DOI 10.26773/smj.250611

SportMont

ORIGINAL SCIENTIFIC PAPER

Effects of the Otago Exercise Program on Balance Among Nursing Home Residents: A 12-Week Quasi-Experimental Study

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Abstract

Balance impairments and fall risks significantly affect the well-being of nursing home residents, compromising mobility and independence. Addressing these challenges requires comprehensive interventions that combine physical and psychological components. This study aimed to evaluate the impact of a 12-week intervention with the Otago Exercise Program (OEP), on improving balance among nursing home residents aged 65 and older. A quasi-experimental design was implemented with 42 participants, divided into an experimental group (EG; n=24) and a control group (CG; n=18). The CG had an average age of 69.44±2.70 years, height of 162.22±9.08 cm, and weight of 65.78±17.99 kg, while the EG had an average age of 74.50±6.40 years, height of 159.50±11.31 cm, and weight of 76.97±14.83 kg. The experimental group engaged in structured OEP sessions with 3 sessions per week. Balance was assessed pre- and post-intervention using the Leonardo Mechanograph platform. The experimental group showed significant improvements in static and dynamic balance compared to the control group, particularly in tests requiring sensory integration and postural adjustments under challenging conditions (e.g., Romberg and Semi-Tandem with eyes closed). Functional mobility also improved, as evidenced by better performance in the Chair Raising Test. The OEP, effectively improves balance and mobility in nursing home residents, with assessments via the Leonardo platform confirming robust gains in functional and biomechanical metrics. These findings provide evidence for adopting multifaceted interventions in fall prevention strategies, particularly in resource-limited care settings.

Keywords: *otago exercise, balance, older adults, nursing homes, health*

Introduction

Aging is a dynamic and inevitable process that spans the entire human lifespan, requiring continuous adaptation to evolving physical and functional challenges (Asejeje et al., 2024). This progression is accompanied by physiological changes such as mitochondrial dysfunction, inflammatory dysregulation, hormonal decline, and a reduced metabolic rate. These alterations contribute to the degeneration of multiple systems, leading to diminished nerve function, bone mass, muscle strength, and overall physical capacity (Cesari et al., 2013; Chang & Lin, 2015; Nascimento et al., 2019; Sieber, 2017). A critical consequence of these changes is impaired balance, which significantly increases fall risk among older adults.

Falls represent a major global public health concern, particularly in individuals aged 65 and older (World Health Organization, 2025). In the United States, falls are the leading cause of both fatal and non-fatal injuries in this age group (Kakara et al., 2023). European statistics further emphasize the burden, with over 30% of older adults experiencing a fall annually a figure that escalates in institutional settings

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(Rubenstein & Josephson, 2002). Globally, between 10% and 20% of falls result in serious outcomes such as injury, hospitalization, or death (Rubenstein, 2006). In community-dwelling older adults, fall rates are consistent across regions such as the United States and the United Kingdom, with approximately 29–30% affected and 5% requiring hospitalization for injuries like fractures (Bergen et al., 2016).

Beyond physical harm, falls often lead to psychological consequences such as fear of falling, which in turn contributes to reduced physical activity and functional decline. Structured exercise interventions have emerged as an effective strategy to counteract this cycle. Evidence shows that balance-focused programs can reduce fall incidence by 20–30% (Sherrington et al., 2019).

Among these interventions, the Otago Exercise Program (OEP) is widely recognized for its efficacy. Developed in New Zealand in the late 1990s, the OEP combines strength and balance exercises with walking routines, using minimal equipment (Campbell et al., 1997; Campbell et al., 1999). It comprises 17 exercises five for strength and 12 for balance and can be safely implemented by community-dwelling older adults (Campbell & Robertson, 2003; Liu & Latham, 2009; Mgbeojedo et al., 2023; Sherrington et al., 2011). The program's adaptability has led to various delivery formats, including group sessions and video-guided modalities, enhancing accessibility (García-Gollarte et al., 2023).

Meta-analyses confirm that the OEP improves static, dynamic, and anticipatory balance, while also reducing fear of falling (Chiu et al., 2021). These findings are further supported by a systematic review and meta-analysis by Thomas et al. (2010) which demonstrated that the OEP significantly reduces both fall rates and all-cause mortality among older adults. Similarly, modified versions of the program have proven effective in enhancing balance and stability, broadening its applicability across various older populations (Martins et al., 2018).

Moreover, beyond physical improvements, exercise-based interventions like the OEP positively impact psychological well-being. Karinkanta et al. (2012) found that regular participation in structured physical activity not only enhances health-related quality of life but also alleviates fear of falling, a factor strongly associated with reduced mobility and autonomy.

These benefits are particularly relevant in nursing home settings, where residents face compounded risks related to balance impairment, reduced autonomy, and increased healthcare needs. As global life expectancy increases, the need for multifaceted strategies to support healthy aging becomes more pressing. Physical activity interventions tailored to older populations have demonstrated effectiveness in delaying frailty, enhancing autonomy, and improving quality of life (Márcio et al., 2019; Nezhkina et al., 2022). Balance training presents a promising approach to mitigating fall risk and promoting functional independence (Ribeiro et al., 2017; Sampaio et al., 2024).

Despite existing supporting the OEP, limited research has been conducted on its application within institutionalized populations of advanced age. Moreover, this study is among the first to explore the effectiveness of the OEP among older adults residing in Albania nursing homes, addressing a significant gap in regional and demographic-specific data.

This study aims to evaluate the effectiveness of the OEP in improving balance and reducing fall risk among nursing home residents aged 65 and older. The findings will contribute to the development of evidence-based fall prevention strategies and support efforts to enhance the quality of life in institutionalized older adults.

Methods

Research Design

This study employed a quasi-experimental design to evaluate the effectiveness of the Otago Exercise Program (OEP) in improving balance and reducing fall risk in older adults residing in nursing homes. Participants were allocated to either an experimental group (EG) or a control group (CG), and assessments were conducted pre- and post-intervention over a 12-week period. Written informed consent was received from all participants of the study. The study protocol was registered and received ethical approval (Prot. Nr. 1108/2). The trial adhered to clarify guidelines and the Declaration of Helsinki principles.

Participants

A total of 42 participants aged 65 years and older were recruited from both state and private nursing homes in Tirana, Albania. Initially, 24 individuals were assigned to each group. However, the control group was reduced to 18 participants due to attrition: two individuals passed away and four were transferred to a specialized mental health facility due to severe psychological deterioration. The final group sizes were 24 for the EG and 18 for the CG. The CG had an average age of 69.44±2.70 years, height of 162.22±9.08 cm, and weight of 65.78±17.99 kg, while the EG had an average age of 74.50±6.40 years, height of 159.50±11.31 cm, and weight of 76.97±14.83 kg.

The inclusion criteria for the study required participants to be residents of a nursing home, either state-run or privately operated, and aged 65 years or older. Participants needed to be able to walk independently or with the assistance of mobility aids. Additionally, eligibility required documentation of at least one fall within the previous 12 months. Finally, participants had to demonstrate the capacity to complete the EQ-5D-3L questionnaire, which assesses health-related quality of life.

During the initial visit, the following procedures were conducted: (1) establishing rapport with the participant; (2) providing a clear explanation of the program's objectives; (3) collecting clinical history and screening for safety and adherence-related factors; (4) performing baseline balance and strength evaluations; and (5) prescribing the appropriate exercise protocol (Campbell & Robertson, 2003).

Procedure and Assessments

Participants underwent baseline and post-intervention evaluations using the Leonardo Mechanography platform (Novotec Medical GmbH, Pforzheim, Germany software package 4.2) to assess static and dynamic balance. Assessments followed the Standard Test Procedures supported by Leonardo Mechanography – Basic Version (BAS), as recommended by the manufacturer (Novotec Medical GmbH, n.d.). The following standardized tests were employed: Romberg EO-SEA (Eyes Open – Arms Forward – Standard Ellipse Area), Romberg EC-SEA (Eyes Closed – Arms Forward – Standard Ellipse Area), Romberg EO-rPL (Eyes Open – Arms Forward – Relative Pathlength), Semi-Tandem EO-SEA (Eyes Open – Side Arms – Standard Ellipse Area), Semi-Tandem EO-rPL (Eyes Open –

Side Arms – Relative Pathlength), Semi-Tandem EC-rPL (Eyes Closed – Side Arms – Relative Pathlength), Chair Rising Test.

Intervention Protocol

The experimental group participated in a 12-week structured exercise regimen following the OEP. Sessions were conducted three times per week, lasting 45–60 minutes each, for a total of 135–180 minutes weekly. The program included warm-up, strength, and balance training components (Campbell & Robertson, 2003), as outlined in Table 1. Progression was monitored to ensure safety and promote gradual improvement in functional mobility.

Table 1. Structure of the Otago Exercise Program (OEP) Intervention

Component	Description
Duration	12 weeks
Frequency	3 sessions per week (45–60 minutes/session)
Total Weekly Time	135–180 minutes
Warm-up	6 preparatory exercises
Strength Training	5 lower-limb exercises using ankle cuff weights (starting at 1 kg)
– Knee flexors & extensors	
– Hip abductors	
– Ankle dorsiflexors & plantar flexors	
Balance Exercises	12 dynamic and progressively challenging exercises:
– Initially performed with support	
– Progressively performed independently	
Repetitions	2 sets of 10 repetitions before progressing to more difficult versions
Intensity	Moderate intensity; no excessive fatigue
Cool-down	2 recovery/stretching exercises

Statistical Analysis

Descriptive statistics were calculated to summarize participants' demographic and baseline data. The Shapiro-Wilk test was applied to assess the normality of distribution. Given the non-parametric nature of the data, we used Mann–Whitney U test: to compare differences between the intervention and control groups. Also, we used the Wilcoxon Signed-Rank test: to evaluate within-group changes from baseline to post-intervention. All statistical analyses were conducted using SPSS software version 23 (IBM SPSS, Version 23.0, Armonk, NY, USA). A p-value of <0.05 was considered statistically significant.

Results

The table 2 reveals minimal changes in anthropometric measures for both groups. The control group, with an average age of 69.44 years, showed a slight increase in weight (65.78 kg to 66.76 kg) and BMI (25.13 to 25.28 kg/m²). Similarly, the experimental group, older on average (74.50 years), also experienced minor increases in weight (76.97 kg to 77.98 kg) and BMI (30.30 to 30.68 kg/m²).

If the body measurement data of both groups were alike, the results would probably be more important, since the 5-year age gap favoring the control group and the obesity of the experimental group are factors that affect the expected results after the experiment.

According to the results from table 3, by the Mann-Whitney U Test suggest that the intervention had a significant effect on postural stability, as reflected in the Romberg EO-rPL

Table 2. Anthropometric Data of Control and Experimental Groups Before and After the Intervention

Group	Variables	M±SD
Control	Age (years)	69.44±2.70
	Height (cm)	162.22±9.08
	Weight (kg) - pre	65.78±17.99
	Weight (kg) - post	66.76±18.06
	BMI (kg/m²) - pre	25.13±6.70
	BMI (kg/m²) - post	25.28±6.17
Experimental	Age (years)	74.50±6.40
	Height (cm)	159.50±11.31
	Weight (kg) - pre	76.97±14.83
	Weight (kg) - post	77.98±15.87
	BMI (kg/m²) - pre	30.30±5.36
	BMI (kg/m²) - post	30.68±5.65

Notes: M= Mean, SD= Standard Deviation

and Romberg EC-rPL measures. Specifically, the experimental group showed a significant improvement in postural control with both eyes open and closed, as indicated by the reduction in relative path length (rPL).

However, no significant differences were found in the Romberg EO-SEA and Romberg EC-SEA measures, which suggests that the intervention did not impact balance in terms of the standard ellipse area when standing with eyes open or closed.

Table 3. Differences between Groups at the end of the Experiment (check by Mann Whitney U test) –Romberg Test

Measurements Test U	N	Mean Rank	Sum of rank	U	Sig	p	Interpretation
C_Romberg EO-SEA (cm^2)	18	22.33	402.00	201	0.703	>0.05	No significant difference
E_Romberg EO-SEA (cm^2)	24	20.88	501.00				
C_Romberg EC-SEA (cm^2)	18	25.67	462.00	141	0.057	>0.05	No significant difference
E_Romberg EC-SEA (cm^2)	24	18.38	441.00				
C_Romberg EO-rPL (mm/s)	18	26.25	472.50	131	0.03	<0.05	Significant difference
E_Romberg EO-rPL (mm/s)	24	17.94	430.50				
C_Romberg EC-rPL (mm/s)	18	28.56	514.00	89	0.001	<0.05	Significant difference
E_Romberg EC-rPL (mm/s)	24	16.21	389.00				

Notes: C=Control Group, E=Experimental Group;.Romberg EO-SEA = Romberg Eyes Open - Arms Forward - Std. Ellipse Area; Romberg EC-SEA = Romberg Eyes Closed - Arms Forward - Std. Ellipse Area; Romberg EO-rPL = Romberg Eyes Open - Arms Forward - rel. Pathlength Area; Semi Tandem EO-SEA = Romberg Eyes Open - Side Arms - Std. Ellipse Area; Semi Tandem EO-rPL = Romberg Eyes Open - Side Arms - rel. Pathlength Area; Semi Tandem EC-rPL = Romberg Eyes Closed - Side Arms - rel. Pathlength Area.

The results of the Mann-Whitney U Test from table 4 suggest that the intervention had a significant effect on balance and strength. Specifically, the experimental group showed significant improvements in postural control during both Semi Tandem EO-SEA, Semi Tandem EC-SEA, and Semi Tandem EO-rPL measures, indicating better balance performance. However, no significant difference was found in the Semi Tandem EC-rPL measure, suggesting no change in balance control when eyes were closed. The experimental group also showed a significant improvement in the Chair Raising Test, demonstrating enhanced strength or functional capacity after the intervention.

Table 4. Differences between Groups at the end of the Experiment (check by Mann Whitney U test) –Semi Tandem Test and Chair Raising Test

Measurements Test U	N	Mean Rank	Sum of rank	U	Sig	p	Interpretation
C_Semi Tandem EO-SEA (cm^2)	18	28.06	505.00	98.00	0.003	<0.05	Significant difference
E_Semi Tandem EO-SEA (cm^2)	24	16.58	398.00				
C_Semi Tandem EC-SEA(cm^2)	18	30.11	542.00	61.00	0.000	<0.05	Significant difference
E_Semi Tandem EC-SEA(cm^2)	24	15.04	361.00				
C_Semi Tandem EO-rPL (mm/s)	18	27.89	502.00	101.00	0.003	<0.05	Significant difference
E_Semi Tandem EO-rPL (mm/s)	24	16.71	401.00				
C_Semi Tandem EC-rPL (mm/s)	18	25.00	450.00	153.00	0.109	>0.05	No significant difference
E_Semi Tandem EC-rPL (mm/s)	24	18.88	453.00				
C_Chair Raising Test (s)	18	27.31	491.50	111.50	0.008	<0.05	Significant difference
E_Chair Raising Test (s)	24	17.15	411.50				

Notes: C=Control Group, E=Experimental Group; Romberg EO-SEA = Romberg Eyes Open - Arms Forward - Std. Ellipse Area; Romberg EC-SEA = Romberg Eyes Closed - Arms Forward - Std. Ellipse Area; Romberg EO-rPL = Romberg Eyes Open - Arms Forward - rel. Pathlength Area; Semi Tandem EO-SEA = Romberg Eyes Open - Side Arms - Std. Ellipse Area; Semi Tandem EO-rPL = Romberg Eyes Open - Side Arms - rel. Pathlength Area; Semi Tandem EC-rPL = Romberg Eyes Closed - Side Arms - rel. Pathlength Area.

The results from table 5 indicate that most variables showed no statistically significant differences between the before and after measurements in both control and experimental groups. However, a notable exception is the Romberg EO-rPL (Eyes Open, Path Length) variable for the experimental group, which demonstrated a significant reduction (p=0.04)

This suggests that the intervention applied to the experimental group had a measurable impact on postural stability with eyes open, as indicated by the decreased path length. Other variables, while some showed trends toward significance (e.g., Romberg EC-rPL in the experimental group), did not reach the statistical threshold for significance.

According to table 6, the experimental group showed statistically significant improvements across multiple variables, particularly in postural stability and functional performance, such as in the Chair Raising Test and Semi Tandem rPL variables. The control group also demonstrated some significant improvements, but these were more limited compared to the experimental group.

These findings suggest the intervention's effectiveness in enhancing balance and functional mobility, especially in challenging conditions such as eyes-closed tasks.

Table 5. Wilcoxon Paired Z-Test Results for Romberg Test Performance

Variables	Group	Wilcoxon Pair - Z test	Sig	p	Interpretation
Romberg EO-SEA (cm^2)	CG	-0.544	0.586	>0.05	No significant difference
	EG	-0.029	0.977	>0.05	No significant difference
Romberg EC-SEA (cm^2)	CG	-0.109	0.913	>0.05	No significant difference
	EG	-1.386	0.166	>0.05	No significant difference
Romberg EO-rPL (mm/s)	CG	-0.240	0.811	>0.05	No significant difference
	EG	-2.057	0.040	<0.05	Significant difference
Romberg EC-rPL (mm/s)	CG	-0.152	0.145	>0.05	No significant difference
	EG	-3.371	`0.059	>0.05	No significant difference

Notes: CG=Control Group; EG=Experimental Group; Romberg EO-SEA = Romberg Eyes Open - Arms Forward - Std. Ellipse Area; Romberg EC-SEA = Romberg Eyes Closed - Arms Forward - Std. Ellipse Area; Romberg EO-rPL = Romberg Eyes Open - Arms Forward - rel. Pathlength Area.

Table 6. Wilcoxon Paired Z-Test Results for Semi Tandem and Chair Stand Tests Performance

Variables	Group	Wilcoxon Pair - Z test	sig	p	Interpretation
Semi Tandem EO-SEA (cm^2)	CG	-1.459	0.145	>0.05	No significant difference
	EG	-1.886	0.059	>0.05	No significant difference
Semi Tandem EC-SEA(cm^2)	CG	-3.114	0.002	<0.05	Significant difference
	EG	-3.686	0.000	<0.05	Significant difference
Semi Tandem EO-rPL (mm/s)	CG	-0.849	0.396	>0.05	No significant difference
	EG	-3.743	0.000	<0.05	Significant difference
Semi Tandem EC-rPL (mm/s)	CG	-2.373	0.018	<0.05	Significant difference
	EG	-4.286	0.000	<0.05	Significant difference
Chair Raising Test (s)	CG	1.415	0.157	>0.05	No significant difference
	EG	2.214	0.027	<0.05	Significant difference

Notes: Semi Tandem EO-SEA = Romberg Eyes Open - Side Arms - Std. Ellipse Area; Semi Tandem EO-rPL = Romberg Eyes Open - Side Arms - rel. Pathlength Area; Semi Tandem EC-rPL = Romberg Eyes Closed - Side Arms - rel. Pathlength Area.

Discussion

The findings of this study underscore the effectiveness of the (OEP) in enhancing balance among older adults residing in nursing homes. This intervention directly addresses major challenges associated with aging, including reduced mobility and increased fall risk two key contributors to morbidity and loss of independence (Ambrose et al., 2013; Rubenstein & Josephson, 2002; Rodrigues et al., 2023; Xu et al., 2022).

Beyond its physical benefits, the OEP may also offer psychosocial advantages by promoting group activities and fostering interpersonal engagement, which are vital in reducing social isolation in institutionalized older adults (Bjerk et al., 2018). Notably, the experimental group showed significant improvements in demanding balance tasks, such as tests performed with eyes closed. These outcomes are likely driven by neuromuscular adaptations induced by the OEP, which focuses on enhancing lower-limb strength and proprioceptive function (Chiu et al., 2021).

These improvements in balance performance can be explained through multiple interconnected physiological and neurological mechanisms. The OEP enhances lower-limb strength and muscular coordination, which are critical for stability under challenging conditions, including visual deprivation (Sherrington et al., 2017). Repeated practice of functional movements likely enhances loops (Lacroix et al., 2016). In parallel, motor learning induced by balance training, may promote sensorimotor integration and neuroplastic adaptations in cortical and subcortical areas responsible for postural control, such as the cerebellum and prefrontal cortex (Nicolson et al., 2021; Sehm et al., 2014). Moreover, interventions involving dynamic balance under constrained conditions have been shown to increase activity in neural networks associated with executive function and spatial orientation, domain known to deteriorate with age (Li et al., 2021; Voelcker-Rehage & Niemann, 2013). Thus, the OEP, likely generates a synergistic effect by improving both biomechanical and neurocognitive components of balance.

Our results reinforce the substantial body of evidence supporting the OEP as a core component of fall prevention strategies. The program's emphasis on balance and strength training aligns with previous studies that report a 20–30% reduction in fall incidence among community-dwelling older adults (Li et al., 2021; Racey et al., 2021; Sadaqa et al., 2023; Sherrington et al., 2017; van Gameren et al., 2021). Furthermore, there is growing evidence that such interventions may also enhance cognitive functions particularly executive function and spatial awareness through balance training (Lacroix et al., 2016; Nicolson et al., 2021).

The use of the Leonardo Mechanograph platform added methodological rigor by providing high-resolution biomechanical data, which further substantiated the intervention's effectiveness (García-Gollarte et al., 2023; Hoang et al., 2021;

Wiegmann et al., 2019; Wiegmann et al., 2022). The observed improvements in postural control likely resulted from the synergistic effects of physical, cognitive, and emotional stimuli inherent in this multifaceted intervention. The OEP appears to facilitate motor learning, particularly under challenging conditions such as tasks requiring postural adjustments with visual deprivation.

Importantly, this holistic approach not only addresses fall risk but also contributes to broader aspects of well-being, such as promoting active aging, maintaining functional independence, and mitigating chronic conditions including hypertension and type 2 diabetes through sustained physical activity (Márcio et al., 2019; Ribeiro et al., 2017).

This study provides actionable insights for healthcare professionals and policymakers. Structured and scalable interventions that incorporate culturally appropriate elements have significant potential, especially in resource-constrained settings. The flexibility of the OEP, which can be delivered in both group and individual formats, enhances its applicability across various institutional environments (Campbell & Robertson, 2003). Additionally, leveraging digital platforms or partnerships with community organizations could facilitate broader, more cost-effective implementation (García-Gollarte et al., 2023; Liu & Latham, 2009).

Nevertheless, the quasi-experimental design of this study limits the generalizability of the findings. Larger randomized controlled trials are needed to validate these results and explore long-term effects. Future research should also examine the feasibility of embedding such programs within existing healthcare systems, considering workforce training, infrastructure, and sustainability (Sherrington et al., 2019; WHO, 2025).

Moreover, evaluating the cost-effectiveness of the intervention is crucial, given the escalating healthcare costs associated with falls in older populations (WHO, 2025). Examining potential gender differences in intervention outcomes may also provide insights into tailoring strategies to meet the diverse needs of older adults (Li et al., 2021; Nicolson et al., 2021).

Conclusion

The OEP is a highly effective and practical strategy for reducing fall risk and improving balance among older adults living in nursing homes. These findings highlight the value of culturally adaptable, evidence-based interventions in enhancing the effectiveness of traditional fall prevention strategies. The use of advanced biomechanical assessment tools, such as the Leonardo Mechanograph, strengthens the evidence base and supports broader adoption in clinical and community settings.

As populations continue to age, integrating scalable, low-cost, and multifaceted exercise programs like the OEP into healthcare systems will be essential for promoting healthy aging and reducing the economic burden of fall-related injuries. Especially considering that numerous socio-economic factors influence barriers to physical activity (Ilić et al., 2024).

Future research should explore the long-term sustainability, cost-effectiveness, and adaptability of such interventions across diverse populations and care environments.

Acknowledgments

We extend our sincere gratitude to the nursing home residents who participated in this study and to their caregivers and staff for their cooperation and support throughout the intervention. Special thanks are due to the Sports University of Tirana for providing institutional support and resources that made this research possible. We also acknowledge the contributions of colleagues who assisted with data collection and analysis, as well as the reviewers who provided constructive feedback on this manuscript.

Conflict of Interest

The authors declare no conflict of interest related to this study. The research was conducted independently, and no financial or personal relationships influenced the design, execution, or reporting of the findings.

Received: 19 Aprile 2025 | **Accepted:** 17 May 2025 | **Published:** 01 June 2025

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