrics indicated a complete shift in the sample population: 100% of the participants achieved a low fall risk classification. This total eradication of moderate-risk profiles underscores the potent therapeutic efficacy of the OEP as a targeted neuromuscular intervention. These results strongly parallel the clinical trial outcomes published by Benson *et al.* [45], which indicated that older adults engaged in structured OEP protocols exhibited profound reductions in their absolute completion times during mobility assessments, reflecting substantial gains in dynamic stability.

Similarly, a systematic review by Tan *et al.* [46] validated that home-based and community-delivered OEP applications yield significant improvements in lower-limb strength and balance metrics. Crucially, Tan *et al.* demonstrated that even within single-group, pre-post experimental designs lacking concurrent control arms, the post-intervention improvements remained statistically robust and clinically meaningful, which lends strong methodological and theoretical validity to the absolute risk reductions observed in Gelang Village.

The physiological mechanisms driving this transition from moderate to low fall risk are rooted in the specific task-oriented design of the OEP. The intervention incorporates progressive, localized resistance exercises that isolate and overload key lower-extremity muscle groups. Specifically, the protocol targets the hip abductors through lateral strengthening maneuvers, the tibialis anterior via active toe raises, the gastrocnemius-soleus complex through calf raises, and the quadriceps and hamstrings through targeted knee extension and flexion sequences [47]. Roberts *et al.* [48] observe that augmenting lower-limb torque and muscle cross-sectional area directly enhances an older adult's ability to execute rapid corrective motor strategies when experiencing external balance perturbations.

Remarkably, this structured neuromuscular training appears to override or neutralize certain baseline demographic and clinical vulnerabilities. While literature indicates that advanced age and female gender are independently linked to severe functional declines [34], [40], the female-dominated cohort in this study experienced uniform risk reduction. Furthermore, the OEP effectively mitigated the heightened fall risk typically associated with chronic illnesses and polypharmacy-induced orthostatic hypotension [45]. The repetitive balance components of the program optimize vestibular-ocular reflexes and somatic proprioception, thereby enhancing real-time motor control and dynamic equilibrium to counteract transient systemic instabilities [49].

Despite these universal improvements, a critical nuance emerged within the post-test data: a small subgroup of participants exhibited a minor increase in absolute TUG scores (indicating slower performance), although this shift was not substantial enough to displace them from the low fall risk category. Additionally, no participants reached a theoretically "zero-risk" or fully youthful baseline category. Gerontological literature suggests that these variations are heavily dictated by intervention duration and behavioral adherence. Al-Qahtani *et al.* [50] note that while brief 4-week interventions stimulate immediate neurological adaptations and motor unit

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Vol. 6 No.3, pp. 250-261, June 2026

recruitment, long-term structural changes in muscle morphology and advanced vestibular recalibration demand sustained, multi-month exercise cycles.

Furthermore, persistent underlying pathologies, such as advanced chronic hypertension, continue to chronically alter cerebral tissue perfusion and central balance regulation, placing a physiological ceiling on short-term physical therapy [42]. Lastly, exercise adherence in community-dwelling seniors is deeply non-linear, governed by fluctuating levels of family social support, baseline cognitive executive function, and individual self-efficacy [46]. Minor variations in home-exercise compliance or incorrect execution of the progressive movements likely account for the slight TUG score increases noted in the outlier subgroup.

C. THE EFFECT OF THE OTAGO EXERCISE PROGRAM ON FALL RISK AMONG OLDER ADULTS IN GELANG VILLAGE, SIDOARJO REGENCY

Hypothesis testing using the Wilcoxon Signed-Rank Test demonstrated a highly significant result ($p = 0.000$; $p < 0.05$), indicating rejection of the null hypothesis (H_0) and acceptance of the alternative hypothesis (H_1). These findings indicate that the Otago Exercise Program had a significant effect on reducing fall risk among older adults. The Wilcoxon analysis showed that negative ranks were greater than positive ranks, indicating that post-test Timed Up and Go (TUG) scores were generally lower than pre-test scores. In addition, the negative Z-score obtained from the analysis confirmed that most participants experienced improvements in functional mobility and walking performance following the intervention.

These findings are consistent with previous studies demonstrating the effectiveness of the Otago Exercise Program in improving balance and reducing fall risk among older adults. Hamilton et al. [51] reported that the Otago Exercise Program significantly improved balance performance and reduced the incidence of falls among community-dwelling older adults. Similarly, Pratama et al. [52] found that implementation of the Otago Exercise Program in rural older adults populations resulted in a significant reduction in fall risk categories and improved mobility outcomes. The consistency between the present findings and previous studies strengthens the evidence supporting the effectiveness of the Otago Exercise Program as a fall prevention strategy for older adults.

Further analysis in this study also demonstrated that several intrinsic risk factors, including high body mass index (BMI), history of falls within the previous six months, and history of syncope, were associated with higher fall risk before the intervention. These findings are consistent with previous literature reporting that obesity may alter postural stability and gait mechanics [39], previous falls may reduce confidence and increase fear of movement [41], and syncope may reflect cardiovascular or autonomic dysfunction associated with impaired balance control [37].

However, after completion of the intervention, all participants, including those with obesity, previous falls, and syncope history, were classified as having a low fall risk. This finding suggests that the balance and lower-extremity strengthening exercises incorporated within the Otago Exercise Program may improve postural control, muscle strength, and adaptive balance responses sufficiently to reduce the influence of pre-existing intrinsic risk factors among older adults.

Despite the positive outcomes observed, several limitations of this study should be acknowledged. First, the use of a one-group pretest-posttest quasi-experimental design without a control group limits the ability to establish strong causal relationships between the intervention and the observed outcomes. The absence of a comparison group may increase the possibility of internal validity threats, including the Hawthorne effect and natural maturation processes [46]. Second, the relatively small sample size ($n = 30$) and recruitment from a single community setting in Gelang Village may limit the generalizability of the findings to broader older adults populations [50]. Third, the post-intervention assessment was conducted immediately after the four-week intervention period, preventing evaluation of long-term retention and sustainability of balance improvements [46]. Furthermore, fall risk was assessed using the Timed Up and Go (TUG) test as a functional mobility indicator rather than direct observation of actual fall incidence over an extended period [51].

Nevertheless, the findings of this study have important implications for nursing practice and community-based older adults care programs. The Otago Exercise Program is relatively low-cost, easy to implement, and requires minimal equipment, making it suitable for integration into community healthcare services such as Posyandu Lansia programs in Indonesia. Community nurses and healthcare workers may utilize this exercise program as a preventive intervention to improve balance, mobility, and independence among older adults while reducing fall-related complications and hospitalization rates. In addition, implementation of the program should be supported by environmental modifications, including improved lighting, installation of handrails, use of non-slip flooring, and safer toilet facilities to reduce extrinsic fall risk factors. Integration of the Otago Exercise Program with routine health monitoring, medication evaluation, and caregiver involvement may further contribute to the development of comprehensive and sustainable healthy aging programs for older adults populations.

V. CONCLUSION

This study aimed to determine the effect of the Otago Exercise Program on fall risk among older adults in Gelang Village, Sidoarjo Regency. The findings demonstrated that prior to the intervention, almost all participants were categorized as having a low risk of falling, while a small proportion were classified as having a moderate fall risk based on the Timed Up and Go (TUG) assessment. Following the four-week implementation of the Otago Exercise Program, all participants were categorized within the low fall-risk group, indicating an overall improvement in mobility and balance performance. Statistical analysis using the Wilcoxon Signed-Rank Test revealed a highly significant difference between pre-test and post-test scores, with a p-value of 0.000 ($p < 0.05$), confirming that the Otago Exercise Program had a significant effect on reducing fall risk among older adults. The findings suggest that structured balance and lower-extremity strengthening exercises may improve postural stability, gait performance, and functional mobility, thereby contributing to fall prevention in community-dwelling older adults.

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Vol. 6 No.3, pp. 250-261, June 2026

Furthermore, the intervention appeared beneficial even among participants with intrinsic risk factors such as obesity, history of falls, syncope, chronic disease, and medication use. Despite these positive findings, this study has several limitations, including the absence of a control group, relatively small sample size, single-community setting, and short intervention duration, which may limit the generalizability and long-term interpretation of the results. Therefore, future studies are recommended to employ randomized controlled trial designs with larger and more heterogeneous populations, longer intervention and follow-up periods, and additional outcome measures such as muscle strength, balance performance, quality of life, and actual fall incidence. Further investigation into environmental modifications and adherence factors is also necessary to optimize the effectiveness of fall-prevention programs for older adults.

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DATA AVAILABILITY

No datasets were generated or analyzed during the current study.

AUTHOR CONTRIBUTION

Dwi Miftakhurroiba Rahma conceptualized and designed the study, conducted data collection, performed statistical analysis, interpreted the findings, and drafted the original manuscript. Minarti contributed to the development of the research methodology, supervised the implementation of the intervention, and provided critical revisions to improve the scientific quality of the manuscript. Adin Mu'afiro assisted in data interpretation, provided methodological and academic guidance, and contributed to manuscript review and refinement. Sri Utami contributed to the validation of the research process, provided input on the discussion and interpretation of results, and critically reviewed the manuscript for important intellectual content. Zarinah Binti Abdul Aziz contributed to the conceptual strengthening of the study, provided international academic perspectives, and assisted in the final evaluation and improvement of the manuscript. All authors reviewed, approved, and agreed to be accountable for the final version of the manuscript and ensured the integrity and accuracy of all aspects of the study.

DECLARATIONS

ETHICAL APPROVAL

This study received ethical approval from the Komite Etik Penelitian Kesehatan (KEPK) of Poltekkes Kemenkes Surabaya with ethical clearance number No.EA/3854/KEPK-Poltekkes_Sby/V/2025. Written informed consent was obtained from all participants prior to data collection. Participant confidentiality, anonymity, and privacy were maintained throughout the study in accordance with ethical standards for human research.

CONSENT FOR PUBLICATION PARTICIPANTS.

Consent for publication was given by all participants

COMPETING INTERESTS

The authors declare no competing interests.

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