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Effect of Balance Training with Foot Orthosis on Falling in Elderly

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ABSTRACT

Background: Falls are a leading cause of injury and reduced quality of life (QoL) among the elderly.
Objective: This study aimed to evaluate the effect of balance training combined with foot orthosis versus orthosis alone on fall risk in elderly individuals.
Subjects and methods: Sixty elderly participants aged 65–75 years were randomly divided into two groups: Group A received both a balance training program and orthotic prescription, while group B received only the orthotic prescription. The intervention lasted two months with group A training three times per week. Assessment tools included the Berg Balance Scale (BBS), Timed Up and Go Test (TUGT), Dynamic Gait Index, and Tinetti Test (TT).
Results: The results indicated significant post-intervention improvements in all measured outcomes for both groups, with group A showing significantly greater gains in balance and mobility measures ($p < 0.001$).
Conclusion: The findings support the effectiveness of combining balance training with foot orthosis in reducing fall risk and improving balance performance among the elderly.
Keywords: Foot orthosis, Balance training, Falling in elderly, TUG, TT.

INTRODUCTION

The notion of physiology of aging states that a succession of complicated processes occur, eventually leading to a gradual loss in the function of all organ systems. These alterations may affect general function and capacities, ultimately reducing independence and QoL. Gait and mobility as posture and the basic movement patterns involved in walking alter **(1, 2)**.

Concurrently, falls are a serious public health issue on a global scale. With an estimated 684 000 fatal falls annually, falls rank second in terms of unintentional injury deaths, after traffic accidents. The mortality rate is higher among persons over 60 in every part of the world **(3)**. While ER visits have climbed by 19% over the last ten years, the frequency of fall fatalities among older adults has increased by 59% **(4)**.

The percentage of people over 60 will almost double from 12% to 22% of the global population between 2015 and 2050 **(5)**. According to an analysis of 104 research with a total sample size of 36,740,590, 26.5% (95% CI 23.4–29.8%) of older individuals worldwide have falls **(6)**. Over one-fourth of Americans over 65 fall every year, and by 2030, it is expected that treating injuries from falls would cost more than $101 billion. Researchers estimate that by 2030, there will be seven fatal falls every hour, with fall fatality rates increasing by 30% between 2007 and 2016 **(7)**.

In 2022, there were 6.8 million senior people in Egypt, which is predicted to be 7.7% of the country's overall population. In 2050, this proportion is predicted to rise to 17.9% **(8)**. Women declined at a higher rate than males **(9)**. To maintain stable gait and balance, the body employs control systems, including the central nervous system (CNS) for coordination, the musculoskeletal system for maintenance and movement, the sensory system for continuous feedback, and vision for acquiring external information to navigate uneven surfaces and enhance dynamic stability **(10)**.

Inactivity is supposed to have a detrimental effect on balance control and hasten the decline of physiological processes. Therefore, it has been demonstrated that physical exercise counteracts this tendency. However, it is still unclear what kind of exercise might be best for this endeavour. Training for balance and leg strength has been found to be an effective way to lower the risk of falls. Additionally, it has been demonstrated that older adults with impaired balance are more likely to fall than those with normal postural control, highlighting the need of balance training for the elderly. Exercises such as Pilates, stair climbing, vibration training, and dance have all been the subject of several studies. The capacity to balance has significantly improved for all of these. It is unclear from the examined research if a particular training program is better than others for improving older people's balance. On the other hand, function declined in all no-activity groups **(4)**.

Exercise programs that included both a high challenge to balance and more than three hours of exercise per week were found to reduce the rate of falls by 39%, according to meta-regression results. Activities that moved the center of mass, narrowed the base of support, and minimized upper limb support were considered high challenges to balance **(11)**. Various interventions have been explored to maximize sensory input from plantar soles, including vibration stimuli, personalized foot orthosis, textured insoles, and sandals with magnetic and textured insoles. Some of these interventions have been shown to enhance balance **(12)**.

Wearing insoles is one of the simplest and most affordable therapies for foot issues. The purpose of the current study was to address the dearth of research on

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the impact of balance training combined with orthosis vs orthosis alone on the risk of falls in the elderly. For elderly people in good health who don't have any serious health issues. The use of various pre-made insoles that improve balance is common. By enhancing tactile and proprioceptive sensory inputs, these insoles improve sensitivity to detect changes in the foot's mechanical events. They assist lower limb muscle activation, which improves lower extremity stability and they optimize kinematic properties by altering the contact surface and foot position. Numerous research on insoles have found that using them instantly improves gait and balance [(13)].

This study aimed to evaluate the effect of balance training combined with foot orthosis versus orthosis alone on fall risk in elderly individuals.

SUBJECTS AND METHODS

Participants: Sixty elderly patients aging 65-75 years of both gender included in this study. Patients were recruited from outpatient clinics of El-Qenaiat Central Hospital, Zagazig, Egypt. Patients were randomly divided into two equal groups: Group (A) (combined experimental group) composed of 30 elderly patients who received balance training program beside orthotic prescription three times per week for two months and group (B) (orthotic only group) composed of 30 elderly patients who received orthotic prescription only for two months.

Inclusion criteria: Patients to be between 65 and 75 years old, of either gender, with a BMI [(14)] ranging from 25 to 29.9 kg/m². All participants were clinically and medically stable and used foot orthosis. Additionally, eligible individuals scored between 35 and 45 on the BBS [(15)], 19–21 on the moderate fall risk scale [(12)], 19–23 on the Tinetti tool score [(16)] and more than 13.5 seconds on the TUGT [(17)].

Exclusion criteria: Patients being bedridden, having a history of vestibular disorders, CNS conditions (e.g., stroke, dementia & Parkinson's disease), peripheral neuropathy, or foot surgery, using medications that could influence study outcomes; prior use of insoles within the last month [(12)], presence of severe foot deformities preventing regular shoe wear or insole adaptation and diagnosis of life-threatening conditions such as renal failure or myocardial infarction. Patients with myasthenia gravis, hyperthyroidism, hemorrhage, acute viral infections, tuberculosis, mental disorders, pacemakers, uncontrolled diabetes, hypertension, or those who smoke.

Design of the study: This study utilized a two-group pre-test post-test randomized controlled design. Participants were cognitively aware and capable of providing consent. Sample size was established using G*Power (version 3.1.9.2) based on a Mixed Model ANOVA, with a type I error rate of 5%, an effect size of 1.59 for the primary outcome (balance), and 85% power, resulting in a minimum of 30 subjects per group. Blocked randomization was applied [(18)], and both patients and assessors were blinded to group allocation. A total of 60 elderly patients were recruited from Outpatient Clinics of El-Qenaiat Central Hospital in Zagazig, Egypt. They were randomly assigned into two groups: Group A (experimental) included 30 patients who received a combined balance training program and orthotic prescription three times per week for two months, while group B (control) consisted of 30 patients receiving only orthotic prescription over the same period.

For group A only, the intervention began with a warm-up phase lasting approximately five minutes, consisting of free passive stretching exercises for the lower limbs [(19-21)]**.** This followed by a second part comprising eight different balance exercises that incorporated both proprioceptive and vestibular training components. The **proprioceptive training** included activities such as standing static balance, lateral weight transfer, lateral weight transfer near a chair, tandem stance with eyes closed, walking on toes, and postural control using a gymnastic ball. The **vestibular training** included exercises involving balance with head movement and seated lateral stepping, all designed to enhance the patients' balance, coordination, and overall postural stability.

Materials: For assessment, a standard weight and height scale (UGM-200 HEALTH SCALE, China) was used to measure each patient's weight and height to calculate their BMI (kg/m²). Treatment equipment included a standard armchair with a seat height of 46 cm and arm height of 67 cm, as per **Schoppen *et al.*** [(22)]**,** and a gymnastic ball selected based on the user's lower leg length to ensure that the thigh was parallel to the ground when seated, promoting balance through its inherent instability [(23)]. A tongue depressor or pen used as a visual reference point for the eyes during vestibular training. Additionally, all participants received orthotics in the form of insoles made of ethylene-vinyl acetate (EVA; Technical Ltd, São Paulo, Brazil), selected according to each subject's shoe size and worn inside their own regular footwear, as described by **Asgari *et al.*** [(24)]. For group A and B, insoles were worn inside the subjects' own regular shoes [(12)]**.**

Balance and physical activity assessment: The evaluation procedures of this study began with taking a detailed patient history to gather information about general health, physical activity levels, and current medications. The process divided into several parts. First, during preparatory procedures, all medical and demographic data were collected, the importance of physical therapy was explained, vital signs (blood pressure, temperature, respiratory rate and heart rate) were monitored, and patients were instructed to report any side effects during treatment sessions [(25)].

Anthropometric measurements, including height, weight, and BMI were recorded. Balance and gait were assessed using multiple standardized tools. The TUG test measured the time it took for a patient to stand from a chair, move 3 meters, turn, return, and seat down, making it a valid screening tool for fall risk in the elderly [17, 22].

Ethical approval: This study was approved by the Faculty of Physical Therapy, Cairo University Ethics Committee. All participants were fully informed about the study's goal, methods, and potential dangers. Signed consent was provided by each participant. The study adhered to the Helsinki Declaration throughout its execution.

Statistical analysis

Descriptive statistics were used in the statistical analysis, which was performed with SPSS version 24. For descriptive statistics, t-tests, X^2-tests, and mixed model ANOVA were used to examine the data. Gender was shown as frequencies and percentages, whereas demographic characteristics (age, height, weight and BMI) were summarized as mean ± SD. Group differences in demographics were assessed using unpaired t-tests and chi-square tests, with normality checked via the Shapiro-Wilk test. Intervention effects on the TUG test were examined using mixed model ANOVA, with time (pre- vs. post-intervention) as a within-subject factor, group (A vs. B) as a between-subject factor, and their interaction tested. Results included F, p, partial eta squared and power. Analysis was done using the proper tools, and $p \leq 0.05$ was the threshold for statistical significance.

RESULTS

The combined group had an average age of 68.1 ± 3.97 years, with an average weight of 75.37 ± 6.28 kg. The mean height for the group was 167.47 ±7.49 cm and the body mass index (14) was calculated at 27.05 ± 1.41kg/m^2. These values represent the overall characteristics of the participants, showing consistency in age, weight, height, and BMI across both groups. Table (1) represented statistics of age, weight, height and BMI within and between groups. The demographic analysis showed no significant differences between group A and group B. Gender distribution analysis revealed that group A consisted of 26.7% males and 73.3% females, while group B had 40% males and 60% females. The X^2-test showed no significant difference in gender distribution between the groups (p = 0.446).

Table (1): Statistics of age, weight, height and BMI within and between groups

	Group (A)	Group (B)	MD(LL-UL)	t	P
Age	67.2±3.82	69±4.11	-1.8 (-4.7664-1.1664)	-1.243	0.224
Weight	73.93±6.84	76.8±5.72	-2.86667 (-7.58316-1.84983)	-1.245	0.223
Height	165.87±8.61	169.07±6.36	-3.2 (-8.86238-2.46238)	-1.158	0.257
BMI	26.85±1.08	27.25±1.73	-0.4 (-1.47739-0.67739)	-0.761	0.453

Mixed model ANOVA results indicated significant post-intervention (group effect) improvements in balance, mobility, and gait for both groups, with group A consistently showing larger effect sizes. For the TUG, group A had higher percentage changes, larger mean differences, and significant F values ($p < 0.001$) compared to group B. The effect sizes (partial eta squared) for post-intervention outcomes ranged from 0.624 to 0.819 for group A, reflecting strong intervention effects, while group B had moderate effect sizes. Power analysis confirmed robust statistical power (1.000) for all significant findings, supporting the reliability of the results.

Table (2): Statistics of the four balance tests within and between groups

Variable	**Group (A)**	**Group (B)**	**Group effect**			
			F	**Sig**	**Partial Eta Squared**	**Power**
Time effect			**Interaction effect**			
Pre-TUG	17.07 ± 1.61	17.13 ± 1.47	0.014	0.907	0.000	0.051
Post-TUG	10.07 ± 1.88	14.4 ± 1.59	46.374	0.000	0.624	1.000
MD	11.733(11.017-12.449)	6.2(5.484-6.916)	125.255	0.000	0.817	1.000
% of Change	IN29.18%	IN14.9%				
Sig	0.000	0.000				

DISCUSSION

The results of the current study revealed significant improvements in participants' balance following the six-week training program. There was a dose-response relationship where research indicated that older adults who participated in a higher frequency of balance training (three sessions per week) exhibited the most significant improvements in dynamic balance measures, including TUG and limits of stability [(26)]. Balance exercises improved proprioceptive feedback, which is vital for real-time adjustments in posture and balance during walking. Better proprioception aided in precise foot placement and stability while turning, directly influencing TUG performance [(26)].

Ramadani and Basuki [(27)] investigated the effect of 4-weeks balance training on gait in 31 obese older adults (BMI > 30 kg/m^2). Following the four-week balance training intervention, participants were re-evaluated using the TUG test. The TUG test is particularly valuable for older adults, as it assesses not only walking speed but also the ability to transition from sitting to standing, walk a short distance, turn, and return to sitting. Improvements in TUG scores are indicative of better functional mobility, which is crucial for reducing fall risk in obese older adults. The results indicated a significant improvement in the time taken to complete the test, suggesting enhanced mobility and balance among the participants after the training. The study emphasized that the changes observed were statistically significant, reinforcing the effectiveness of the balance training program.

Pratama and Furqonah [(28)] examined the effectiveness of balance exercises and gait training in improving balance and walking speed on a patient with hemiparesis due to ischemic stroke. The patient was a 57-year-old male who had experienced a stroke that affected his left side, leading to various physical challenges. The effectiveness of the interventions was measured using the TUGT. Initially, the patient's TUGT score was 14.14 seconds, indicating a mild risk of falling. After six evaluations, this time improved to 9.50 seconds, suggesting a significant enhancement in the patient's balance and independence. The study concluded that both balance exercises and gait training were effective in improving the balance and walking speed of the patient and reducing risk of fall. Several studies such as those by **Labata-Lezaun *et al.*** [(29)] and **Adcock *et al.*** [(30)] found no statistically significant difference in static balance between intervention and control groups, suggesting that while exercise interventions may be beneficial overall, the specific modalities used may not always outperform no training.

Several investigations focused on specific populations or novel training methods. Studies by **Keklikoğlu *et al.*** [(31)] and **Alizadehsaravi *et al.*** [(32)] highlighted that not all training modalities significantly influenced gait or balance parameters. Additional studies explored balance training effects in various populations, including stroke patients [(28)] and elderly individuals comparing core stability and balance training [(27)]. These studies underscored the potential of alternative or combined approaches in enhancing mobility and reducing fall risk. Nevertheless, the current study faced limitations such as a narrow age range (65–75), regional focus (El-Qenaiat Central Hospital, Zagazig, Egypt), short intervention duration, and lack of adherence monitoring, which may limit the generalizability and long-term applicability of the results.

CONCLUSION

The study concluded that integrating balance training with foot orthosis significantly improved balance, gait, and functional mobility in elderly participants compared to using orthosis alone. Group A, which received both interventions, demonstrated notably higher improvements across TUG balance assessment tools, indicating the superior effectiveness of the combined approach. These findings highlighted the importance of structured balance training programs in fall prevention strategies for older adults. However, the study's limitations, including a restricted age range, localized sample, short intervention duration, and lack of adherence monitoring suggest the need for broader and longer-term investigations to confirm these results and ensure their generalizability.

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