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Relationship Between Preferred Gait Speed and Falls within One Year After Discharge among Older People Who Underwent Hip Fracture Surgery

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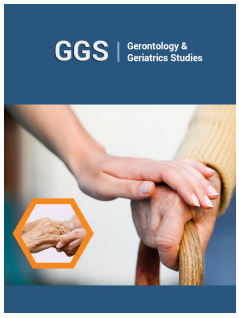

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Abstract

To investigate the relationship between performance at discharge and falls within the following year among older people who underwent hip fracture surgery and were discharged from the convalescent rehabilitation ward (CRW) to their homes. Enrolled in this retrospective study were 235 people, of whom 117 responded to a questionnaire regarding falls. Of these 117, the fall group included 31 participants and the non-fall group included 86 participants. The primary outcome was a fall within one year after discharge from CRW. The secondary outcomes were age, sex, length of CRW stay, standing test for imbalance and disequilibrium, preferred gait speed, Functional Independence Measure (FIM) and Mini-Mental State Examination (MMSE) at discharge.

Logistic regression analysis adjusted for potential confounders showed that only preferred gait speed remained statistically significant in influencing the odds ratio of falls (OR=19.70, 95% confidence interval [CI] 1.50–259.10). There were significant differences in FIM score and MMSE score between falls inside and outside the home ($p<0.05$). A high preferred gait speed was associated with falls within one year after discharge among older people who underwent hip fracture surgery. Falls inside the home were associated with lower functional outcomes and cognitive function compared to falls outside the home. Tailoring fall prevention interventions based on the location of falls and considering additional risk factors is crucial for effective fall prevention in this population.

Keywords: Future fall; Hip fracture surgery; Preferred gait speed; Older people; Rehabilitation

Abbreviations: ADL: Activities of Daily Living; AUG: Area Under the Curve; cFIM: 5-item Cognition Subscale of FIM; CI: Confidence Interval; CRW: Convalescent Rehabilitation Ward; CRWs: Convalescent Rehabilitation Wards; FIM: Functional Independence Measure; mFIM: 13-item Motor Subscale of FIM; MMSE: Mini-Mental State Examination; NCGG: National Center for Geriatrics and Gerontology; OR: Odds Ratio; QOL: Quality of Life; ROC: Receiver-Operation Characteristic; SIDE: Standing Test for Imbalance and Disequilibrium; TUG: Timed "Up & Go"

Introduction

Fall-related hip fractures present a significant public health concern due to their impact on morbidity, mortality, Quality of Life (QOL), healthcare costs, and social services, especially among older people [1,2]. In Japan, surgical treatment is standard management for older patients with hip fractures, approximately 80% of whom are then transferred from acute care wards to Convalescent Rehabilitation Wards (CRWs) [3]. The primary objective of CRWs is to provide effective rehabilitation for patients with cerebrovascular disease or fracture, aiming to rapidly improve their ability to perform Activities of Daily Living (ADL) and regain

mobility to facilitate a return home [4]. To achieve this, CRWs offer rehabilitation programs that include ambulatory movements and intensive physical strength training, with a focus on improving ADL capacity.

Despite the intensive rehabilitation provided, older patients who have undergone hip fracture surgery remain at a high risk of experiencing subsequent falls and fall-related hip fractures. Kristensen et al. reported that 32% of older people who had undergone hip fracture surgery experienced one or more falls during the period following discharge [5]. Similarly, Di Monaco et al. reported that 20% of community-dwelling women with a fall-related hip fracture sustained at least one fall during a 6-month follow-up [6]. Furthermore, within 5 years, more than 70% of these people experienced bilateral hip fractures [7]. Therefore, it is crucial to improve the performance of rehabilitation and implement measures to prevent falls after discharge.

Several reports have identified risk factors for falls among older people who have recently undergone hip fracture surgery. For instance, timed "Up & Go" (TUG) test scores obtained upon discharge from an acute orthopedic hip fracture unit could predict falls in older people with hip fractures during a 6-month follow-up period [5]. In a study of community-dwelling older people, falls following hip fractures could be predicted by premorbid functional status of factors such as independence in ADL, balance and mobility measures [8]. However, the relationship between performance at discharge and future falls remains unclear. The objective of this study was to investigate the relationship between performance at discharge and falls within one year after discharge among older people who underwent hip fracture surgery and were discharged from CRW to their homes. We hypothesize that poor balance (as measured by the standing test for imbalance and disequilibrium, SIDE) [9] and slower gait speed (as measured by preferred gait speed) at discharge are associated with falls within one year after discharge.

Methods

This retrospective study was approved by the Medical Ethics Committee of the National Center for Geriatrics and Gerontology (NCGG) (No. 920-3) and conformed to the provisions of the Declaration of Helsinki (as revised in Brazil, 2013). All participants provided written informed consent via mail.

Participants

Enrolled in the study were older people who underwent hip fracture surgery and were discharged from CRW at NCGG between 1 June 2014 and 28 February 2022. The inclusion criteria were age ≥65 years, discharge from the CRW to home; and no missing data for SIDE [9], preferred gait speed, functional independence measure (FIM) [10] or Mini-Mental State Examination (MMSE) [11] at discharge. Participants were excluded if they were admitted to a hospital or nursing home within one year after discharge, passed away, or did not respond to the questionnaire.

Interventions

All participants underwent intensive rehabilitation for 120–180 minutes per day, 7 days per week at the CRW. The rehabilitation program was delivered by physical and occupational therapists and included therapeutic exercise, range of motion, muscle strengthening, gait and balance training; as well as task-oriented training for ADL and rehabilitation conducted with an awareness of re-fall prevention based on established guidelines, from the time of hospitalization.

Measurements

Measurement of exposure

To assess falls occurring within one year after discharge from CRW, a questionnaire on falls was distributed and administered by mail one year after discharge. Each participant or their primary caregiver was asked to respond to the following questions: 1) Does the participant live alone or with another person? 2) Did the participant experience any falls within one year after discharge from CRW? 3) In the case of a fall, what was the location? In the present study, a fall was defined as any involuntary contact of any part of the body, except for the soles of the feet, with the floor, based on Gibson's report [12].

Measurement of covariates

Age at discharge, sex, and length of stay at CRW were obtained from medical records. The length of stay at CRW was the number of days from the date of transfer to CRW to the date of discharge from CRW.

Measurement of outcomes

SIDE level, preferred gait speed, mFIM score, and MMSE score were obtained from medical records. They were assessed by each patient's therapist during the week prior to discharge. SIDE assesses standing balance on a 6-point scale. The level of balance is based on how well a person can maintain a sequence of postures (wide-base, narrow-base, tandem standing, and single-foot stance), with higher levels indicating better standing balance [9]. We also measured each participant's preferred gait speed by asking them to walk 16 meters at a self-selected speed. We measured the time taken to walk between points at 3 meters and 13 meters. FIM indicates a person's ability to perform ADL based on a 7-point scale. It comprises 18 items, including a 13-item motor subscale (mFIM) and a 5-item cognition subscale (cFIM). The total score ranges from 18 to 126, with higher scores indicating better functional ability [10]. MMSE measures cognitive function on a scale of 0 to 30, with higher scores indicating better cognitive function [11].

Statistical analysis

Of the patients to whom questionnaires were sent according to the intake criteria, those who returned the questionnaire were termed responders, and those who did not were termed non-responders. The responders were divided into two groups based on their responses to the questionnaire: those who had a fall

within one year after discharge (fall group) and those who did not (non-fall group). Descriptive statistics were used to summarize the numerical and categorical variables, including mean, standard deviation, median, interquartile range, and percentage distributions. Independent t-test or Mann–Whitney U test was performed to compare discharge variables between the fall and non-fall groups and between the responder and non-responder groups. Binomial logistic regression was used to explore the association between falls within one year after discharge and the following variables: SIDE level, preferred gait speed, mFIM score, and MMSE score at discharge. Among these variables, preferred gait speed, mFIM score and MMSE score were treated as continuous variables, whereas SIDE level was considered categorical. The analysis was adjusted for potential confounding factors, including age at discharge, sex, and length of stay at CRW, which were considered covariates in the model. The parameters of the logistic regression model were estimated using maximum likelihood estimation. The significance of the estimated parameters was assessed using the Wald test, and 95% Confidence Intervals (CI) were calculated to provide a measure of precision. Model fit was evaluated using a goodness-of-fit test such as the Hosmer–Lemeshow test. Receiver-Operating Characteristic (ROC) curve analysis was performed to assess the predictive accuracy of the model. The Area Under the Curve (AUC) was calculated and cutoff values for optimal sensitivity and specificity were determined using the Youden index.

The fall group was further stratified into two subgroups: those who fell when inside the home (inside group) and those who fell when outside the home (outside group). The inside group included falls in a bedroom, living room, hallway, bathroom, entrance, kitchen and stairway. The outside group included falls that occurred in a driveway, sidewalk, park, garden, street, gymnasium, facility, hospital, or care facility. Independent t-test or Mann–Whitney U test was performed to compare discharge variables between the inside and outside groups. Statistical analysis was conducted using IBM SPSS Statistics (version 29.0.0.0 (241) for Mac; IBM, Chicago, IL, USA), with a significance level set at $p<0.05$.

Results

A total of 235 people who met the inclusion and exclusion criteria received the study questionnaire, of whom 117 responded, resulting in a response rate of 49.8%. There were significant differences between the responder and non-responder groups in terms of FIM, mFIM, cFIM, and MMSE ($p<0.05$). In the responder group, there were 31 in the fall group (8 men, 23 women; mean age, 83.7±7.3 years) and 86 in the non-fall group (12 men, 74 women; mean age, 81.7±7.4 years). There were no significant differences between the fall and non-fall groups in terms of variables at discharge (Table 1). The analysis revealed a significant association between falls within one year after discharge and the examined variables. Prior to adjusting for potential confounding factors, both the SIDE level ($p=0.028$) and preferred gait speed ($p=0.023$) showed significant effects on the odds of falls. However, after adjusting for potential confounders such as age at discharge, sex and length of stay at CRW, only preferred gait speed remained statistically significant ($p<0.05$) in influencing the odds of falls. The odds ratio (OR) indicated that a higher preferred gait speed was associated with increased odds of falls (OR = 19.70, 95% CI 1.50-259.10) (Table 2).

Table 1: Participant Characteristics at Discharge (N=389)

CRW: convalescent rehabilitation ward; SIDE: standing test for imbalance and disequilibrium; FIM: functional independence measure; mFIM: motor subscale of FIM; cFIM: cognition subscale of FIM; MMSE: Mini-Mental State Examination; SD: standard deviation; fall group: participants who fell within one year after discharge; non-fall group: participants who did not fall within one year after discharge.

† Independent t-test. All other variables were compared using Mann–Whitney U test.

‡ Median (interquartile range).

Characteristic	Non-Responders (n=118)		Responders (n=117)		p value	Fall group (n=31)		Non-fall group (n=86)		p value
	Mean	SD	Mean	SD		Mean	SD	Mean	SD	
Age, years †	83	-6.9	82.2	-7.4	0.343	83.7	-7.3	81.7	-7.4	0.19
Sex										
Male, n (%)	24	-20.3	20	-17.1	0	8	-25.8	12	-14	0
Female, n (%)	94	-79.7	97	-82.9	0	23	-74.2	74	-86	0
Length of stay at CRW, days	59.1	-19.6	59.9	-21.6	0.729	62.5	-20.2	58.6	-22.1	0.406
SIDE, level ‡	3	2	4	2	0.499	3	2	4	3	0.173
Preferred gait speed, m/sec †	0.68	-0.3	0.68	-0.32	0.999	0.72	-0.36	0.68	-0.3	0.047
FIM, points	103.3	-17.9	109.5	-14.5	0.003	108.4	-14.8	111.4	-14.5	0.572
mFIM, points	75	-13.2	78.6	-10.5	0.03	77.6	-11	79.9	-10.3	0.61
cFIM, points	28.3	-5.9	30.8	-5.3	<0.001	30.8	-4.9	31.3	-5.4	0.545

MMSE, points	22.6	-6	24.9	-4.9	0.004	25	-5.4	25.3	-4.7	0.504
Living condition after discharge										
Alone, n (%)	0	0	21	-17.9	0	2	-6.5	19	-22.1	0
Not alone, n (%)	0	0	96	-82.1	0	29	-93.5	67	-77.9	0

Table 2: Binomial Logistic Regression Analysis of Falls within One Year after Discharge and Discharge Performance (n=117)

SIDE: standing test for imbalance and disequilibrium; mFIM: motor subscale of functional independence measure; MMSE: Mini-Mental State Examination; CI: confidence interval† Adjusted for age at discharge, sex, and length of stay at the convalescent rehabilitation ward

Independent Variable			Unadjusted Model			Adjusted Model †		
			p value	Odds	95% CI	p value	Odds	95% CI
SIDE, level	0.028	0.581	0.358	0.943	0.06	0.552	0.298	1.024
Preferred gait speed, m/sec	0.023	9.012	1.363	59.566	0.023	19.705	1.499	259.109
mFIM, points	0.071	0.945	0.888	1.005	0.447	0.969	0.893	1.051
MMSE, points	0.135	1.054	0.984	1.13	0.107	1.073	0.985	1.169

The goodness-of-fit tests demonstrated that the logistic regression model adequately fit the data (p>0.05 for the Hosmer-Lemeshow test). The ROC curve analysis for assessing the predictive accuracy of preferred gait speed for falls yielded poor results, with an AUC of 0.533 (95% CI 0.402-0.664). The cutoff value was determined as 1.04m/sec with sensitivity of 0.290 and specificity of 0.907 (Figure 1). Of those in the fall group, there were 15/31 in the inside group (3 men, 12 women; mean age, 84.8±7.9 years) 15/31 in the outside group (5 men, 10 women; mean age, 82.1±6.5 years) and the fall location was unknown in one participant. Comparison of the discharge variables between the inside and outside groups revealed significant differences in terms of FIM score (p=0.042) and MMSE score (p=0.014) (Table 3).

Table 3: Discharge Performance According to Fall Location

CRW: convalescent rehabilitation ward; SIDE: standing test for imbalance and disequilibrium; FIM: functional independence measure; MMSE: Mini-Mental State Examination; SD: standard deviation; Inside group: participants who fell inside the home, including in bedrooms, living rooms, hallways, bathrooms, entryways, kitchens, and stairway. Outside group: participants who fell outside the home, such as in a driveway, on a sidewalk, in a park or garden, on a street, or in a gymnasium, facility, hospital, or care facility. † Independent t-test. All other variables were compared using Mann–Whitney U test. ‡ Median (interquartile range).

Discharge variable	Inside group (n=15)		Outside group (n=15)		p value
	Mean	SD	Mean	SD	
Age, years †	84.8	7.9	82.1	6.5	0.309
Sex					
Male, n (%)	3	20	5	33.3	0
Female, n (%)	12	80	10	66.7	0
Length of stay at CRW, days	68.6	19.3	56	20.3	0.204
SIDE level ‡	2	2	4	3	0.058
Preferred gait speed m/sec †	0.65	0.31	0.82	0.39	0.197
FIM, points	104.9	14.7	114.5	9.7	0.042
MMSE, points	22.8	5.8	27.8	3.1	0.014

Discussion

The results of this study suggest that among older people who underwent hip fracture surgery and were discharged from CRW to their homes, high preferred gait speed was significantly associated with falls within one year after discharge. However, the accuracy of predicting falls was poor, with an AUC of 0.533, indicating that other factors beyond those measured in this study may also contribute to fall risk. In contrast, standing balance (as measured by SIDE) had no significant effect after adjusting for covariates. In general, slow gait

speed in older people has been shown to increase the risk of falls. A meta-analysis reported that older people with a walking speed of less than 1m/sec have approximately twice the risk of falling compared to those with a walking speed of 1m/sec or higher [13]. In comparison with older people who have not experienced falls, those who have experienced falls were reported to have shortened step length, large fluctuations in their pace and a slow walking speed [14]. In contrast, the present findings suggested that a high preferred gait speed was associated with falls within one year after discharge among older people who underwent hip fracture surgery. The present population comprised older people who had recently undergone hip fracture surgery and therefore may have had unique physical and functional characteristics compared to the general population of older people. A high preferred gait speed may not necessarily be indicative of good balance and stability during walking. Older people exhibit delayed responses in modifying the lateral propulsive forces under the supporting foot, reduced rates of lateral force production, delayed responses in modifying the stepping foot trajectory, and prolonged movement execution times relative to those of young people [15]. Therefore, people who exhibit these aspects of age-related decline and walk at a fast pace may be at increased risk of falling, especially if they are unable to produce defensive lateral reactions. Furthermore, the evidence regarding mobility improvement in patients with hip fractures after interventions primarily relies on gait speed assessments conducted in controlled settings [16]. To comprehensively understand falls in real-life scenarios after hip fracture, a transition from traditional clinical and in-lab gait assessments to out-of-lab evaluation is essential.

The study identified significant differences in functional outcomes (FIM score) and cognitive function (MMSE score) between people who fell inside the home and those who fell outside the home. This suggests that the location of falls might be associated with specific risk factors and circumstances. Falls that occur indoors are often related to environmental hazards within the home, such as obstacles or slippery surfaces [17] which may pose challenges to functional abilities. In contrast, falls that occur outdoors might be influenced by factors such as uneven terrain or distractions [18] which may require different cognitive skills for navigation and awareness. The observed differences in functional outcomes and cognitive function between these subgroups might indicate that different strategies are needed to prevent falls in each setting. Tailoring fall prevention interventions based on the location of falls could help address specific risk factors and enhance overall effectiveness. Bergland et al. [19] reported that a faster comfortable walking speed was one of the independent predictors of more outdoor falls and a slower comfortable walking speed was one of the independent risk factors for indoor falls among older women [19]. The present results revealed no significant differences in the preferred gait speed between people who fell inside the home and those who fell outside the home, but people who fell inside the home tended to have a slower preferred gait speed than those who fell outside. Our findings are in agreement with previous research.

Approximately half of the people who received the study questionnaire responded. Functional outcomes (FIM score) and cognitive function (MMSE score) were significantly higher for those who responded compared to those who did not. The people who choose to respond might have differed in their overall health status or level of functioning compared to those who did not respond. These findings highlight the potential presence of non-response bias, which can impact the generalizability of the study results. It is possible that people with poorer functional outcomes or cognitive function were less likely to respond to the questionnaire, leading to an underrepresentation of people with more severe impairments. Accordingly, the study findings might be biased toward people with relatively better functional and cognitive abilities. This could have implications for the internal validity and representativeness of the study findings.

The major strength of the present study is that it focused on older people who underwent hip fracture surgery and were discharged from CRW, enabling the identification of factors related to falls in the home environment. Moreover, by conducting the questionnaire survey one year after discharge, we could follow up on participants' long-term living conditions in their homes. However, this study has several limitations. First, the study used a retrospective design and relied on self-reported data for falls, which may introduce recall bias and limit the accuracy of the fall data. Second, the study lacked detailed hip-fracture-specific content such as muscle strength and hip range of motion. Third, the study was conducted at a single CRW in Japan, which may limit the generalizability of the findings to other populations or settings. Finally, the study did not evaluate the effectiveness of specific interventions or strategies to prevent falls in older people who underwent hip fracture surgery and were discharged from CRW.

Conclusion

Our study found that a high preferred gait speed was associated with falls within one year after discharge among older people who underwent hip fracture surgery and were discharged from CRW to their homes. We found that standing balance (as measured by SIDE) had no significant effect after adjusting for covariates. In contrast, the study identified significant differences in functional outcomes (FIM score) and cognitive function (MMSE score) between people who fell inside the home and those who fell outside the home. Tailoring fall prevention interventions based on the location of falls and considering additional risk factors is crucial for effective fall prevention in this population. Further studies are needed to identify additional risk factors and effective strategies to prevent falls in this population. A comprehensive evaluation of physical and cognitive abilities is necessary to prevent falls in older people who have undergone surgery for hip fractures.

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Conflict of Interest

The authors declare no conflict of interest.

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