Incidence and Multidimensional Predictors of Occasional and Recurrent Falls among Malaysian Community-Dwelling Older Adults

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Abstract

Background: Falls incidence rate and comprehensive data on factors that predict occasional and repeated falls from large population-based studies are scarce. This study aimed to determine the incidence of falls and identify predictors of occasional and recurrent falls within the social, medical, physical, nutritional, biochemical, cognitive dimensions among community-dwelling older Malaysians.

Methods: Data from 1,763 Malaysian community-dwelling older adults aged ≥60 years were obtained from the LRGS-TUA longitudinal study. Participants were categorized into three groups according to the presence of a single fall (occasional fallers), ≥two falls (recurrent fallers), or absence of falls (non-fallers) at an 18-month follow-up.

Results: Three hundred and nine (17.5%) participants reported fall occurrence at 18-month follow-up, of whom 85 (27.5%) had two or more falls. The incidence rate for occasional falls and recurrent falls was 8.47 and 3.21 per 100 person-years, respectively. Following multifactorial adjustments, being single (OR: 5.310: 95% CI: 1.963-14.361), having higher depression score (OR: 1.123; 95% CI: 1.045-1.207), lower hemoglobin level (OR: 0.873; 95% CI: 0.797-0.956), and taking a longer time to complete the chair stand test (OR: 0.936; 95% CI: 0.881-0.995) remained independent predictors of occasional falls. While, having higher depression score (OR: 1.116; 95% CI: 1.010-1.233), being a stroke survivor (OR: 5.639; 95% CI: 1.502-21.129), having higher percentage of body fat (OR: 1.038; 95% CI: 1.010-1.067), lower hemoglobin level (OR: 0.853; 95% CI: 0.741-0.982), and taking longer time to complete the chair stand test (OR: 0.907; 95% CI: 0.824-0.998) appeared as recurrent falls predictors.

Conclusions: Having depression, lower muscle strength and hemoglobin levels predict both occasional and recurrent falls among Malaysian community-dwelling older adults. This finding has implications for future research planning, which should aim to identify effective strategies for preventing falls among older adults by modifying these identified predictors.

1. Introduction

Falls in older adults is associated with injury-related hospitalization, disability and death [1]. Moreover, fall-related injuries in older adults result in expensive medical costs [2]. Population-wide falls prevention programs that effectively reduce overall health and social care burden associated with falls-related complications are therefore, urgently required [3].

Female, advancing age and chronic diseases such as arthritis, diabetes, chronic kidney disease and stroke are among the risk factors identified for falls in older adults [4, 5]. Nutritional deficiencies, such as vitamin D deficiency, are linked to osteoporosis, fractures and muscle weakness, increasing both the risk of falls and severe consequences [6]. Reduced physical function, manifesting as muscle weakness and loss of dynamic balance, have also emerged as robust predictors of falls [7]. When balance, muscle strength, and endurance decline below a certain threshold in older adults, falls are likely to occur. In the psychosocial context, older adults who live alone, had fewer years of education, or who experienced loneliness and depression are more likely to be at risk of falls [4]. A strong association also exists between falls and declined cognitive impairment [8].

It is noteworthy that most falls risk factors studied among community-dwelling older adults were performed via cross-sectional studies. Such studies lack comprehensiveness as they mostly examined physical, nutritional, biochemical and biomarker status separately. Since falls are multifactorial, identifying the multidimensional falls risk predictors may be beneficial for early falls prevention strategies in community-dwelling older adults. This study aimed to determine the incidence of falls and identify predictors of occasional and recurrent falls within the social, medical, physical, nutritional, biochemical, cognitive dimensions among community-dwelling older Malaysians.

2. Methodology

2.1 Participants

This prospective cohort study involved 1,763 participants from the first wave of the Long-term Research Grant Scheme - Towards Useful Ageing (LRGS-TUA) study who were followed up at 18-months (wave 2). Participants were recruited based on a multistage random sampling method from four states representing Malaysia's northern, central, southern, and east coast zone. This study is a part of LRGS-TUA, approved by the Medical Research and Ethics Committee of Universiti Kebangsaan Malaysia (UKM 1.5.3.5/244/NN-060-2013). Before data collection, participants were screened for inclusion and exclusion criteria. Older adults aged 60 years and above, who were ambulant (with or without walking aids), and able to converse in Malay, English, Mandarin, or Tamil language were included in this study. Older adults with severe hearing or visual problems, musculoskeletal or neurological conditions that could account for possible joint diseases, imbalance and falls, or recent fractures were excluded.

2.2 Data Collection

In wave 1, demographic data and several risk factors were assessed as described in the previous study [9]. The questionnaires used in this study have been validated and reported previously. These assessments are described briefly as below:

2.2.1 Demographic Data

A structured interview was administered to obtain the socio-demographic and clinical data, including age, gender, marital status, living status, years of education, smoking habits, alcohol drinking status, and self-reported medical conditions (e.g. joint pain, incontinence).

2.2.2 Body composition and blood pressure

Height was measured without shoes, using a SECA 206 portable body meter (Seca, Hamburg, Germany). On the other hand, body weight was measured in light clothing without shoes using a Tanita digital lithium weighing scale (Tanita, Tokyo, Japan). Measurements for height and weight were recorded to the nearest 0.1 cm and 0.1 kg, respectively [9]. Then, the circumference of the waist, hip, and calf were measured using a Lufkin tape. Fat-free mass, fat mass, skeletal muscle mass, and percentage body fat were measured using Bioimpedance Analysis (BIA) using In Body S10 (Biospace Co. Ltd, Korea). The systolic and diastolic blood pressure was assessed using a calibrated digital automatic blood pressure monitor (OMRON, Kyoto, Japan).

2.2.3 Dietary Status

Participants were interviewed using the Dietary History Questionnaire and nutrient intake was determined using the Nutritionist Pro software [9].

2.2.4 Biochemical and biomarkers analysis

Fasting venous blood was collected by a trained phlebotomist after an overnight fast for fasting blood sugar, albumin, hemoglobin, and serum lipid profile.

2.2.5 Cognitive Status

i. Mini-Mental State Examination

General cognitive function was assessed using the Malay version of the Mini-Mental State Examination (MMSE), which is a valid and reliable screening tool for dementia in the Malaysian population [10].

ii. Digit Span

Digit Span [subtest for the Wechsler Adult Intelligence Scale (WAIS)] is sensitive to be used as a measure of working memory [11]. This test is used to assess attention.

iii. Montreal Cognitive Assessment

The Malay version of the Montreal Cognitive Assessment (MoCA) [12] was used in this study. MoCA is used to test for orientation, short memory recall, attention and concentration, working memory and mental arithmetic, language comprehension, visuospatial domain, executive cognitive functioning, naming of objects, and abstract thought components.

iv. Digit symbol

Digit symbol (a subset of WAIS) was used to evaluate visual-motor speed and coordination, visual search, and cognitive flexibility [13]. This test requires the participant to fill in small blank squares with symbols that match to number labeled in each square. It is one of the most age-sensitive and useful cognitive tests to distinguish between mild Alzheimer-type dementia and healthy aging.

2.2.6 Psychosocial

The validated Malay version of the Geriatric Depression Scale-15 [14] was used to evaluate the depression status among the participants.

2.2.7 Physical Performance

i. Time Up and Go (TUG) test

In the TUG test, participants' time while rising from an armless chair (46 cm height), walking 3 meters, turning, walking back, and sitting down were taken. TUG test was performed twice consecutively, and the average of the two scores was used for further analyses. Participants were instructed to walk at a normal pace with or without their regular walking aids.

ii. 2-minute step test

The 2-minute step test measures aerobic endurance. Participants were instructed to march on the spot to about 90° hip flexion and 90° knee extension. The test was continued for 2 minutes and the number of steps taken was counted.

iii. 30-second chair rise test

Participants were required to sit on a chair (without armrest) with hands on opposite shoulders crossed at the wrists, then rise to full standing and sitting down again. This was repeated for 30 seconds, twice, with rest in between. This test reflects lower limb muscle strength.

iv. Dominant handgrip muscle strength test

The dominant handgrip muscle strength test was performed using a handgrip dynamometer (Jamar Plus + Hand Dynamometer, SI Instruments Pty Ltd, SA, Australia). The maximum effort was measured two times with shoulder in sustained adduction and neutral rotation, elbow flexed at 90 degrees, forearm neutral, and wrist between 0–15 degrees of ulnar deviation. The highest reading was taken as the result.

2.2.8 Falls History at Baseline and Follow-Up

During the first wave, participants were asked, “Have you had a fall in the past 12-months?”. At the 18-month follow-up interview, participants were then asked, “Have you had a fall in the past 18-months?”. If they responded positively to the above question, a further question, “How many times have you fallen?” was then administered. A fall was defined to participants as 'an event whereby a person is inadvertently coming to rest on the ground or lower level, excluding intentional change in position to rest on other objects' [15]. Participants that reported no falls in the past during follow-up were categorized as non-fallers. Those with one fall were categorized as occasional fallers, while those who reported two or more falls were categorized as recurrent fallers.

2.3 Statistical Analysis

The cumulative incidence of falls was calculated by dividing the number of new cases of single fall or recurrent falls at 18-month follow-up with the total number of participants at the beginning of the study. The incidence rate of falls was calculated as the number of new cases of single fall or recurrent falls divided by the total person-years observed between the two data collection points. The participants were further divided into four age-groups based on the five-year age categories (60–64, 65–69, 70–74, and 75 years and above) and the age-specific incidence rate of falls was calculated using the person-years analysis method. Participants were considered at risk and contributed to the person-years from the date of their baseline evaluation to the follow-up date where they were asked if they have experienced falls.

Socio-demographic data, body composition, nutrition, biochemical, cognitive, and physical performance scores were compared between non-fallers and occasional fallers, as well as non-fallers and recurrent fallers by using the independent t-test or Chi-square test. Variables that were found to be significant ($p < 0.05$) in the univariate tests were further analyzed using binary logistic regression analyses before being entered into the final multivariate logistic regression model to determine falls predictors. All statistical analyses were performed using Statistical Package for the Social Sciences (SPSS) version 25 (IBM Corp., Armonk, NY).

3. Results

Three hundred and nine (17.5%) participants reported fall occurrence at an 18-month follow-up, of whom 85 (27.5%) had two or more falls. The incidence rate for occasional falls and recurrent falls was 8.47 and 3.21 per 100 person-years, respectively. The age-specific incidence rates of both occasional and recurrent falls are as shown in Table 1. Overall, the incidence rate of falls was independent of increasing age. The ≥ 75 age group had the highest incidence rate for occasional falls (9.09 per 100 person-years). While the 65–69 years age group had the highest incidence rate for recurrent falls (3.91 per 100 person-years).

Table 1
The age-specific incidence rates of occasional falls and recurrent falls over 18-months.

Age group	No. of Subjects	Occasional falls			Recurrent falls		
		No. of cases	Cases/year	Cases/100 person-years	No. of cases	Cases/year	Cases/100 person-years
60–64	523	64	42.67	8.16	24	16.00	3.06
65–69	528	68	45.33	8.59	31	20.67	3.91
70–74	404	50	33.33	8.25	14	9.33	2.31
≥ 75	308	42	28.00	9.09	16	10.67	3.46
Total	1763	224	149.33	8.47	85	56.67	3.21

Table 2 depicts the baseline characteristics of non, occasional and recurrent fallers. Occasional fallers were more likely ($p < 0.05$) to be women (60.3%), single (3.1%), with higher depression scale scores (2.95 ± 2.42); lower height (154.67 ± 8.53 cm), fat-free mass (35.64 ± 7.07%) and skeletal muscle mass (18.82 ± 4.21); lower intake of energy (1583.99 ± 436.79 kcal/day), carbohydrate (209.95 ± 67.82 g/day) and zinc (3.38 ± 1.60 mg/day); lower hemoglobin levels (13.64 ± 1.85 g/L), scored lower in MMSE (22.62 ± 4.82), MOCA (18.35 ± 5.82) and digit symbol (4.73 ± 2.50); scored lower in chair stand (9.60 ± 3.28) and handgrip muscle strength (20.82 ± 7.27) tests. Recurrent fallers were more likely ($p < 0.05$) to be women

(68.2%), living alone (17.6%), with a medical history of hypercholesterolemia (43.5%), stroke (4.7%) and joint pain (36.5%); higher depression scale score (3.35 ± 2.63); lower height (153.76 ± 8.40 cm), fat-free mass (35.17 ± 7.90) and skeletal muscle mass (18.51 ± 4.70); higher fat mass (26.32 ± 10.16) and percentage of body fat (41.89 ± 10.26%); lower hemoglobin levels (13.42 ± 2.13 g/L); scored lower in chair stand (8.83 ± 3.07), TUG (12.84 ± 5.28 seconds) and handgrip muscle strength (19.57 ± 6.69 kg) tests.

Table 2
The baseline attributes of the participants with no fall, occasional, and recurrent falls.

	Non-fallers (N = 1454) (Prevalence (%) or mean ± SD)	**Occasional fallers (N = 224) (Prevalence (%) or mean ± SD)**	**p-value**	**Recurrent fallers (N = 85) (Prevalence (%) or mean ± SD)**	**p-value**
Age					
60–69	864 (59.4)	132 (58.9)	0.889	55 (64.7)	0.334
≥ 70	590 (40.6)	92 (41.1)		30 (35.3)	
Gender					
Male	751 (51.7)	89 (39.7)	0.001*	27 (31.8)	< 0.001*
Female	703 (48.3)	135 (60.3)		58 (68.2)	
Ethnicity					
Malay	879 (60.5)	146 (65.2)	0.119	58 (68.2)	0.218
Chinese	509 (35.0)	64 (28.6)		22 (25.9)	
Indian	66 (4.5)	14 (6.2)		5 (5.9)	
Single	18 (1.2)	7 (3.1)	0.030*	1 (1.2)	0.960
Living alone	138 (9.5)	22 (9.8)	0.875	15 (17.6)	0.015*
Smoking	251 (17.3)	34 (15.2)	0.439	10 (11.8)	0.189
Alcohol consumption	66 (4.5)	7 (3.1)	0.334	2 (2.4)	0.340
Education (years)	5.38 ± 4.03	4.88 ± 3.79	0.083	4.54 ± 4.04	0.063
Chronic diseases					
Hypertension	714 (49.1)	116 (51.8)	0.455	46 (54.1)	0.369
Hypercholesterolaemia	428 (29.4)	70 (31.3)	0.580	37 (43.5)	0.006*
Diabetes mellitus	363 (25)	57 (25.4)	0.877	24 (28.2)	0.499
Stroke	22 (1.5)	3 (1.3)	0.842	4 (4.7)	0.026*
Joint Pain	337 (23.2)	64 (28.6)	0.078	31 (36.5)	0.005*
Cardiovascular diseases	147 (10.1)	21 (9.4)	0.733	7 (8.2)	0.576

	Non-fallers (N = 1454) (Prevalence (%) or mean ± SD)	Occasional fallers (N = 224) (Prevalence (%) or mean ± SD)	p-value	Recurrent fallers (N = 85) (Prevalence (%) or mean ± SD)	p-value
Cataract & glaucoma	127 (8.7)	27 (12.1)	0.109	7 (8.2)	0.874
Asthma	111 (7.6)	18 (8.0)	0.834	10 (11.8)	0.169
Gout	68 (4.7)	7 (3.1)	0.295	5 (5.9)	0.611
Gastric ulcer	178 (12.2)	34 (15.2)	0.218	15 (17.6)	0.144
Urinary Incontinence	143 (9.8)	26 (11.6)	0.412	11 (12.9)	0.354
Hearing & vision problems	173 (11.9)	23 (10.3)	0.479	15 (17.6)	0.116
Psychosocial					
Depression	2.54 ± 2.19	2.95 ± 2.42	0.012*	3.35 ± 2.63	0.007*
Physical					
Weight (g)	61.44 ± 12.21	60.14 ± 12.52	0.139	61.45 ± 13.43	0.992
Height (cm)	156.51 ± 8.44	154.67 ± 8.53	0.003*	153.76 ± 8.40	0.004*
Circumference: waist (cm)	88.21 ± 11.20	88.08 ± 11.97	0.870	89.88 ± 12.62	0.239
Circumference: Hip (cm)	96.54 ± 9.18	96.95 ± 10.37	0.575	98.46 ± 11.61	0.139
Circumference: calf (cm)	33.55 ± 3.75	33.12 ± 3.85	0.114	33.41 ± 4.08	0.744
Fat mass	24.19 ± 9.09	24.47 ± 9.67	0.680	26.32 ± 10.16	0.038*
Fat free mass	37.16 ± 7.89	35.64 ± 7.07	0.004*	35.17 ± 7.90	0.025*
Skeletal muscle mass	19.75 ± 4.71	18.82 ± 4.21	0.003*	18.51 ± 4.70	0.019*
Percentage of body fat (%)	38.68 ± 10.38	39.69 ± 10.20	0.178	41.89 ± 10.26	0.006*
Systolic (mmHg)	140.70 ± 22.40	141.13 ± 20.34	0.795	138.81 ± 23.46	0.471
Diastolic (mmHg)	77.26 ± 13.44	76.87 ± 12.96	0.689	77.31 ± 12.88	0.975
Nutrition					
Energy (kcal/day)	1658.03 ± 485.42	1583.99 ± 436.79	0.037*	1625.96 ± 509.31	0.560

	Non-fallers (N = 1454) (Prevalence (%) or mean ± SD)	Occasional fallers (N = 224) (Prevalence (%) or mean ± SD)	p-value	Recurrent fallers (N = 85) (Prevalence (%) or mean ± SD)	p-value
Protein (g/day)	70.85 ± 22.10	68.75 ± 23.29	0.201	69.36 ± 22.77	0.550
Carbohydrate (g/day)	224.76 ± 77.79	209.95 ± 67.82	0.004*	218.05 ± 81.67	0.447
Sugar (g/day)	21.51 ± 15.12	20.42 ± 14.94	0.331	18.51 ± 12.94	0.077
Fat (g/day)	52.87 ± 20.69	51.79 ± 20.36	0.477	53.13 ± 20.72	0.912
Cholesterol (mg/day)	158.51 ± 113.21	162.88 ± 122.33	0.606	172.06 ± 130.20	0.294
Saturated fat (mg/day)	8.39 ± 5.73	8.20 ± 6.14	0.681	9.05 ± 6.10	0.307
MUFA (g/day)	8.32 ± 5.02	8.44 ± 5.65	0.750	8.71 ± 5.73	0.498
PUFA (g/day)	5.44 ± 3.43	5.49 ± 3.67	0.834	5.40 ± 3.22	0.916
Vitamin D (mg/day)	0.35 ± 2.50	0.27 ± 0.97	0.682	0.34 ± 1.05	0.990
Vitamin E (mg/day)	12.04 ± 62.58	14.77 ± 71.91	0.563	4.33 ± 2.40	0.262
α-tocopherol (mg/day)	0.45 ± 1.17	0.51 ± 1.45	0.506	0.54 ± 1.22	0.495
Sodium (mg/day)	1466.23 ± 979.55	1401.85 ± 1068.97	0.545	1466.36 ± 799.12	0.854
Potassium (mg/day)	1510.35 ± 552.18	1443.59 ± 522.91	0.099	1402.60 ± 534.01	0.083
Calcium (mg/day)	520.70 ± 248.06	501.46 ± 242.21	0.292	473.34 ± 212.43	0.089
Iron (mg/day)	13.51 ± 5.41	12.96 ± 4.84	0.160	13.26 ± 6.10	0.681
Phosphorus (mg/day)	1094.54 ± 418.46	1081.38 ± 425.24	0.671	1067.02 ± 389.09	0.559
Magnesium (mg/day)	131.86 ± 64.94	128.51 ± 68.80	0.489	123.00 ± 63.66	0.227
Zinc (mg/day)	3.63 ± 1.99	3.38 ± 1.60	0.047*	3.40 ± 1.65	0.310
Selenium (mg/day)	23.98 ± 18.23	22.47 ± 17.17	0.260	23.88 ± 16.95	0.961
Biochemical					
Hemoglobin (g/L)	14.20 ± 2.30	13.64 ± 1.85	< 0.001*	13.42 ± 2.13	0.008*

	Non-fallers (N = 1454) (Prevalence (%) or mean ± SD)	Occasional fallers (N = 224) (Prevalence (%) or mean ± SD)	p-value	Recurrent fallers (N = 85) (Prevalence (%) or mean ± SD)	p-value
Glucose (mmol/L)	6.19 ± 2.28	5.95 ± 1.69	0.096	6.18 ± 2.00	0.987
Cholesterol (mmol/L)	5.41 ± 1.12	5.47 ± 1.09	0.532	5.54 ± 1.05	0.359
HDL (mmol/L)	1.40 ± 0.34	1.41 ± 0.39	0.726	1.47 ± 0.46	0.121
LDL (mmol/L)	3.34 ± 1.03	3.36 ± 0.95	0.806	3.42 ± 0.98	0.523
Triglyceride (mmol/L)	1.50 ± 0.76	1.55 ± 0.76	0.513	1.45 ± 0.63	0.598
Albumin (g/L)	42.93 ± 2.77	42.86 ± 2.75	0.736	42.42 ± 2.90	0.158
Cognitive Test					
Digit Span	7.62 ± 2.42	7.46 ± 2.37	0.346	7.43 ± 2.40	0.479
MMSE	23.32 ± 4.64	22.62 ± 4.82	0.037*	22.77 ± 5.16	0.299
MoCA	19.23 ± 5.57	18.35 ± 5.82	0.031*	18.56 ± 5.88	0.294
Digit Symbol	5.14 ± 2.59	4.73 ± 2.50	0.038*	4.55 ± 2.29	0.059
Physical performance					
2-min step test (number)	62.44 ± 25.45	60.70 ± 24.96	0.350	56.31 ± 32.72	0.104
Chair stand test (number)	10.05 ± 2.98	9.60 ± 3.28	0.039*	8.83 ± 3.07	< 0.001*
TUG (seconds)	11.33 ± 3.56	11.62 ± 3.49	0.258	12.84 ± 5.28	0.013*
Handgrip strength (kg)	22.59 ± 7.66	20.82 ± 7.27	0.002*	19.57 ± 6.69	0.001*

Variables that were significant in the univariate test were entered into binary logistic regression. The univariate predictors of occasional and recurrent falls are as shown in Table 3. These variables were then further analyzed using multivariate logistic regression analysis (Table 4). Being single (OR: 5.310: 95% CI: 1.963–14.361), having higher depression scores (OR: 1.123; 95% CI: 1.045–1.207), lower hemoglobin levels (OR: 0.873; 95% CI: 0.797–0.956), and lower chair stand test scores (OR: 0.936; 95% CI: 0.881–0.995) appeared as occasional falls predictors in this model [χ^2 (df = 8, N = 1763) = 7.909, p = 0.442 with 86.8% accuracy]. On the other hand, having higher depression scores (OR: 1.116; 95% CI: 1.010–1.233), stroke (OR: 5.639; 95% CI: 1.502–21.129), higher percentage of body fat (OR: 1.038; 95% CI: 1.010–1.067), lower hemoglobin levels (OR: 0.853; 95% CI: 0.741–0.982), and lower in chair stand test scores

(OR: 0.907; 95% CI: 0.824–0.998) were identified as predictors of recurrent falls [χ^2 (df = 8, N = 1763) = 6.459, p = 0.596 with 94.9% accuracy].

Table 3
Univariate scores for individual predictors of occasional and recurrent falls.

Domain	Variable	B	SE	p-value	Exp(B)	[95% CI]
Occasional falls						
Sociodemographic	Gender (Female)	.483	.146	.001*	1.620	1.217–2.158
	Marital status (Single)	.945	.451	.036*	2.573	1.063–6.233
Psychosocial	Depressive symptoms	.075	.030	.013*	1.078	1.016–1.143
Body composition	Height	− .026	.009	.003*	.974	.958-.991
	Fat-free mass	− .026	.010	.007*	.974	.956-.993
	Skeletal muscle mass	− .045	.016	.006*	.956	.926-.987
Nutrition	Energy	.000	.000	.037*	1.000	.999-1.000
	Carbohydrate	− .003	.001	.009*	.997	.995-.999
	Zinc	− .071	.042	.089*	.932	.859-1.011
Laboratory	Hemoglobin	− .127	.041	.002*	.881	.881-.955
Cognitive test	MMSE	− .031	.015	.037*	.970	.942-.998
	MoCA	− .027	.013	.031*	.973	.949-.998
	Digit Symbol	− .066	.032	.039*	.936	.879-.997
Physical performance	Chair stand test	− .051	.025	.039*	.951	.906-.998
	Handgrip strength	− .031	.010	.002*	.969	.951-.988
Recurrent falls						
Sociodemographic	Gender (Female)	.831	.239	.001*	2.295	1.437–3.665
	Living alone	.715	.298	.017*	2.043	1.139–3.666
Chronic disease	Hypercholesterolemia	.614	.226	.007*	1.848	1.186–2.879
	Stroke	1.168	.555	.036*	3.214	1.082–9.547
	Joint pain	.643	.234	.006*	1.903	1.203–3.009

Domain	Variable	B	SE	p-value	Exp(B)	[95% CI]
Psychosocial	Depressive symptoms	.134	.042	.001*	1.144	1.053–1.243
Body composition	Height	− .039	.014	.004*	.961	.936-.987
	Fat mass	.025	.012	.039*	1.025	1.001–1.049
	Fat-free mass	− .034	.015	.025*	.967	.939-.996
	Skeletal muscle mass	− .059	.025	.020*	.943	.897-.991
.	Percentage of body fat	.031	.011	.006*	1.031	1.009–1.054
Biochemical	Hemoglobin	− .186	.070	.008*	.830	.723-.952
Physical performance	Chair stand test	− .143	.039	< .001*	.867	.802-.937
	Timed up and go	.076	.023	.001*	1.079	1.032–1.128
	Handgrip strength	− .055	.016	.001*	.947	.917-.977

Table 4
Independent predictors for occasional and recurrent falls at 18 months follow-up.

Domain	Variables	B	SE	p-value	Exp(B)	[95% CI]
Occasional falls						
Sociodemographic	Marital status (Single)	1.670	.508	.001*	5.310	1.963–14.361
Psychosocial	Depressive symptoms	.116	.037	.002*	1.123	1.045–1.207
Laboratory	Hemoglobin	− .136	.046	.003*	.873	.797-.956
Physical performance	Chair stand test	− .066	.031	.033*	.936	.881-.995
Recurrent falls						
Chronic disease	Stroke	1.730	.674	.010*	5.639	1.502–21.129
Psychosocial	Depressive symptoms	.110	.051	.031*	1.116	1.010–1.233
Body composition	Percentage of body fat	.037	.014	.008*	1.038	1.010–1.067
Biochemical	Hemoglobin	− .159	.072	.027*	.853	.741-.982
Physical performance	Chair stand test	− .098	.049	.045*	.907	.824-.998

4. Discussion

We identified the incidence rate and multidimensional falls risk predictors at 18-month follow-up among 1763 community-dwelling older Malaysians in the present study. The incidence rate of occasional and recurrent falls observed in our present study was 8.47 and 3.21 per 100 person-years respectively, with no increase with age. Falls prevalence of 15–18% [16, 17] and 27% over a six-month follow-up period [18] had previously been reported among community-dwelling older Malaysians. The prevalence of recurrent falls has been reported as 8.3% [19].

Despite the apparent association between age and decline in both physical and cognitive functions [20], our results showed that advancing age did not predict the incidence of occasional and recurrent falls. In an age-specific population, the incidence of falls was not age-dependent, as opposed to the prevalence of falls, which was reported to be age-dependent [21]. In other words, while the number of cases of falls does not increase with increasing age, cumulatively, the number of individuals who would have fallen within the older population over any given period would be observed due to the consistent addition of new cases.

Occasional falls could be accidental and are usually associated with extrinsic factors [22, 23]. In comparison, recurrent falls among older adults are usually related to multifactorial intrinsic factors and are usually associated with a more complex risk profile model. However, our current findings showed that the identified predictors for both occasional and recurrent falls were similar, with the exception of being single was a predictor of occasional falls while having a history of stroke and higher percentage body fat were identified as predictors of recurrent falls. Having a higher depression scale score, lower hemoglobin levels, and taking longer to complete the chair stand test appeared as robust predictors of both occasional and recurrent falls in community-dwelling older adults.

Depression has been shown to be associated with both occasional and recurrent falls among community-dwelling older adults previously [24, 25]. Depressive symptoms may affect the older adult's mobility and executive function [26]. The causal relationship between depression and falls was not fully explained by adjustment for the medical comorbidities, nutritional, physical and laboratory factors. The use of medications was not adjusted for within this study, which may account for the increased risk of falls among individuals with symptoms of depression [27]. Depression in older adults has been attributed to structural brain changes that interfere with cortical-subcortical circuits, basal-ganglia, and limbic networks, which in turn affect postural stability leading to the occurrence of falls [27]. Furthermore, antidepressants have been associated with single and recurrent falls [28, 29]. The proposed mechanisms for the antidepressant related falls include orthostatic hypotension, dizziness, compromised vision and mental confusion [29].

Lower hemoglobin levels increased the risk of both occasional and recurrent falls. Potential mechanisms linking the age-associated decline in hemoglobin and falls include fatigue, reduced muscle strength and muscle quality. The decline in oxygen delivery is attributed to the reduction of hemoglobin levels, whereby hemoglobin functions as an oxygen carrier to skeletal muscles, leading to a reduction in muscle function and declining mobility. This finding was in agreement with the three-year Longitudinal Aging Study Amsterdam demonstrating frequent episodes of falls among older adults with anemia as compared to their non-anemic counterparts [30]. Low hemoglobin levels were also shown to increase the risk of recurrent falls among the U.S. population, aged 45 years and above [31]. The presence of lower hemoglobin may also reflect underlying nutritional deficiencies or chronic conditions affecting hemoglobin production. Others include undetected causes of hemoglobin loss due to medical conditions such as peptic ulcer disease or malignancy and medications, including ulcer-inducing drugs and those that inhibit marrow function. However, these factors had not been fully accounted for within this study.

The chair stand test, a measure of lower extremity muscle strength, has been demonstrated to be beneficial in determining fall risk [32]. Older adults who were unable to perform the chair stand test were reported to be associated with a higher risk of fall-related injuries [33]. Moreover, lower extremity weakness was reported to increase the odds of occasional and recurrent falls in older adults [34] since it was associated with abnormal gait, loss of balance, declined mobility, flexibility and functional performance [35]. Besides, strengthening of lower limb muscles has been reported to be effective in preventing falls in older adults [35]. Similarly, we have demonstrated that muscle strength was associated with falls among Malaysian community-dwelling older adults in our earlier pooled data findings [36].

Our study results also showed that the risk of recurrent falls at 18 months was increased among older adults with higher percentage body fat. One of the probable reasons for the existence of a relationship between higher percentage body fat and increased risk of falls could be due to declined lower extremity muscle strength following excess adiposity, which could affect postural stability and balance [37]. Excess adipose tissue accumulation may also lead to dynapenic obesity, a condition linked to a decline in muscle strength, loss of muscle mass, and sarcopenic obesity [38, 39]. As a result, it may lead to impaired mobility and balance and consequently, increase fall risk in older adults. In an observational study involving 164,737 participants between the ages of 19 to 106 years, older adults with obesity had the odd ratio of 1.10 and 1.12 for one fall and two or more episodes of falls respectively [40].

Increased body fat predisposes individuals to underlying medical conditions such as diabetes, hypertension, heart disease, stroke and osteoarthritis and may also be an indicator of reduced physical activity. Recent studies have also linked adiposity with low-grade inflammation, which not only predisposes individuals to osteoarthritis and dementia but also increases the risk of sarcopenia and osteoporosis [41]. Further, stroke also has been identified as one of the major risk factors of falls and recurrent falls [42]. Stroke survivors also tend to develop a fear of falls, which is associated with physical and functional decline, decreased quality of life, impaired social interaction, depression and anxiety [43, 44]. Previously, having depressive symptoms and loss of dynamic balance has been demonstrated to increase the risk of falls among stroke survivors [45, 46].

Lastly, being single (unmarried) was a risk factor of occasional falls during the 18th-month follow-up in this current longitudinal study. Single older adults were often associated with living alone, having loneliness, depressive symptoms, and poor health [47, 48]. All of these characteristics were also associated with increased risk of falls in older adults. In addition, older adults living alone were reported to have a higher risk of declined physical fitness due to limited participation in physical activity with higher possibilities of fall-related injuries and elevated risk of mortality and morbidity [49, 50].

5. Conclusions

In conclusion, the incidence rates of occasional and recurrent falls in community-dwelling older Malaysian were 8.47 and 3.21 per 100 person-years respectively. Following multifactorial adjustments, being single, having a higher depression scale, lower hemoglobin levels, and lower chair stand test scores remained independent predictors of occasional falls. While having a higher depression scale, a history of stroke, a higher percentage of body fat, lower hemoglobin levels, and lower chair stand test scores appeared as recurrent falls predictors in this model. In this study, we identified predictors for prospective falls using a comprehensive, multidomain approach. Further studies are required to determine the value of individualized interventions informed by such an approach to risk factor identification.

List Of Abbreviations

Bioimpedance Analysis - BIA

Long-term Research Grant Scheme - Towards Useful Ageing - LRGS-TUA

Mini-Mental State Examination – MMSE

Montreal Cognitive Assessment – MoCA

Time Up and Go - TUG

Wechsler Adult Intelligence Scale - WAIS

Declarations

Ethics approval and consent to participate

This study is a part of LRGS-TUA longitudinal study, approved by the Medical Research and Ethics Committee of Universiti Kebangsaan Malaysia (UKM 1.5.3.5/244/NN-060-2013). Written informed consent was obtained from study participants. In the case of participants with cognitive decline and not capable of providing ethical consent, informed consent was obtained from their legal guardian, family, or caregiver on their behalf.

Consent for publication

Not applicable.

Availability of data and materials

The datasets used and/or analyzed during the current study are available from the corresponding author on reasonable request.

Competing interests

The authors declare that they have no competing interests.

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Authors' contributions

DKAS, SS, NFR, RS, MPT involved in the conception and study design. TCO and DV contributed to data analysis and interpretation. TCO drafted the original manuscript. All authors read and approved the final manuscript.

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