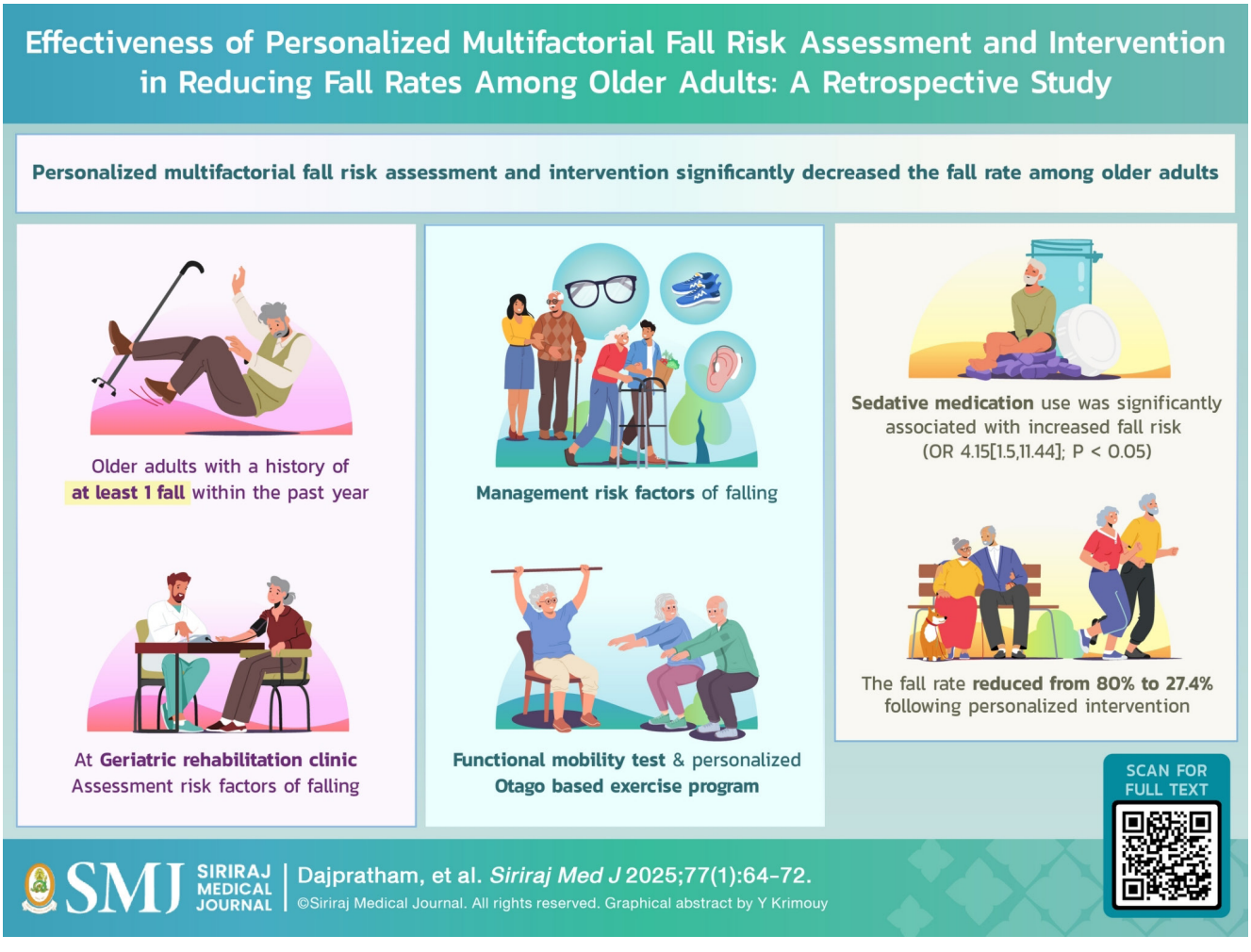
Effectiveness of Personalized Multifactorial Fall Risk Assessment and Intervention in Reducing Fall Rates Among Older Adults: A Retrospective Study

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ABSTRACT

Objective: This study aimed to investigate the effectiveness of personalized multifactorial fall risk assessment and intervention in reducing the incidence of recurrent falls after one year.

Materials and Methods: This retrospective study reviewed medical records from the Geriatric Rehabilitation Clinic at Siriraj Hospital, including data from patients with a history of falls (fallers) or gait instability (non-fallers) between April 2016 and April 2021. Upon entering the clinic, older patients received personalized multifactorial fall risk assessment and intervention. Functional mobility was also evaluated using the Timed Up and Go (TUG) test, Functional Reach, and 30-second Chair Stand test. Fallers were followed for one year, and classified into recurrent fallers or zero-fallers based on whether they experienced at least one fall during the follow-up period.

Results: Of the 134 patients initially reviewed, 105 met the criteria for analysis. The cohort was predominantly female (65.5%) with an average age of 81.5 years (SD 6.8). Common risk factors included hypertension, back/leg pain, and cognitive impairment. After 12 months, 27.4% of fallers experienced recurrent falls. Sedative medication use was significantly associated with increased fall risk (OR 4.15[1.5,11.44]; $P < 0.05$). Other risk factors were not statistically significant. The fall rate reduced from 80% to 27.4% following personalized intervention.

Conclusion: Personalized multifactorial fall risk assessment and intervention significantly decreased the fall rate among older patients. Sedative medications were notably linked to increased fall risk, highlighting the need for careful medication management and targeted fall prevention strategies.

Keywords: Aged; balance; exercise therapy; falls; gait disorders; rehabilitation; risk factors (Siriraj Med J 2025; 77: 64-72)

INTRODUCTION

Falls and instability among the older people have significant global repercussions, including disability and increased mortality.[1] On an individual level, falls often lead to a decline in self-care abilities, reduced independence, and even death, emphasizing their severe impact. Nationally, the economic burden of falls is considerable, with healthcare costs escalating due to hospitalizations and long-term care expenses for fall-related injuries. A 2014 study in the United States estimated that the annual cost of elderly fall care ranges from $68 million to $2.8 trillion, underscoring the substantial financial strain associated with falls.[2]

A fall is defined as an unexpected and sudden loss of control, causing an individual to collapse to the ground or assume a seated or prone position, typically due to impaired balance.[3]

To address these challenges, the American Geriatric Society and British Geriatric Society have established guidelines focusing on fall prevention and comprehensive risk assessments for older adults. These guidelines emphasized proactive strategies, including regular evaluations using tools such as the Timed Up and Go Test, the Morse Fall Scale, and the Berg Balance Test.[4] Additionally, the CDC's Stopping Elderly Accidents, Deaths & Injuries (STEADI) Initiative emphasized three key components: Screen, Assess, and Intervene.[5] For individuals experiencing recurrent falls or abnormal gait, thorough assessments by interdisciplinary teams are essential. Evidence-based interventions, such as balance training, muscle strengthening exercises for the hips, knees, and ankles, and joint flexibility exercises were crucial in managing fall risks.[6] Additionally, making appropriate modifications to the home environment was recommended to further reduce fall risks among the older people.[7,8]

At Siriraj Hospital, the Geriatric Rehabilitation Clinic works in conjunction with the geriatric clinic to provide specialized care for individuals aged 70 and older, or those aged 60 and above with cognitive impairments. The clinic focuses on enhancing the functional capacity of older adults at risk of functional decline. Patients with movement or balance issues and a history of falls receive comprehensive, multifactorial fall risk assessments and personalized interventions. This study aimed to investigate the characteristics and fall risk among older patients attending the geriatric rehabilitation clinic. In addition, the incidence of recurrent fall was also examined as an outcome of the fall management interventions in this vulnerable population.

MATERIALS AND METHODS

Study Design

This retrospective study involved a review of medical records from the Geriatric Rehabilitation Clinic at Siriraj Hospital. The research project was reviewed and approved

by the Human Research Ethics Committee of the Faculty of Medicine Siriraj Hospital (Project SI 1003/2020, Code 761/2020 [IRB1]). Authorization to access medical record information was granted by the hospital director.

Participants

We evaluated patients treated at the Geriatric Rehabilitation Clinic for eligibility based on the following inclusion criteria: a history of at least one fall within the past year or walking instability between April 2016 and April 2021, along with abnormal functional mobility tests. Additionally, patients needed to have accessible medical record data from at least one baseline, one follow-up assessment within the year, and one year follow-up visit. Patients were excluded if their data on risk factors, complications from various diseases, functional mobility tests, or dependency status were incomplete at the three specified time points.

Data collection and assessment

Study measurements were recorded at initial and one year follow-up visits. Patients with at least one fall or gait instability underwent a multifactorial fall risk assessment and intervention. This assessment included evaluating various fall risk factors such as comorbidities, medication use (including sedatives and hypnotic drugs), visual and auditory function, cognitive function, frequent urination (≥8 times per day), urinary incontinence (stress, urge, overflow, and mixed incontinence), foot deformities (e.g., hallux valgus, hammer toe, Charcot arthropathy), back/leg pain, and external factors like home environment and presence of pets. Activities of daily living (ADL) were assessed using the KATZ ADL[9] and LAWTON IADL scales.[10]

Fall history was documented by recording the location and time of each fall. Balance impairments were evaluated using functional mobility tests, including the Timed Up and Go (TUG), Functional Reach, and 30-second Chair Stand tests, with results documented in clinic records. According to the CDC's STEADI tool,[5] a TUG score of 12 seconds or more, a low number of 30-second chair stands based on age groups, and a Functional Reach score of less than 10 inches indicate a fall risk.[9]

Patients exhibiting abnormal functional mobility tests were scheduled for regular follow-ups, approximately 2-3 times annually. During these visits, they underwent repeat functional mobility assessments and received personalized advice, counseling, exercise recommendations, and environmental adjustments based on the multifactorial fall risk assessment results. Follow-up visits included a comparison of current functional mobility test results with previous assessments, and patients and their caregivers were provided feedback regarding their performance. Patients were then encouraged to adhere to the recommended interventions, with exercise programs reviewed and adjusted according to each individual's functional capacity.

Multifactorial fall risk interventions

The Geriatric Rehabilitation Clinic collaborated closely with the geriatric clinic, where geriatricians addressed medical issues that could contribute to falls, such as polypharmacy, postural hypotension, and cardiopulmonary conditions. Physiatrists in the rehabilitation clinic assessed and managed neuro-musculoskeletal issues and other risk factors, including gait and balance impairments, back and leg pain, and foot deformities. For specific conditions like visual or auditory impairments that required further assessment by other specialties, consultations were initiated. Living environments were screened, and necessary adjustments were recommended. Exercise recommendations in our clinic were based on the Otago Exercise Program (OEP), a home-based initiative designed for fall prevention in older adults.[11] This program emphasized three key areas: strength, balance, and endurance. Strength and balance training was recommended three days a week, for 15-20 minutes twice daily, while endurance training involved 30 minutes of daily walking, which could be divided into 10-minute sessions throughout the day. These exercise programs were tailored to each patient's functional status and physical capacity. To ensure proper execution of the exercises at home, patients and their caregivers were instructed on the exercises in the clinic. Clinicians demonstrated each exercise, emphasizing proper technique and safety precautions. For patients who experienced instability during standing or walking, additional support was recommended, such as using their hands for balance while performing the exercises. In terms of enhancing exercise adherence, patients were encouraged to record their exercise sessions using smartphones. This self-monitoring strategy helped reinforce their commitment and allowed clinicians to review the patient's progress during follow-up visits. For patients who did not use smartphones, written instructions were provided as an alternative. To further ensure adherence and proper execution, caregivers were asked to supervise the patients during their exercise sessions at home. This support from caregivers was vital for reinforcing the routine and providing assistance if needed. As the program was conducted in an outpatient (OPD) setting, our role was to select the appropriate exercises from the OEP, which patients were expected to perform at home. Adherence was closely monitored

through regular follow-up appointments, during which clinicians reviewed the patients' exercise performance and made any necessary adjustments. We also ensured that all procedures adhered to the Privacy and Data Protection Act (PDPA) of 2019, especially in regard to patients using smartphones to record their exercises.

Data collection and classification

Demographic data, including age, gender, body mass index (BMI), fall risk factors, functional mobility tests, and ADL scores (KATZ ADL and LAWTON IADL), were collected at the initial assessment and again at 12 months. This information was extracted from medical records and entered into a prepared case record form. Participants were initially categorized into two groups: fallers (those with at least one fall in the preceding year) and non-fallers (those without falls). Fallers were further classified into two subgroups: recurrent faller (those with multiple falls) and zero-fall (those with no falls during the follow-up year).

Sample size calculation

The sample size calculation was based on a study involving multifactorial interventions to reduce the risk of falls among elderly individuals living in the community.[12] This study indicated an average decrease in recurrent falls of 33%, an acceptable width of 95% confidence interval (24%, 42%). The sample size would be 105 cases.

Statistical analysis

Statistical analyses were performed using PASW Statistics version 18.0 (SPSS Inc., Chicago, IL, USA).[13] Descriptive statistics were applied to assess demographic characteristics, fall risk factors, functional mobility test results, and ADL abilities at baseline between fallers and non-fallers. Comparisons were also made between recurrent fall and zero fall groups at the one-year follow-up. Categorical variables, such as gender and the presence of common risk factors, were compared using Chi-square tests, while Fisher's exact test was used for the number of 30-second chair stands. Continuous data, including age, BMI, number of medications, functional test times, and ADL scores, were compared using independent sample t-tests. Statistical significance was defined as a p-value < 0.05. Odds ratios with 95% confidence intervals were reported for univariate analyses.

RESULTS

From April 2016 to April 2021, a review of outpatient medical records at the Siriraj Geriatric Rehabilitation Clinic identified 134 patients who underwent multifactorial fall risk assessment and intervention for falls and unsteady walking. Of these, 18 patients did not return for follow-up, seven were unable to participate due to conditions such as cerebrovascular disease or other serious illnesses, and four missed their follow-up appointments. Therefore, data from 105 patients were included in the final analysis. The cohort was predominantly female (65.5%), with an average age of 81.5 years (SD 6.8) and an average body mass index (BMI) of 22.8 kg/m^2 (SD 3.2). The most common risk factors were hypertension (82.9%), back or leg pain (81.0%), and cognitive impairment (61.0%). Falls were most frequently reported at home (82.2%) and during the daytime (74.6%).

Participants were divided into two groups based on their fall history over the past year: 84 patients were categorized as Fallers, individuals with a history of falls, while 21 were classified as Non-fallers, individuals with no fall history. Basic demographic and clinical characteristics, including gender, age, BMI, and common risk factors, were provided in Table 1. The Faller group exhibited higher prevalence rates for several factors compared to the Non-faller group. Specifically, pet ownership was more common among Fallers, as was diabetes, frequent urination, foot deformities, and the use of sedating medications. The Fallers also had longer completion times for the TUG test. Most Fallers reported difficulties in performing activities of daily living. No significant differences were observed in the other functional mobility tests between the Faller and Non-faller groups.

After 12 months of follow-up, 27 patients from both groups experienced falls, while 78 patients did not. Among the 84 patients with a history of falls prior to the study, 23 (27.4%) experienced recurrent falls, while 61 (72.6%) did not. The recurrent fall group had significantly higher use of sedating medications compared to the zero-fall group (OR 4.15 [1.5,11.44]; $P < 0.05$) and this magnitude could be interpreted as large effect size.[14] Other risk factors did not show significant differences between the groups. The recurrent fall group was more likely to have hypertension, diabetes, cognitive impairment, foot deformities, and polypharmacy. Additionally, the recurrent fall group took longer to complete the TUG test compared to zero fall group, suggesting a higher fall risk despite improvements since the initial assessment (Table 2).

DISCUSSION

This study explored the characteristics, prevalent risk factors, and functional mobility among older adults attending a geriatric rehabilitation clinic. Our findings indicated that the majority of participants were elderly

TABLE 1. Demographic characteristics, common risk factors, and functional tests of all participants at baseline (N=105).

Variables	Faller (N=84)	Non-Faller (N=21)	P value	Odds ratio (95%CI)
Demographic characteristic				
Sex : Female	55 (65.5)	13(61.9)	0.759	1.17 (0.43,3.13)
Age (year)[1]	81.21±7	82.5±5.8	0.430	0.97 (0.90,1.04)
Body mass index (BMI: kg/m^2)[1]	22.8±3.2	22.9±3.4	0.943	0.99 (0.81,1.22)
Common risk factor				
Pets	27(32.1)	4(19.0)	0.239	2.01 (0.62, 6.56)
Diabetes Mellitus	36(42.9)	6(28.6)	0.232	1.88 (0.66, 5.31)
Frequency urination	49(58.3)	9(42.9)	0.202	1.87 (0.71, 4.90)
Foot deformity	23(27.4)	4(19.0)	0.435	1.60 (0.49, 5.27)
Sedative drugs	34(40.5)	7(33.3)	0.548	1.36 (0.50, 3.72)
Number of medication[1]	8.2±2.6	8.6±3.5	0.578	0.95 (0.80, 1.13)
Urinary incontinence	33(44.0)	10(47.6)	0.768	0.87 (0.33, 2.26)
Auditory impairment	18(21.4)	5(23.8)	0.775	0.87 (0.28, 2.71)
Cardiovascular disease	28(33.3)	8(38.1)	0.681	0.81 (0.30, 2.19)
Cognitive impairment	50(59.5)	14(66.7)	0.548	0.74 (0.27, 2.01)
Visual impairment	49(58.3)	14(66.7)	0.486	0.70 (0.26, 1.91)
Back/ leg pain	67(79.8)	18(85.7)	0.758	0.66 (0.17, 2.49)
Hypertension	68(81.0)	19(90.5)	0.517	0.45 (0.94, 2.12)
Functional mobility test				
Time up and go (sec)[1]	30.5±14.0	26.7±12.8	0.285	1.02 (0.98, 1.06)
Functional reach (inch)[1]	7.9±3.5	7.7±2.5	0.795	1.02 (0.86, 1.22)
30 sec chair stand (times)[2]	6(2-17)	6(4-11)	0.547	0.98 (0.82,1.16)
KATZ AD[1]	5.1±1.5	5.6±.9	0.068	0.73 (0.46, 1.16)
Lawton IAD[1]	2.3±2.5	3.1±2.6	0.187	0.89 (0.74, 1.06)

Data presented as number (%), [1]mean ± SD, [2]median (Min-Max); *p value< 0.05 indicates statistical significance

females, with hypertension, back and leg pain, cognitive disorders, visual impairment, and frequent urination identified as the most common risk factors for falls, listed in order of prevalence.

Upon comparison of individuals with and without a history of falls at baseline, associations were observed between pet ownership, diabetes mellitus, frequent urination, foot deformities, and the use of sedative medications; however, these associations did not achieve statistical significance. Over the one-year follow-up, we identified significant risk factors for recurrent falls. Specifically, the use of sedative/hypnotic drugs was significantly associated with recurrent falls, with a prevalence of 65.2% in the recurrent faller group compared to 31.1% in the zero-fall group (OR 4.15[1.5,11.44]; $P < 0.05$). While cognitive impairment, hypertension, foot deformities, and polypharmacy were more prevalent among recurrent fallers, these factors did not reach statistical significance.

The Timed Up and Go (TUG) test demonstrated that both the faller and recurrent faller groups took longer to complete the test than the non-faller and zero-fall groups. Notably, no significant differences were found in other balance assessments at baseline or at the one-year follow-up. At baseline, 80% of participants reported

TABLE 2. Demographic characteristic, common risk factors, and functional tests of the faller group at 1-year follow-up (N=84).

Variables	Recurrent fall (N=23)	Zero fall (N=61)	P value	Odd ratio (95%CI)
Demographic characteristic				
Sex : Female	17(73.9)	38(62.3)	0.318	0.58 (0.20, 1.69)
Age (year)[1]	80.7±6.9	81.4±8.1	0.705	0.99 (0.92, 1.06)
Body mass index (BMI: kg/m^2)[1]	22.8±3.3	22.8±3.2	0.980	0.99 (0.84, 1.19)
Common risk factor				
Sedative drugs	15(65.2)	19(31.1)	0.005*	4.15 (1.50, 11.44)
Cognitive impairment	16(69.6)	34(55.7)	0.250	1.82 (0.65, 5.04)
Hypertension	20(87.0)	48(78.7)	0.538	1.81 (0.46, 7.03)
Foot deformity	7(30.4)	16(26.2)	0.700	1.23 (0.43, 3.54)
Number of medication[1]	8.7±2.7	8.0±2.6	0.323	1.10 (0.91, 1.34)
Diabetes Mellitus	10(43.5)	26(42.6)	0.944	1.04 (0.39, 2.73)
Frequency urination	13(56.5)	36(59.0)	0.836	0.90 (0.34, 2.38)
Pets	7(30.4)	20(32.8)	0.837	0.90 (0.32, 2.53)
Back/ leg pain	18(78.3)	49(80.3)	1.000	0.88 (0.27, 2.85)
Visual impairment	12(52.2)	37(60.7)	0.482	0.71 (0.27, 1.86)
Auditory impairment	4(17.4)	14(23)	0.768	0.71 (0.21, 2.42)
Cardiovascular disease	6(26.1)	22(36.1)	0.387	0.63 (0.22, 1.82)
Urinary incontinence	8(34.8)	29(47.5)	0.294	0.59 (0.22, 1.59)
Functional test				
Time up and go (sec)[1]	28.25±14.6	21.9±13.9	0.318	1.03 (0.97, 1.10)
Functional reach (inch)[1]	9.0±0.0	9.9±3.5	N/A	N/A
30 sec chair stand (times)[2]	7(2-13)	6(2-17)	0.882	0.96 (0.77, 1.19)
KATZ ADL[1]	4.6±1.9	5.2±1.6	0.194	0.84 (0.65, 1.09)
Lawton IADL[1]	2.4±2.6	2.7±2.7	0.697	0.96 (0.80, 1.16)

Data presented as number (%), [1]mean ± SD, [2]median (Min-Max), *p value< 0.05 indicates statistical significance

having fallen in the previous year, a higher prevalence than observed in other studies, likely attributable to the specialized nature of our clinic. For instance, Assantachai et al. reported a fall prevalence of 19.8% among elderly individuals in urban Thailand over six months,[15] which aligned with our findings that high blood pressure, cognitive impairment, and functional difficulties are prevalent among fallers.[16]

Our results support a recent review indicating that multifactorial fall risk assessment and intervention strategies could effectively reduce fall rates.[17] *Lee et al.* documented a 32% reduction in falls among participants who received such interventions.[16] Additionally, our study highlighted a fourfold increase in the risk of falling associated with sedative medications among recurrent fallers. This finding corroborated the work of Woolcott et al., who identified sedatives as significant contributors to fall risk.[18] Various medication categories, including antihypertensives, antiarrhythmics, anticholinergics, antihistamines, and other fall-risk-increasing-drugs, have been linked to heightened fall risk.[19-24] Among older patients with comorbidities, cumulative exposure to anticholinergic and sedative medications was associated with poorer performance in multiple gait dimensions,

including slow walking speed and impaired walking balance.[25,26]

Cognitive decline significantly increased fall risk in older adults due to specific associations between gait parameters and cognitive function.[27] In our study, cognitive impairment did not emerge as a statistically significant risk factor for recurrent falls, potentially due to the personalized multifactorial fall risk assessments and interventions including the OEP implemented upon clinic entry. Counseling on home modifications and safety concerns during daily activities was also emphasized, underscoring the effectiveness of home fall-hazard interventions in reducing both fall rates and the number of fallers among high-risk individuals.[28] In addition, the OEP has positive effects on motor function in improving neurocognitive function in older adult.[29]

Hypertension is prevalent in the older population and is recognized as a risk factor for falls, often necessitating medications that may further exacerbate fall risk.[30,31] Orthostatic hypotension, particularly when coupled with hypertension, has been independently associated with an increased risk of future falls. In our study, hypertension was not identified as a significant risk factor for recurrent falls, likely due to the proactive management of medications and efforts to minimize polypharmacy by geriatricians.

Although foot deformities were not statistically significant as a risk factor for recurrent falls, they remained a consistent concern among both baseline and recurrent fallers, suggesting that footwear modifications could enhance safety. Cultural factors, such as the Thai preference for barefoot living at home, may contribute to ongoing fall risks. Additionally, diabetes was recognized as a common risk factor that can lead to falls due to complications such as peripheral neuropathy,[32] retinopathy, vestibular dysfunction, cognitive impairment and hypoglycemic events associated with insulin use.[33] The implementation of diabetic foot problem screening, foot care advice, and appropriate shoe prescriptions in our geriatric rehabilitation clinic may explain the lack of significant association between diabetes and recurrent falls in our study.

Falls among older adults arise from a complex interplay of risk factors, emphasizing the necessity for comprehensive assessment and intervention strategies to mitigate these risks. The recurrent fall group in our study exhibited poorer balance function, as evidenced by longer TUG completion times compared to the zero-fall group. Both multifactorial and exercise interventions were associated with beneficial outcomes related to fall prevention.[34] Given the constraints of time and resources in outpatient settings, some clinicians may opt to implement only a single strategy. However, network meta-analyses indicated that exercise alone was linked to reductions in fall rates, incidence of fallers, and fall-related fractures compared to usual care.[35] A review by Guirguis-Blake et al. supported strength and balance training as effective interventions for older adults with a history of recurrent falls. Promoting such interventions can enhance health, independence, and overall quality of life.[36] The OEP has been demonstrated to effectively reduce falls and related injuries while also improving cognitive function, lower limb strength, and balance abilities, which were critical for fall prevention in older adults.[37] Additionally, it has shown cost-effectiveness for individuals over 80 years of age.[38]

This study possessed several strengths, notably demonstrating the benefits of personalized multifactorial fall risk assessments and interventions among high-risk elderly individuals, and showcasing the feasibility of implementing such strategies in an outpatient setting. However, limitations should be acknowledged. Selection bias may have occurred due to the recruitment of participants with a history of falls or gait instability, resulting in a higher fall rate compared to community-based studies. Furthermore, during the COVID-19 pandemic, the utilization of telemedicine for follow-up visits led to the exclusion of 16% of participants who were unable to attend in-person functional mobility tests. Recall bias concerning fall history may also have influenced outcomes and specific interventions. Lastly, this study was conducted within a tertiary care geriatric clinic, where resources for personalized assessments and interventions were available; therefore, the findings may not be generalizable to other care settings. Future research should consider prospective cohort studies with larger sample sizes to address these limitations, facilitate more comprehensive data collection, and strengthen the robustness of study findings.

CONCLUSION

The personalized multifactorial fall risk assessment and intervention reduced the prevalence of falls among older adults from 80% to 27.4%. Sedative medication was identified as a significant factor associated with an increased risk of falls. The majority of falls occurred during the daytime, highlighting the importance of addressing medication-related fall risks and implementing personalized preventive strategies.

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DECLARATION

Grants and Funding Information

None

Conflict of Interests

The authors declare no conflict of interest.

Authors Contributions

P.D. : conception and design, interpretation of data, revising it critically for important intellectual content; and final approval of the version to be published. P.T. : acquisition of data, revising it critically for important intellectual content and final approval of the version to be published. R.P. : acquisition of data, revising it critically for important intellectual content and final approval of the version to be published. R.P. : analysis and interpretation of data, drafting the article. S.H. : interpretation of data, drafting the article. W.M. : revising it critically for important intellectual content and final approval of the version to be published.

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