The Journal of Physical Therapy Science

S P T S

Original Article

Analysis of fall risk factors and environmental hazards for older adults in Japan: assessing fall situations and locations

Daiki Yokoyama, RPT, MS[1, 2]*, Kenichiro Mitsuyama, OTR[3], Keizo Inami, RPT, MS[1],
Kazuki Fujisaki, RPT, MS[1], Masato Yokoyama, RPT, MS[1], Sumiyo Arai, RPT, PhD[1],
Tomohiro Otani, RPT, MS[1]

[1] Department of Physical Therapy, Ota College of Medical Technology: 1373 Higashinagaoka-cho,
Ota-shi, Gunma 373-0812, Japan
[2] Department of Rehabilitation Sciences, Gunma University Graduate School of Health Sciences,
Japan
[3] Department of Rehabilitation, Long-term Care Health Facility Yamazakura, Japan

Abstract. [Purpose] This study aimed to examine falls among older adults in Japanese households and determine the risk associated with each fall location. [Participants and Methods] This study included 99 participants (249 fall events) who received daycare rehabilitation at a nursing care facility. Data on fall circumstances were collected from the medical records and accident reports. The analyzed variables included age, medical status, level of care required, fall history, location, and mode of transportation during the falls. [Results] Falls occurred most commonly in bedrooms. Falls at an entrance were associated with no assistive device (OR: 1.76, 95% CI: 1.06–1.80) and 1 history of falls (OR: 1.22, 95% CI: 1.03–3.10). Risk factors for falls in bedrooms included Parkinson's disease (OR: 1.83, 95% CI: 1.11–1.87), orthopedic disease (OR: 1.11, 95% CI: 1.15–3.43), and cane walking (OR: 1.08, 95% CI: 1.33–4.13). Falls in a hallway were associated with no assistive device (OR: 1.75, 95% CI: 1.15–1.91). [Conclusion] Bedrooms and hallways in Japanese households were identified as locations with a high risk of falls. The unique architectural and cultural features of Japanese homes may contribute to this risk. Rehabilitation programs should consider individual fall histories, medical conditions, and differences in mobility.
Key words: Accidental fall, Home hazards, Local older adults

INTRODUCTION

Falls among older adults are listed as the fifth leading cause of eventual need for long-term care services in Japan[1], and are thought to result in diminished physical function and depression[2]. Furthermore, 6.6% of falls have been reported to result in severe disorders, including bone fractures, indicating that falls are an essential health issue[3]. A 2018 World Health Organization report showed that 28–35% of individuals over 65 years old worldwide experience falls yearly, and the incidence increases with age[4]. Therefore, the problem of falls requires urgent preventive measures worldwide, particularly in countries with aging populations, such as Japan.

Falls often occur during daily activities at home, with almost 50% occurring indoors[5]. Many previous studies aimed at identifying fall hazards have shown little difference between the home environments of fallers and non-fallers[6–8]. Those studies mainly targeted the older population in EU nations and the United States. Few studies have been conducted on older adults living in Japan. Japanese housing may have higher potential fall risks owing to its architectural characteristics concern-

ing cultural traditions, such as the combined use of tatami mats or wooden flooring, thresholds between the hallway and each room, and the elevation of the floor at the entrance, where residents or guests take off their shoes to get in.

This study aims to investigate the circumstances and characteristics of falls in Japanese homes.

PARTICIPANTS AND METHODS

The participants were individuals aged 65 years old or older who had received day care rehabilitation at a nursing care facility in Saitama, Japan, between April 1, 2020, and March 31, 2023. Baseline data are presented in Table 1. One case with missing data was excluded from the study (Fig. 1). The mean age of the participants was 80.2 ± 7.8 years, and 99 individuals had 249 falls during the study period.

We collected information on each situation in which a fall occurred from medical records and accident reports. The following items were extracted: age, sex, nursing care level, personal history of falls, location of the fall (e.g., living room, bathroom, and entrance), personal mobility style at the time of the fall, and current or past medical history prior to the fall (suffering from major diseases or not). A fall is "a sudden and unintentional change of position, with or without loss of consciousness, in which the person lands on the ground"[9].

For the statistical analysis, we performed descriptive statistics for each variable and analyzed the trends. We used the location of each fall (e.g., entrance, bedroom, hallway, bathroom, living room, kitchen, and toilet) as the dependent variable. Furthermore, the independent variables of the following 11 items were entered: personal history of falls (i.e., once, twice, thrice, or more times), morbidity (cerebrovascular disease, orthopedic disease, Parkinson's disease, internal disease), and mobility function or use of an assistive device (e.g., no assistive device, cane, walker, and wheelchair). Multiple logistic regression analysis was conducted using the forward stepwise method with the eleven items as the independent variables. In conducting the analysis, given multicollinearity, correlation analysis on the independent variables was conducted using Cramer's coefficient of association. We thereby checked for items with high correlation coefficients of 0.9 or more. All statistical analyses were conducted using IBM SPSS Statistics for Mac, version 26 (IBM Corp., Armonk, NY, USA). The level of significance was set at p<0.05.

Table 1. Baseline characteristics of study population

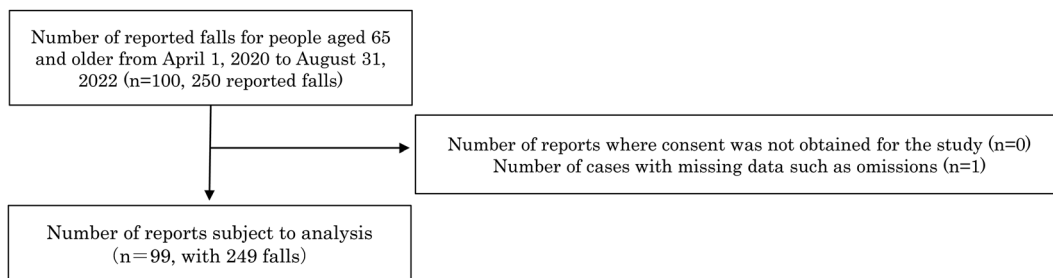| Variables	Overall (n=99)	
	Male (n=56)	Female (n=43)
Age, year; mean ± SD	80.4 ± 8.1	79.9 ± 7.6
Nursing care level; n (%)		
Support required 1,2	5 (5.1%)	6 (6.1%)
Nursing care level 1	12 (12.1%)	6 (6.1%)
2	14 (14.1%)	18 (18.2%)
3	14 (14.1%)	8 (8.1%)
4	9 (9.1%)	3 (3.0%)
5	2 (2.0%)	2 (2.0%)
History of fall; n (%)		
1 fall	26 (26.3%)	16 (16.2%)
2 falls	6 (6.1%)	6 (6.1%)
>3 falls	24 (24.2%)	21 (21.2%)

SD: standard deviation.

Fig. 1. Participant flow in the study.

RESULTS

The baseline data are shown in Table 1. One case with missing data was excluded from the study (Fig. 1). A total of 57 individuals experienced two or more falls during this period. Table 2 shows the fall situations. The most common place for falls was the bedroom (59 individuals; 23.7%), followed by the hallway (32 individuals; 12.9%) and the entrance (24 individuals; 9.6%). Among the major diseases, cerebrovascular disease was the most common (89 individuals, 35.7%), followed by orthopedic disease (74 individuals, 29.7%).

Table 3 shows the results of the multiple logistic regression analysis. No independent variables were excluded. By the logistic regression analysis, in association with "entrance" as the location of falling, "without any assistive device" (OR: 1.76, CI: 1.06–1.80), and "number of falls: once" (OR: 1.22, CI: 1.03–3.10) were extracted. Moreover, for "bedroom", the following was extracted: Parkinson's disease (OR: 1.83, CI: 1.11–1.87), orthopedic disease (OR: 1.11, CI: 1.15–3.43), and "cane walking" (OR: 1.08, CI: 1.33–4.13). For "hallway," the variable "without any assistive device" (OR: 1.75, CI: 1.15–1.91) was selected (model χ^2 test: $p<0.01$).

Table 2. Indicates a fall situation

Variables	Overall (n=249)
Location of fall; n (%)	
Entrance	24 (9.6%)
Bedroom	59 (23.7%)
Hallway	32 (12.9%)
Bath room	9 (3.6%)
Living room	16 (6.4%)
Kitchen	12 (4.8%)
Toilet	15 (6.0%)
Others	82 (32.9%)
Major disease; n (%)	
Cerebrovascular disease	89 (35.7%)
Orthopedic disease	74 (29.7%)
Parkinson's disease	44 (17.7%)
Medical disease	36 (14.5%)
Others	6 (2.4%)
Assistive device; n (%)	
None	130 (52.2%)
Cane	60 (24.1%)
Walker	21 (8.4%)
Wheelchair	13 (5.2%)
Others	25 (10.0%)

Table 3. Risk model for the prediction by location obtained by multiple logistic regression

Dependent variables	Independent variables	B	SE	OR	95% CI	p-value
Entrance	w/o assist.devices	1.54	0.67	1.76	1.06–1.80	*
	1st fall	1.01	0.44	1.22	1.03–3.10	*
	Constant	−10.45				
Bedroom	Parkinson's disease	1.73	0.51	1.83	1.11–1.87	**
	Orthopedic disease	0.98	0.46	1.11	1.15–3.43	*
	Cane	0.88	0.48	1.08	1.33–4.13	*
	Constant	−6.42				
Hallway	w/o assist.devices	1.92	1.09	1.75	1.15–1.91	*
	Constant	−11.53				

*$p<0.05$; **$p<0.01$.
B: regression coefficient; SE: standard error; OR: odds ratio; CI: confidence intervals; w/o assist.devices: without assistive devices.

J. Phys. Ther. Sci. Vol. 36, No. 9, 2024

548

DISCUSSION

This study aimed to investigate and identify the characteristics of falls occurring in Japanese houses. We found that the "bedroom" was where falls happened most frequently, followed by the "hallway". As the predictors of fall risks regarding the different locations in the house, "entrance", "bedroom", and "hallway" were extracted. In association with "entrance", "without any assistive device", and "number of falls: once" were extracted. "Parkinson's disease", "orthopedic disease", and "cane" were extracted in association with "bedroom". Furthermore, "without any assistive device" was extracted for "hallway".

It has been reported that bedroom falls are most common in residential settings, such as long-term care facilities for the elderly, and that patients with dementia have higher rates of falls[10, 11]. In addition, previous studies investigating risk factors for falls in residential settings have identified wheelchair users and patients with pain[12]. Not surprisingly, patient characteristics and environments differ between institutional and residential settings, and this study found different results compared to those studies.

For falls at the entrance, those without assistive devices and falling for the first time were extracted as risk factors. Suzukawa et al.[13] reported that individuals with a relatively small need for nursing care were more likely to fall at the house entrance compared to those in need of a more significant amount of care, which may be in line with our finding that the entrance was associated with risk predictors, no assistive device, and first-time fallers. The findings of this study, which revealed a high proportion of older adults without a history of falls experiencing falls at the entrance, are crucial aspects of this research. Elderly individuals who have experienced one or more falls have a threefold increased risk of falling again within the following year compared to participants without a history of falls[14]. In other words, even a single fall should not be considered acceptable. In Japanese households, it is customary to remove and put on shoes at the entrance. There are various methods for removing and putting on shoes at the entrance. It is anticipated that older adults who are anxious about falls due to a history of falling will perform the task while seated on a chair placed for this purpose, whereas those without such history are predicted to engage in the task under more unstable conditions. Furthermore, it is expected that older adults without a history of falls will not actively use assistive devices, although this cannot be inferred from the results of this study. Going forward, it is imperative to conduct a detailed analysis of fall occurrences at entrances and elucidate the circumstances surrounding falls in this setting. Northridge et al.[15] also reported that locations where objects and staff are placed randomly and untidily, can increase the risk of falling in older adults. The entrance of a Japanese house can be cluttered with objects on the floor, such as shoes that have been removed, over which older adults can easily trip. We believe the risk of falling at the entrance can be reduced by keeping the entrance tidy.

The most common fall location in this study was the bedroom. One of the features of a traditional Japanese house/lifestyle is the use of a "futon" mattress[16]. Older adults prefer futons rather than beds. Futons are placed directly on the floor (tatami mat) and can trip, possibly causing falls. In a random sampling survey of the locations of falls among older adults aged 60 years and older, the bedroom was the fourth most common location of falls, after the living room, entrance, and stairs[17]. However, because the target population included highly active older adults, this study did not investigate falls in older adults with disabilities. The participants in this study were older adults who were recipients of nursing care, and it was suggested that these participants were more likely to fall into their bedrooms. Additionally, Parkinson's disease or Parkinsonism, orthopedic diseases, and walking with a cane were identified as risk factors for falling in the bedroom.

Patients Parkinson's disease are known to be prone to falls[18], with particular concern surrounding orthostatic hypotension[19]. As previously reported, it has been observed that preparatory exercises such as postural adjustments and squats[20], along with appropriate pharmacological interventions[16], are especially critical, particularly within the bedroom environment, when initiating movement. Additionally, orthopedic conditions have been identified as contributing factors. However, this study did not investigate specific medical conditions in detail. Among the most prevalent chronic ailments in the elderly is osteoarthritis. Patients with knee osteoarthritis have been reported to exhibit a higher propensity for stumbling over obstacles compared to their counterparts without the condition[21]. Given the traditional Japanese practice of sleeping on futons, it is conceivable that individuals with orthopedic conditions predisposing them to stumbling and falls may have been more prevalent.

The hallway was the second most common location for falls behind the bedroom, and "without assistive devices" was identified as a risk factor. Yokoyama et al.[22] reported that falls in the hallway among elderly residents in the community are more likely to result in injuries after the fall, highlighting the importance of fall prevention in these areas. Japanese houses have Japanese- and Western-style rooms with different floor elevation levels. There are also thresholds between the rooms and hallways. Additionally, hallways are subject to many previously reported extrinsic fall risks[23], including poor lighting and slippery floors[24, 25]. In the future, while detailed investigations into fall incidents are warranted, it is speculated that measures such as installing motion sensor lighting could contribute to fall prevention.

This study has several limitations. First, a significant limitation is that we were not able to comprehensively investigate all falls that may have occurred during the study period. Our data were collected from fall situation reports containing information from fallers, their family members, or care managers, except when a staff member visually witnessed a fall. Establishing a data system that encompasses more thorough information on all falls and fall situations should be beneficial for future research and practical fall prevention. Second, the fall reports in this study include instances of multiple falls. It is

possible that the same individual may have fallen more than once at the same location, introducing potential bias. To address this limitation, future studies should increase the sample size to mitigate bias and enhance the robustness of the findings.

In conclusion, this study identified the risk factors for each common situation or location of falls in Japanese houses among older adults with disabilities. Risk factors have been identified in areas typical of Japanese homes, such as bedrooms and hallways. Furthermore, it was suggested that in providing rehabilitation to prevent falls, differences in the types of mobility and choice of assistive devices, including personal history of falls and health or medical conditions, affect the incidence rate of falls.

Conflict of interest

There are no conflicts of interest to disclose in this study.

REFERENCES

1) Ministry of Health, Labour and Welfare: 2018 White paper on aging society. https://www8.cao.go.jp/kourei/whitepaper/w-2018/zenbun/30pdf_index.html (Accessed Apr. 25, 2024)

2) Thiem U, Klaaßen-Mielke R, Trampisch U, et al.: Falls and EQ-5D rated quality of life in community-dwelling seniors with concurrent chronic diseases: a cross-sectional study. Health Qual Life Outcomes, 2014, 12: 2. [Medline] [CrossRef]

3) Hagiya H, Koyama T, Zamami Y, et al.: Fall-related mortality trends in older Japanese adults aged ≥65 years: a nationwide observational study. BMJ, 2018, 9: 1–7.

4) World Health Organization: Who global report on falls prevention in older age (online). https://extranet.who.int/agefriendlyworld/wp-content/uploads/2014/06/WHo-Global-report-on-falls-prevention-in-older-age.pdf (Accessed Mar. 25, 2024)

5) Pynoos J, Steinman BA, Nguyen AQ: Environmental assessment and modification as fall-prevention strategies for older adults. Clin Geriatr Med, 2010, 26: 633–644. [Medline] [CrossRef]

6) Clemson L, Cumming RG, Roland M: Case-control study of hazards in the home and risk of falls and hip fractures. Age Ageing, 1996, 25: 97–101. [Medline] [CrossRef]

7) Campbell AJ, Borrie MJ, Spears GF, et al.: Circumstances and consequences of falls experienced by a community population 70 years and over during a prospective study. Age Ageing, 1990, 19: 136–141. [Medline] [CrossRef]

8) Gill TM, Williams CS, Tinetti ME: Environmental hazards and the risk of nonsyncopal falls in the homes of community-living older persons. Med Care, 2000, 38: 1174–1183. [Medline] [CrossRef]

9) Montero-Odasso M, van der Velde N, Martin FC: World guidelines for falls prevention and management for older adults: a global initiative. Age Ageing, 2022, 51: afac205. [CrossRef]

10) Sato S, Hayakawa T, Kanda H, et al.: Individual factors of fall according to time of day in a residential care facility for the elderly. Rigakuryoho Kagaku, 2017, 32: 133–137 (in Japanese). [CrossRef]

11) Hitcho EB, Krauss MJ, Birg S: Characteristics and circumstances of falls in a hospital setting: a prospective analysis. J Gen Intern Med, 2004, 19: 732–739. [Medline] [CrossRef]

12) Kakogawa N, Fuchigami T, Koshimoto H: Fall risk factor of long-term care health facility residents: analysis of the places where falls occurred. Rigakuryoho Kagaku, 2016, 31: 195–198 (in Japanese). [CrossRef]

13) Suzukawa M, Shimada H, Makizako H, et al.: [Incidence of falls and fractures in disabled elderly people utilizing long-term care insurance]. Nihon Ronen Igakkai Zasshi, 2009, 46: 334–340 (in Japanese). [Medline] [CrossRef]

14) Rubenstein LZ, Josephson KR: The epidemiology of falls and syncope. Clin Geriatr Med, 2002, 18: 141–158. [Medline] [CrossRef]

15) Northridge ME, Nevitt MC, Kelsey JL, et al.: Home hazards and falls in the elderly: the role of health and functional status. Am J Public Health, 1995, 85: 509–515. [Medline] [CrossRef]

16) Ministry of Internal Affairs and Communications: Results of the 2014 National Survey on Major Durable Consumer Goods. https://www.stat.go.jp/data/zensho/2014/pdf/gaiyo.pdf (Accessed Apr. 24, 2024)

17) Cabinet Office: Results of the 2010 awareness survey regarding housing and living. https://www8.cao.go.jp/kourei/ishiki/h22/sougou/zentai/index.html (Accessed Apr. 24, 2024)

18) Wielinski CL, Erickson-Davis C, Wichmann R, et al.: Falls and injuries resulting from falls among patients with Parkinson's disease and other parkinsonian syndromes. Mov Disord, 2005, 20: 410–415. [Medline] [CrossRef]

19) LeWitt PA, Kymes S, Hauser RA: Parkinson disease and orthostatic hypotension in the elderly: recognition and management of risk factors for falls. Aging Dis, 2020, 11: 679–691. [Medline] [CrossRef]

20) Lahrmann H, Cortelli P, Hilz M, et al.: EFNS guidelines on the diagnosis and management of orthostatic hypotension. Eur J Neurol, 2006, 13: 930–936. [Medline] [CrossRef]

21) Pandya NK, Draganich LF, Mauer A, et al.: Osteoarthritis of the knees increases the propensity to trip on an obstacle. Clin Orthop Relat Res, 2005, (431): 150–156. [Medline] [CrossRef]

22) Yokoyama D, Mitsuyama K, Yoshida M, et al.: Factors related to falls and fall injuries in elderly care recipients. Rigakuryoho Kagaku, 2024, 39: 72–78 (in Japanese). [CrossRef]

23) Tiefenbachová P, Zeleníková R: The effect of educational intervention by nurses on home environmental risk factors for falls. Cent Eur J Nurs Midw, 2019, 10: 1019–1025. [CrossRef]

24) Tinetti ME, Speechley M, Ginter SF: Risk factors for falls among elderly persons living in the community. N Engl J Med, 1988, 319: 1701–1707. [Medline] [CrossRef]

25) Ang GC, Low SL, How CH: Approach to falls among the elderly in the community. Singapore Med J, 2020, 61: 116–121. [Medline] [CrossRef]

J. Phys. Ther. Sci. Vol. 36, No. 9, 2024

550