Incidence and Predictors of Falls in the Chinese Elderly

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Abstract

Introduction: This is the first prospective longitudinal study carried out in a Chinese elderly population with the objective of identifying the incidence and predictors of falls. Materials and Methods: This is a population-based cohort study in Hong Kong with 1517 ambulatory elderly Chinese recruited using a multi-stage sampling method. Baseline data on demographic, co-morbid diseases, drugs, Activities of Daily Living (ADL) [Barthel Index and Lawton's Instrumental Activities of Daily Living (IADL)], Geriatric Depression Scale (GDS-15), cognitive assessment by the Abbreviated Mental Test (AMT), fear of falling, self-perceived mobility problem, hand grip strength, lower limb power, balance and gait tests were performed. Every subject was followed up for 1 year. Results: Four hundred and one falls occurred in 294 fallers (19.3%) over 1 year of follow-up. The prevalence of falls and recurrent falls were 19.3% and 4.75%, respectively. The incidences of falls (i.e., the fall events) were 220, 324 and 270 per 1000 person-years for men, women and both gender, respectively. The independent predictors of falls were previous history of falls, advancing age, Parkinson's disease, knee extension power and gait speed. The independent predictors of recurrent falls were previous history of falls, self-perceived mobility problem, the knee extension strength and the Total Mobility Score of the Tinetti Balance and Gait Evaluation. Conclusions: The incidence of falls in the Chinese elderly was 270 per 1000 person-years. History of falls, old age, Parkinson's disease, decreased lower limb power and impairment in balance and gait function were important independent predictors of falls or recurrent falls in the Chinese elderly. Effective fall prevention programmes targeted at improving these risk factors for falls should be developed for the Chinese elderly in Hong Kong and Asia.

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Introduction

Falls are common events in the elderly. Previous Western studies have shown that up to one third of community-dwelling older adults will fall each year. The incidences of falls in community-based older populations have been reported to vary between 224 and 809 per 1000 person-years in the UK, Finland, New Zealand, United States and Sweden.[1-13] The variation may be due to several reasons including recall bias related to the ascertainment of falls in retrospective studies[1-3,5,10,12] and the age and race of the study subjects.[1-13] A retrospective cross-sectional study on falls in Hong Kong showed a prevalence rate of 18% over the past year. This is lower in comparison with studies carried out in UK, US and Europe.[14] For the incidence of falls in the Chinese elderly, there has been no previous prospective follow-up study.

Syncope associated with falls accounts for only 10% of total falls. In non-syncopal falls, approximately 10% are related to acute medical illnesses i.e., pneumonia, dehydration or anaemia. The remaining majority of non-syncopal falls have diverse and complex causes and are broadly grouped under intrinsic and extrinsic risk factors.[15] The following intrinsic *risk factors* have been described: previous history of falls, very old age, arthritis of knees,

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stroke, Parkinson's disease, postural hypotension (≥20 mm Hg), limitations in physical function, weak hand grip strength, motor weakness (e.g., difficulty in standing up from a chair), poor balance while standing, turning, changing position or walking, poor tandem gait, gait impairment, cognitive impairment, depressive symptoms, poor vision, the use of hypnotic, anti-depressants or tranquillisers and the use of 4 or more prescribed drugs. Significantly, the greater the number of risk factors in an older adult, the higher the risk of falling. The risk of falling increases from approximately 10% for those with none or 1 risk factor to approximately 70% for those with 4 or more risk factors.[11,16]

In the Chinese elderly, there were no prospective data on the predictors of falls. Only 1 retrospective study reported that previous white-collar employment, self-perceived poor health, dizziness, slow gait velocity, difficulties in activities of daily living, non-practice of "morning walk", and history of strokes were risk factors for falls.[14] Recall bias would be a problem in this retrospective study. Cumming et al[17] have reported that 13% to 32% of older adults who have fallen previously have forgotten about their falls. Older adults with lower Mini-Mental Status Examination (MMSE) scores are more likely to forget about their falls than the others. Hence, forgetting "falls and the related risk factors" may result in the underestimation of the true prevalence and risk factors of falls in Hong Kong Chinese older adults. A prospective study would overcome the recall bias. Among the Chinese older fallers, 40% of them were multiple fallers.[14] However, there has been no prospective published study on the predictors of recurrent falling in the Chinese older population. Therefore, a prospective study on the Chinese elderly was needed. The objective of the present prospective cohort study was to determine the incidence and predictors of falls in the Chinese elderly in Hong Kong.

Materials and Methods

Definition of Falls

For the purpose of this study, a fall is defined as an event which results in a person coming to rest unintentionally on the ground or other lower level, not due to any intentional movement, a major intrinsic event (e.g., stroke) or extrinsic force (e.g., forcefully pushed down, knocked down by a car).[11,18]

Subjects

This is a prospective population-based cohort study performed in the community of Hong Kong. The research protocol was approved by the Ethics Committee of the University of Hong Kong. Based on previous findings on risk factors of falls,[11,14] 5 commonly reported risk factors were employed in the sample size calculation. The sample sizes calculated would be 170, 110, 1300, 410 and 300 for the use of sedatives, lower limb disability, functional level, depression and cognitive impairment respectively (α= 0.05; power = 0.9; lost to follow-up = 15% over 1 year). A final sample size of approximately 1300 subjects was selected.[19]

A random sample of Hong Kong Chinese older adults aged 65 or over was taken. The implementation of the Privacy Ordinance in Hong Kong made it impossible to get the names and addresses of all the elderly people in Hong Kong to generate the sampling frame. A multi-stage sampling method was therefore adopted. Five districts were selected randomly out of 17 districts (excluding outlying islands) in Hong Kong and the streets in each district were grouped under public and private housing groups. This was based on published data from the 1996 census report, where approximately 50% of all housing units were public and 50% were private,[20] with approximately 50% of the subjects recruited from public and private housing units respectively. Ten streets each were drawn randomly from the public and private housing units. Each household along these streets was visited and eligible subjects were invited to participate in this study. If there was more than 1 eligible subject, only 1 subject (by birthday) per household would be recruited. A total of 1517 population-based elderly subjects (age 65 years or over) were recruited from March 1998 to October 1999.

Subject Inclusion and Exclusion Criteria

The inclusion criteria were Chinese, age ≥65 years old, living at home, could walk independently or with a walking aid and informed consent. The exclusion criteria were non-Chinese, age <65 years old, non-ambulatory (cannot walk with or without a walking aid) and unable to cooperate in the assessment.

Baseline Assessment of Potential Risk Factors for Falls

Direct interviews with the subjects were conducted at the subjects' homes with additional information obtained from the family members for those with cognitive impairment. The data collected covered demographic, socio-economic conditions, known diseases, medications history and Activities of Daily Living (ADL). The above interview was conducted using a structured questionnaire. A clinical and functional assessment was carried out following the interview.

We performed the assessment of vision by a hand-held Rosenbaum visual acuity chart, which was held at 14 inches in front of the patient. We tested the overall visual acuity (VA) of both eyes at baseline (subjects were asked to wear their usual eye-glasses, if applicable). The visual acuity of the subjects was classified into 3 groups: poor (VA = 20/200 or worse), satisfactory (VA = 20/100 to 20/

50) and good (VA = 20/40 to 20/20).

Functional assessments of muscle strength, gait and balance were assessed by direct assessment during home visit. The assessment methods are based on previous published reports.[5,8,11,16,18,21-30] Hand grip strength and knee extension strength were measured using the Jamar hand dynamometer and Nicholas Manual Muscle Tester (MMT), respectively. The balance tests were the feet-together stand, semi-tandem stand, tandem stand and the tandem walk tests. The gait speed was calculated from the 5-metre walking time with the subject instructed to walk as fast as possible. The Tinetti Balance and Gait Evaluation was adopted from a previous study.[26]

Functional Assessment of Muscle Strength, Balance and Gait Stability

Assessment of hand grip strength was evaluated by the use of a hand dynamometer (Jamar Model, Asimow Engineering, Santa Monica, California). The maximal strength was recorded in kg-f. The procedure was repeated twice. All subjects used the right hand, with 1-minute rest. The mean value of 3 trials was noted.

The measurement of the knee extension power was evaluated by the manual muscle tester (MMT) (Nicholas Manual Muscle Tester Model 01160, Lafayette Instrument Company, Lafayette, Indiana). Previous research has established the inter-rater reliability and criterion validity of the machine. A small-scale inter-tester reliability test was carried out between the 2 examiners of this study. Fifteen older adults aged between 65 and 81 years were invited for the reliability test. The testing procedures followed prescribed protocol. The "make test" method was adopted where the knee was held stationary at 0-degree extension during the force application by the examiner. The procedure was repeated for the right knee with a 1-minute rest in between in order to measure the mean value of the 2 trials. Muscle power testing for the left knee followed the same procedure as the right.

The inter-rater reliability as measured by intra-class Pearson correlation coefficients (r) was 0.78 (P <0.05) for the right knee and 0.88 (P <0.05) for the left knee. The test-retest reliability as measured by intra-class Pearson correlation coefficients (r) was 0.95 (P <0.05) for the right knee and 0.89 (P <0.05) for the left knee.

Assessment of standing balance of subjects was done in 3 positions with progressive decrease in the area of base of support. For the first standing balance test, the subject was asked to stand with feet together and eyes opened. For the second standing balance test, the subject was asked to stand in a semi-tandem position. For the third standing balance test, the subject was asked to stand in a tandem position. The performance was rated as normal if one could maintain the position for 10 seconds without foot movement or manual support.

Dynamic stability of 2-m walking with challenged base of support was assessed by the tandem walk method. Repeated loss of balance, repeated failure to keep the foot position or having more than 2 errors while walking was considered as failure of the test.[18]

Performance-orientated Measurement of Balance and Gait

The original version of Tinetti Balance and Gait assessment was used in this study. The inter-rater reliability, content validity and predictive validity were established by the test developers.[26]

Follow-up Assessment

Every subject was followed up for 1 year or until loss to follow-up. Both the occurrence and outcome assessments on falls were performed every 2 months by telephone. The subjects and caregivers were asked about the occurrence of falls and any injury after falls. Home visits were performed at 1 year of follow-up.

Data Analyses

Descriptive analyses were performed for demographic, disease and predictor variables. The prevalence and incidence of falls and recurrent falls were calculated. Univariate analyses for predictors of falls and recurrent falls with Chi-square statistics for categorical and Student's t-test for continuous data were performed. Logistic regression analyses for predictors of falls and recurrent falls were performed for variables which were significant in the univariate analyses. P <0.05 (2-tailed) was considered statistically significant. The statistical package SPSS version 10 for Windows was used for data analyses.

Results

From March 1998 to October 1999, 2071 households with elderly family members aged 65 years and over were invited to participate in the study during home visits. Out of this, 554 declined to be interviewed. A total of 1517 elderly subjects participated in the study, giving a response rate of 73.2%. The subjects who declined were more likely to be female (% of female participants vs refusal subjects = 50.8% vs 36.5%; P <0.01 χ^2 statistics) and slightly older in age [mean age ± standard deviation (SD) of participants vs refusal subjects = 73.2 ± 6.3 vs 72 ± 3.5 years; P <0.01; independent t-test, 2-sided] than participating subjects.

Baseline Characteristics of Subjects

The final baseline sample consisted of 1517 subjects aged 65 years and over. 50.8% of the subjects were men and 49.2% were women. The mean age was 73.2 ± 6.3 years. Co-morbid diseases were common, with 9.3% having 5 or

more chronic diseases and 10.6% receiving 5 or more oral medications. The proportions of subjects with poor (VA = 20/200 or worse) and satisfactory (VA = 20/100 to 20/50) visual acuity are 9.7% and 60.6%, respectively (Table 1).

The 10 most commonly reported medical diagnoses were arthritis (61.4%), hypertension (33%), cataract (26.2%), peptic ulcers (15.4%), diabetes mellitus (12.4%), coronary heart disease (8.6%), hyperlipidaemia (7.4%), chronic obstructive airway disease (6.0%), stroke (6.3%) and asthma (3.0%). Dementia and depression were known to be present in 0.33% and 0.66% of the subjects.

Previous History of Falls

The prevalence of previous falls within the past year was 14.1%. 35.5% and 33.2% of subjects revealed that they had subjective mobility problems and a fear of falling, respectively.

The mean baseline functional scores in terms of the Barthel Index (BI), Lawton's Instrumental Activity of Daily Living (IADL) score, gait speed and Total Mobility Score (TMS) of Tinetti Balance and Gait Evaluation are listed in Table 1.

Table 1. Baseline Characteristics of Subjects (n = 1517)

	Mean ± SD
Sex (female)	49.2%
Age (y)	73.17 ± 6.26
Marital status (married)	58.7%
Education (no education)	51.9%
Number of active diagnoses	2.27 ± 1.54
Number of oral medications	1.64 ± 2.01
Geriatric Depression Scale Score (GDS-15)	3.44 ± 2.5
AMT score (n = 1514)	8.89 ± 1.15
Barthel Index (BI) (0-20)	19.91 ± 0.64
Lawton IADL (0-8)	7.9 ± 0.61
Use of walking aid	10.5%
Smoking (current smoker)	18.9%
Alcohol habit (current drinker)	6.1%
Visual acuity group (%)	
≤20/200	9.7%
20/100 to 20/50	60.6%
20/40 to 20/20	29.7%
Right hand grip (kg-force or kg-f)	23.68 ± 8.69
Right knee's extension power (kg-f)	3.35 ± 1.43
Left knee's extension power (kg-f)	3.32 ± 1.46
Body weight (kg)	57.0 ± 10.7
Height (cm)	157.0 ± 8.6
BMI (kg/m^2)	23.1 ± 3.8
5-m walking time (s)	7.74 ± 8.34
Gait speed (m/s)	0.77 ± 0.22
Tinetti Balance and Gait Evaluation	
Balance Score (BS)	15.2 ± 2.2
Gait Score (GS)	11.4 ± 1.7
Total Mobility Score (TMS)	26.6 ± 3.7
Previous history of falls	14.1%
Falls in past year	9.6%
Falls in ≤1 year (%) and ≥1 year	4.5%
Self-perceived mobility problem	35.5%
Fear of falling (yes)	33.2%
GDS-15 >8	4.7%

AMT: Abbreviated Mental Test; IADL: Instrumental Activity of Daily Living

Outcomes of One-year Longitudinal Follow-up

Sixty subjects (3.96%) refused home visits and face-to-face interviews at 1 year of follow-up. The total duration of follow-up for the 1516 subjects was 1477.3 person-years. Overall, only 8.63% of the subjects (n = 131) did not have 1 full year of outcome data.

Prevalence of Falls

Overall, 401 new falls occurred in 294 persons over 12 months of follow-up of the 1517 community-living elderly subjects. The fall rate (number of falls per 100 persons) was 26.4%. The 1-year prevalence of falls (persons with at least 1 new fall) was 19.3%. The prevalence of recurrent fallers (i.e., 2 or more falls per year) was 4.75% (n = 72). 24.5% of the fallers had recurrent falls with 2 falls in 15.6%, 3 falls in 7.5%, 4 falls in 0.3%, 5 falls in 0.3% and 6 falls in 0.7%.

Incidence of Falls

The incidences of falls (i.e., the fall events) were 220, 324 and 270 per 1000 person-years for men, women and both genders, respectively. The incidence of fallers (i.e., persons with falls) was 198 per 1000 person-years. The incidence was higher in females than males and increased with age. The incidences of falls were 363, 387 and 468 per 1000 person-years for the 75-79, 80-84 and ≥85 years age groups, respectively.

Location of Falls

46.6% of all falls occurred indoors while 53.4% occurred outdoors. Within the home, falls commonly occurred in the living room (30%), bathroom/toilet (23%), dinning room (14.4%), bedroom (12.3%) and kitchen (8.6%). Outside the home, 23.8% of falls occurred on the stairs, along the corridor or in the neighbourhood. 76.2% of the falls occurred in the street or on sidewalks (44.4%), on public staircases or while crossing the road (6.5%).

Injuries

The injury rate after falls in the fallers (n = 290; 4 missing) was 75.2% (n = 218). The majority of them (n = 197) sustained mild or soft tissue injuries only, including bruises, abrasions and haematoma. Twenty-one (7.2%) of the fallers sustained serious injuries, including fractures and subdural haematoma.

Predictors for Falls (One or More Falls)

Female gender and advanced age were associated with a greater prevalence and incidence of falls. Advanced age and not gender was a significant risk factor in the stratified analyses for the prevalence of falls.

In Cox regression analysis for the time to first fall, adjusted for age, females had a significantly higher risk of falling than males (Relative Hazard or RR = 1.30; 95% CI RR, 1.03 to 1.64).

Besides gender and age, the following factors are predictors for at least 1 fall in univariate analyses: the Abbreviated Mental Test (AMT) score, numbers of co-morbid medical diseases and medications, poor visual acuity, arthritis, dementia, history of stroke, Parkinson's disease, hypertension, history of spinal fracture, the number of falls in the past year, the Geriatric Depression Scale Score (GDS-15), BI, Lawton's IADL score, use of walking aid, postural hypotension, right hand grip force, right and left knees' extension power, body height, failure in feet-together stand, semi-tandem stand, tandem stand, tandem walk, 5-metre walking time or gait speed and Tinetti Balance and Gait Score (Table 2). In females, the number of years after menopause and the use of dietary soy products are also predictors of at least 1 fall.

Logistic regression analyses of the clinical predictors revealed that age, dementia, Parkinson's disease, previous history of falls and self-perceived mobility problems are independent clinical predictors of falls (≥1 fall). Logistic regression analyses of the functional predictors revealed that left knee extension power, failure in tandem stand and gait speed were independent functional predictors of falls (≥1 fall). Logistic regression analyses of both the clinical and functional predictors showed that age, Parkinson's disease, previous history of falls, left knee extension power and gait speed were independent predictors of falls (≥1 fall) (Table 3).

Predictors of Recurrent Falls (2 or More Falls)

Univariate analyses showed the following risk factors for recurrent falls: being female, advanced age, low AMT score, number of co-morbid diseases and drugs, poor visual acuity, arthritis, dementia, stroke, coronary heart disease, history of falls, self-perceived mobility problems, fear of falling, low ADL and IADL scores, use of walking aid, postural hypotension, low right hand grip strength, low right knee extension power, failure to stand with feet together, failure in semi-tandem stand, failure in tandem stand, failure in tandem walk, slow gait speed, low balance score, gait score and total mobility score (TMS) (Table 4).

History of cancer, depression, Parkinson's disease, hypertension, diabetes mellitus, chronic bronchitis, hip fracture, vertebral fracture, sedative/hypnotic and hypertensive drug use were not significant predictors of recurrent falls.

Dementia was an important clinical predictor of both single and recurrent falls. Stroke was an important clinical predictor of recurrent falls while Parkinson's disease is a clinical predictor of single but not recurrent falls. Previous history of falls and self-perceived mobility problems were also strong independent clinical predictors of both single and recurrent falls.

Logistic regression analysis of the clinical predictors revealed that age, osteoarthritis (OA) knees, dementia, stroke, previous history of falls and self-perceived mobility problems are independent clinical predictors of recurrent falls (≥2 falls). Logistic regression analysis of the functional predictors revealed that left knee extension power, failure in tandem walk test and TMS in the Tinetti Balance and Gait Test were independent functional predictors of recurrent falls. Logistic regression analyses of both the clinical and functional predictors showed that previous history of falls, self-perceived mobility problems, left knee extension power, total mobility score in the Tinetti Balance and Gait Test were independent predictors of recurrent falls (Table 5).

Among the 3 groups, i.e., non-fallers, single fallers and recurrent fallers, recurrent fallers were most likely to be females and the oldest. They also had the lowest AMT score, highest number of co-morbid medical diseases, poor visual acuity, high GDS score (>8), OA of knees, hypertensive drug, dementia, stroke, Parkinson's disease, coronary heart disease, previous history of falls, walking aids, self-perceived mobility problems, fear of falling and postural hypotension. Moreover, they scored lowest in tests for physical functions, ADL, IADL, strength, balance and gait assessments (Table 6).

Discussion

Prevalence and Incidence

This was the first prospective cohort study of falls in a random population-based sample of the community-dwelling elderly in Hong Kong.[20,31] In a previously published retrospective study on falls, the prevalence rate of falls was 18%.[14] "Forgetting falls" might have caused the estimation of the true prevalence of falls.[17] In our study, subjects and caregivers were given our telephone numbers to report the occurrence of falls. In addition, we actively contacted the subjects and their caregivers every 2 months to ascertain the fall events. Diaries for recording falls were not employed in our study because over 50% of the subjects were illiterate. The prevalence of falls in the present study was 19.3%, which should reflect the true prevalence in our elderly population. The prevalence of recurrent falls was 4.75%, which was much lower than the figure of 40% in the

Table 2. Univariate Analyses of Predictors for Falls

Risk factor variable	Non-fallers (n = 1223)	Fallers (n = 293)	*P*
Age (mean ± sem) (y)	72.7 ± 0.2	75.3 ± 0.4	<0.001
Sex (female) (%)	47.1	57.7	0.001
Previous occupation (white collar work)	4.7	2.7	ns
Education (no education)	51.3	54.6	ns
Marital status (married)	60.3	52.2	0.011
AMT Score (mean ± sem)	8.94 ± 0.03 (1221)	8.69 ± 0.07 (292)	0.002
No. of active diagnoses	2.18 ± 0.04	2.61 ± 0.90	<0.001
Total no. of oral drugs	1.54 ± 0.05	2.02 ± 0.12	<0.001
Visual acuity groups (%)			<0.001
≤20/200	8.6	14.3	
20/100 to 20/50	59.9	63.5	
20/40 to 20/20	31.6	22.2	
Osteoarthritis of knees (%)	5.4	7.8	0.11
With arthritis (%)	59.3	71.3	<0.001
Cancer <5 years (%)	1.4	0.3	ns
Dementia (%)	0.1	1.4	0.006
Depression (%)	0.6	0.7	ns
Stroke (%)	5.6	9.2	0.024
Parkinson's disease (%)	0.4	2.0	0.01
Hypertension (%)	31.2	40.3	0.003
Coronary heart disease (%)	8.3	9.9	ns
Heart failure (%)	1.6	3.4	ns
Rheumatic heart disease (%)	0.1	0.3	ns
Diabetes mellitus (%)	12.4	12.3	ns
Hyperlipidaemia (%)	7.6	6.8	ns
Chronic obstructive airway diseases (%)	6.5	4.1	ns
Asthma (%)	2.7	3.8	ns
Active tuberculosis (%)	2	0	ns
History of hip fracture (%)	1.8	3.4	ns
History of hip fracture and hip operation (%)	2.3	3.4	ns
History of wrist fracture (%)	3.4	4.4	ns
History of spinal fracture (%)	0.5	1.7	0.044
History of cataract (%)	25.8	27.6	ns
Palpitation (%)	13.4	20.1	0.004
Sedative/hypnotic use (%)	3.5	3.1	ns
Hypertensive drug (%)	30.4	40.3	0.001
Parkinson's disease drug (%)	0.7	2	0.037
History of falls (in past 1 year/>1 year/both) (%)			
≤1 year	7.1	19.8	<0.001
>1 year	22.7	26.6	
Both ≤1 year and >1 year	2.9	11.6	
Self-perceived mobility problem (%)	31.3	52.9	<0.001
Fear of falling (%)	29.0	50.2	<0.001
No. of falls in past year (mean ± sem)	0.13 ± 0.01	0.48 ± 0.06	<0.001
GDS-15 score (mean ± sem)	3.31 ± 0.07	3.99 ± 0.16	<0.001
GDS >8	4.5%	5.5%	0.54
BI	19.95 ± 0.01	19.76 ± 0.07	0.007
No. of ADL impairment	0.04 ± 0.01	0.17 ± 0.04	0.003
IADL score	7.94 ± 0.01	7.75 ± 0.06	0.002
Walking aid use (%)			
Nil	92.1	78.5	<0.001
Stick	7.3	18.8	
Quadripod	0.2	1.7	
Frame	0.1	0.7	
Others	0.3	0.3	
Postural hypotension (%)	4.1	7.2	0.025
Systolic BP, supine (mean ± sem) (mm Hg)	142.1 ± 0.65	143.7 ± 1.38	ns
Diastolic BP, supine (mean ± sem) (mm Hg)	79.6 ± 0.36	79.1 ± 0.74	ns

Table 2. Univariate Analyses of Predictors for Falls (continued)

Risk factor variable	Non-fallers (n = 1223)	Fallers (n = 293)	*P*
Right handgrip kg-force (kg-f) (mean ± sem)	24.4 ± 0.25	20.9 ± 0.49	<0.001
Right knee extension power (kg-f)	3.47 ± 0.04	2.83 ± 0.09	<0.001
Left knee extension power (kg-f)	3.46 ± 0.04	2.76 ± 0.09	<0.001
Weight (kg)	57.2 ± 0.3	56.0 ± 0.6	ns
BMI (kg/m^2)	21.9 ± 0.1	22.1 ± 0.2	ns
Failure to stand with feet together (eyes open) (%)	1.0	4.4	<0.001
Failure in semi-tandem stand (%)	4.1	12.3	<0.001
Failure in tandem stand (%)	20.3	41	<0.001
Failure in tandem walk (%) (>2 errors or failed test)	30.5	52.9	<0.001
5 m walking time (s)	7.12 ± 0.16	10.33 ± 0.88	<0.001
Gait speed (m/s)	0.796 ± 0.006	0.674 ± 0.001	<0.001
Tinetti Balance Score	15.46 ± 0.05	14.28 ± 0.193	<0.001
Gait Score	11.55 ± 0.04	10.67 ± 0.14	<0.001
Total Mobility Score	27.01 ± 0.08	24.92 ± 0.33	<0.001

ADL: Activities of Daily Living; AMT: Abbreviated Mental Test; BI: Barthel Index for ADL; BP: blood pressure; GDS: Geriatric Depression Scale; IADL: Instrumental Activities of Daily Living; ns: not significant

previous retrospective study on falls in Hong Kong older adults. Recall bias in the retrospective study is a possible reason for the large discrepancy.

There was no previous published study on the incidence of falls in a population-based sample of community-dwelling Chinese older adults in Hong Kong, Mainland China and Taiwan. The present study has provided the first set of incidence data on falls related to the Chinese elderly. The incidence of falls was 270 per 1000 person-years. The incidence was higher in females than males and increased with age.

Compared to overseas reports, the incidence of falls in Hong Kong appeared to be lower than those published in Western studies (Table 7). However, age was an important risk factor for falls. The incidences of falls in overseas studies were also reported to increase with age. In any comparison with overseas studies, the age of the subjects has to be considered. All our subjects were 65 years old or older. The mean age was 72.2 years. Overall, the incidence of falls in the Hong Kong elderly is comparable to those reported in Western studies in a similar age group. For example, Gabell et al[1] and Lach et al[9] reported the incidences of falls as 224 and 300 per 1000 person-years, respectively.

For the oldest subgroup, the incidence of falls in the old-old age group (i.e., ≥75 years) in Hong Kong was much lower than those published in Western studies (Table 7). In the present study, the incidences of falls for those in the age groups of 75-79, 80-84 and ≥85 years were 363, 387 and 468 per 1000 person-years, respectively. Campbell et al,[8] Perry[10] and Tinetti et al[11] had reported the incidences of falls in their studies as 682, 625 and 809 per 1000 person-years, respectively, in similarly populations. Thus, the incidence of falls in the old-old age group in Hong Kong was only 40% to 50% of the incidences reported in Western studies on community-dwelling old-old populations.

Table 3. Logistic Regression Analyses of Predictors for Falls (1 or more falls) (n = 1516, 1 missing)

Predictor	Relative Risk (RR)	95% CI RR	*P*
Clinical predictor			
Age	1.05	1.03, 1.07	<0.001
Dementia	10.1	1.1, 96.2	0.044
Parkinson's disease	4.61	1.34, 15.8	0.015
Previous history of falls in past one year ± over 1 year	3.43	2.48, 4.74	<0.001
Self-perceived mobility problem	1.75	1.32, 2.32	<0.001
Functional and performance-based predictor			
Left knee extension power (kg-force)	0.84	0.76, 0.94	0.001
Failure in tandem stand	1.61	1.17, 2.23	0.004
Gait speed (m/s)	0.23	0.11,0.50	<0.001
Clinical and functional predictor			
Left knee extension power (kg-force)	0.88	0.79, 0.97	0.013
Gait speed	0.25	0.12, 0.53	<0.001
Age	1.03	1.01, 1.06	0.004
Parkinson's disease	3.58	1.03, 12.47	0.045
Previous history of falls in past 1 year ± over 1 year	3.35	2.43, 4.63	<0.001

CI: confidence interval; Interaction terms are all not significant.

Locations of fall were also different. Falls occurred more commonly in outdoors (53.4%) than indoors (46.6%) settings in the community-dwelling Chinese elderly in our study while falls occurred more commonly in indoors settings (up to 77%) in Caucasian studies.[7,11,16]

Table 4. Univariate Analyses: Predictors for Recurrent Falls (2 or more falls)

Predictor variable	Non-fallers and single fallers (non-recurrent) (n = 1444) (mean ± sem)	Recurrent fallers (n = 72) (mean ± sem)	*P*
Age (y)	73.0 ± 0.2	75.8 ± 0.07	<0.001
Sex (female) (%)	48.3	65.3	0.005
AMT Score	8.91 ± 0.03 (1441)	8.51 ± 0.17	0.022
No. of active diagnoses	2.23 ± 0.04	3.01 ± 0.19	<0.001
Total no. of oral drugs		2.31 ± 0.26	0.011
Visual acuity (%)			0.001
≤20/200	9.3	16.7	
20/100 to 20/50	60.0	72.2	
20/40 to 20/20	30.7	11.1	
Osteoarthritis of knees (%)	5.6	11.1	0.08
Dementia (%)	0.2	2.8	0.02
Depression (%)	0.6	0	ns
Stroke (%)	5.7	18.1	<0.001
Parkinson's disease (%)	0.6	2.8	ns
CHD (%)	8.2	18.1	0.004
History of hip fracture (%)	1.9	5.6	ns
Sedation/hypnotic use (%)	3.5	2.8	ns
Hypertensive drug (%)	32.1	37.5	ns
No. of falls over past year	0.17 ± 0.01	0.71 ± 0.16	0.001
Self perceived mobility problem (%)	33.9	68.1	<0.001
Fear of falling (%)	31.6	63.9	<0.001
GDS-15 score	3.38 ± 0.01	4.85 ± 0.35	<0.001
BI	19.94 ± 0.01	19.43 ± 0.24	0.041
IADL	7.92 ± 0.01	7.46 ± 0.18	0.013
Walking aid use (%)	9.2	37.5	<0.001
Postural hypotension (%)	4.3	12.5	0.005
Systolic BP, supine (mm Hg)	142 ± 1	151 ± 3	0.002
Diastolic BP, supine (mm Hg)	79 ± 0	82 ± 2	0.046
Left calf circumference (cm)	33.7 ± 0.1	32.9 ± 0.3	ns
Left arm circumference (cm)	26.2 ± 0.1	25.9 ± 0.3	ns
Right hand grip (kg-f)	23.9 ± 0.2	19.2 ± 1.0	<0.001
Right knee extension power (kg-f)	3.40 ± 0.03	2.32 ± 0.18	<0.001
Left knee extension power (kg-f)	3.38 ± 0.04	2.19 ± 0.20	<0.001
Weight (kg)	57.1 ± 0.3	54.9 ± 1.2	ns
Height (cm)	157.1 ± 0.2	154.3 ± 1.1	ns
BMI (kg/m^2)	23.1 ± 0.1	23.0 ± 0.4	ns
Failure to stand with feet together (%) (eyes open)	12	11.1	<0.001
Failure in semi-tandem stand (%)	4.9	20.8	<0.001
Failure in tandem stand (%)	22.9	52.8	<0.001
Failure in tandem walk (%)	26.0	62.5	<0.001
5 m walk time (s)	7.39 ± 0.16	14.86 ± 3.15	0.02
Gait speed (m/s)	0.781 ± 0.005	0.601 ± 0.003	<0.001
Tinetti Balance and Gait Evaluation			
Balance Score	15.35 ± 0.05	12.97 ± 0.49	<0.001
Gait Score	11.46 ± 0.03	9.82 ± 0.37	<0.001
Total Mobility Score	26.80 ± 0.09	22.76 ± 0.84	<0.001

AMT: Abbreviated Mental Test; BI: Barthel Index; CHD: coronary heart disease; GDS: Geriatric Depression Scale; IADL: Instrumental Activities of Daily Living

Predictors of Recurrent Falls (2 or more Falls)

Clinical and Functional Risk Factors: Clinical risk factors included being of female gender, advanced age, low AMT score, number of co-morbid diseases and drugs, poor visual acuity, arthritis, dementia, stroke, coronary heart disease, postural hypotension, history of falls, self-perceived mobility problem and fear of falling. Functional and performance-based risk factors included the use of walking aid, low BI (ADL) and IADL score, low right hand grip strength, low right knee extension power, failure in the

Table 5. Logistic Regression Analyses of Predictors for Recurrent Falls (n = 1516)

Variable	Relative Risk (RR)	95% CI RR	*P*
Clinical predictor only			
Age	1.04	1.002, 1.079	0.041
Osteoarthritis of knees	2.30	1.03, 5.13	0.043
Dementia	8.13	1.07, 61.77	0.043
Stroke	2.59	1.30, 5.16	0.007
Previous history of falls (past year ± over 1 year)	3.35	1.99, 5.63	<0.001
Self-perceived mobility problem	2.66	1.54, 4.57	<0.001
Functional predictor only			
Left knee extension power (kg-force)	0.75	0.62, 0.90	0.002
Failed tandem walk test (>2 errors or failed)	1.94	1.05, 3.56	0.034
Total Mobility Score in Tinetti Balance and Gait Test	0.92	0.88, 0.97	<0.001
Clinical and functional predictor			
Previous history of falls (past year ± over 1 year)	3.04	1.80, 5.14	<0.001
Self-perceived mobility problem	1.82	1.01, 3.30	0.047
Left knee extension power (kg-force)	0.75	0.63, 0.90	0.002
Total Mobility Score (Tinetti Balance and Gait Test)	0.93	0.89, 0.97	0.002

CI: confidence interval

feet-together stand test, semi-tandem stand test, tandem stand test and tandem walk test, slow gait speed, low balance, gait and total mobility scores.

Independent Clinical Predictors of Recurrent Falls: Many of these clinical factors were strongly correlated. Multivariate logistic regression analysis for clinical predictors showed that age, OA of knees, dementia, stroke, previous history of falls and self-perceived mobility problem were independent clinical predictors for recurrent falls. Advanced age was an independent predictor of recurrent falls. Dementia was an important clinical predictor of both single and recurrent falls. Stroke was an important clinical predictor of recurrent falls while Parkinson's disease is a clinical predictor of falls but not recurrent falls. Previous history of falls and self-perceived mobility problems were also strong independent clinical predictors of both single and recurrent falls. Visual acuity impairments did not increase the risks of falls and recurrent falls significantly in logistic regression analyses.

Fall Assessment – Clinical Factors: Therefore, in any clinical assessment for fall prevention, questions on the history of previous falls, self-perceived mobility problem, dementia, history of stroke (i.e., can predict recurrent falls) and history of Parkinson's disease (i.e., to predict falls) must be included. Similar findings have been reported. In the retrospective study reported by Ho et al,[14] self-perceived health was an independent risk factor for falls. There is some degree of overlap in the meanings of the 2 terms "self-perceived mobility problem" and "self-perceived health", particularly for older adults.

Independent Functional Predictors of Recurrent Falls: Independent functional predictors of recurrent falls were left knee extension power, failure in the tandem walk test and low total mobility score in the Tinetti Balance and Gait Evaluation. Hand grip strength was insignificant. This showed that lower limb power was more important than that of the upper limb (i.e., hand grip strength) in predicting recurrent falls. Of all the balance and gait tests employed in the present study, the tandem walk test and the total mobility score outperformed other tests in predicting recurrent falls. The total mobility score combined balance and gait assessments into 1 summary score, which could reflect the subject's overall balance and gait function. This score had also been shown to be a good test to discriminate fallers from non-fallers (i.e., area under the curve or AUC = 0.72) in another retrospective study in the Queen Mary Hospital.[32]

Among the 3 groups of non-fallers, single fallers and recurrent fallers, recurrent fallers were most likely to be female and the oldest. Advanced age and female gender were risk factors for falls in our present study as well as most Western studies.[1-13] They also had the lowest AMT score, highest number of co-morbid medical diseases, highest proportions of high GDS score (>8), OA of knees, use of hypertensive therapy, dementia, stroke, Parkinson's disease, coronary heart disease, previous history of falls, use of walking aids, self-perceived mobility problem, fear of falling and postural hypotension. Moreover, they scored lowest in tests for physical functions, ADL, IADL, strength, balance and gait assessments (Table 6).

Functional Predictors Stronger than Clinical Predictors

Compared with clinical predictors, the functional predictors were stronger in predicting both falls and recurrent falls. Hence, direct assessments of lower limb muscle power and balance and gait functions (e.g., tandem stand and tandem walk tests, Tinetti Balance and Gait Evaluation, gait speed) were very important tools in predicting future falls in the elderly.

Prediction of the Future Risk of Falling: The risk of falling in the community-dwelling elderly can be conceived as a 3-stage concept. The presence of clinical factors (e.g., stroke, Parkinson's disease, postural hypotension, history of previous falls, self-perceived mobility problem) would

Table 6. Univariate Analyses of Risk Factors for Single and Recurrent Falls

Variables	Non fallers (n = 1223)	Single fallers (n = 221)	Recurrent fallers (≥2 falls) (n = 72)	*P*	*P* sub-groups a. 0 vs 1 b. 0 vs 2+
Sex (female) (%)	47.1	55.2	65.3	0.002*	–
Age (mean ± sem) (y)	72.7 ± 0.2	75.2 ± 0.5	75.8 ± 0.7	<0.001	a. <0.001; b. <0.001
AMT score	8.94 ± 0.03 (1221)	8.75 ± 0.08 (220)	8.51 ± 0.17 (72)	0.001	a. ns; b. 0.006
GDS >8 (%)	4.5	3.2	12.5	0.016*	
No. of active diagnoses	2.18 ± 0.04	2.48 ± 0.10	3.01 ± 0.19	<0.001	a. 0.027; b. <0.001
Total no. of co-morbid diseases	2.77 ± 0.05	3.11 ± 0.13	3.86 ± 0.22	<0.001	a. 0.031; b. <0.001
Total number of oral drugs (mean ± sem)	1.54 ± 0.06	1.93 ± 0.13	2.31 ± 0.26	<0.001	a. 0.027; b. 0.005
Sedative/hypnotic use (%)	3.5	3.2	2.8	ns*	
Hypertensive drug (%)	30.4	41.2	37.5	0.004*	
Osteoarthritis of knees (%)	5.4	6.8	11.1	0.16 (ns)	
Dementia (%)	0.1	0.9	2.8	0.007*	
Depression (%)	0.6	0.9	0	ns*	
Stroke (%)	5.6	6.3	18.1	0.002*	
Parkinson's disease (%)	0.4	1.8	2.8	0.03*	
Hypertension (%)	31.2	41.2	37.5	0.011*	
Coronary heart disease (%)	8.3	7.2	18.1	0.012*	
Palpitation (%)	13.4	20.4	19.4	0.014*	
Parkinson's disease drug use (%)	0.7	1.8	2.8	ns*	
History of falls in: (%)					
≤1 year	7.1	18.6	23.6	<0.001*	
>1 year	22.7	25.3	30.6		
both ≤1 year and >1 year	2.9	10.0	16.7		
Self-perceived mobility problem (%)	31.3	48.0	68.1	<0.001*	
Fear of falling	29.0	45.7	63.9	<0.001*	
Postural hypotension (%)	4.1	5.4	12.5	0.004*	
BI	19.95 ± 0.01	19.87 ± 0.04	19.43 ± 0.24	<0.001	a. ns; b. <0.001
IADL Score	7.94 ± 0.01	7.84 ± 0.05	7.46 ± 0.18	<0.001	a. ns; b. <0.001
Walking aid (%)	7.9	16.3	37.5	<0.001	a. ns; b. <0.001
Right hand grip (kg-force) (mean ± sem)	24.35 ± 0.25	21.45 ± 0.56	19.23 ± 0.96	<0.001	a. <0.001; b. <0.001
Right knee extension power (kg-force)	3.47 ± 0.04	3.01 ± 0.10	2.33 ± 0.18	<0.001	a. <0.001; b. <0.001
Left knee extension power (kg-force)	3.46 ± 0.04	2.94 ± 0.10	2.19 ± 0.20	<0.001	a. <0.001; b. <0.001
Visual acuity groups (%)					
≤20/200	8.6	13.6	16.7	<0.001*	
20/100 to 20/50	59.9	60.6	72.2		
20/40 to 20/20	31.6	25.8	11.1		
Failure in feet-together stand (%)	1.0	2.3	11.1	<0.001	
Failure in semi-tandem stand (%)	4.1	9.5	20.8	<0.001	
Failure in tandem stand (%)	20.3	37.1	52.8	<0.001	
Failure in tandem walk (or >2 errors) (%)	30.5	48.0	68.1	<0.001	
5 m walking time (s)	7.12 ± 0.16	8.85 ± 0.53	14.86 ± 3.15	<0.001	a. 0.011; b. <0.001
Gait speed (m/s)	0.80 ± 0.06	0.70 ± 0.02	0.61 ± 0.03	<0.001	a. <0.001; b. <0.001
Balance Score	15.51 ± 0.1	14.7 ± 0.2	13.0 ± 0.5	<0.001	a. <0.001; b. <0.001
Gait Score	11.6 ± 0.0	11.0 ± 0.1	9.8 ± 0.4	<0.001	a. <0.001; b. <0.001
Total Mobility Score	27.0 ± 0.1	25.6 ± 0.3	22.8 ± 0.8	<0.001	a. <0.001; b. <0.001

AMT: Abbreviated Mental Test; BI: Barthel Index; GDS: Geriatric Depression Scale; IADL: Instrumental Activities of Daily Living
*χ^2 statistics; other variables by ANOVA with Post Hoc comparison (Bonferroni)

lead to either weakness of the lower limbs, balance and/or gait impairment. For recurrent falls, a history of previous falls would increase the risk of future falls by 3 times. When taking an elderly person's medical history, these factors should alert healthcare professionals to the need for fall prevention. It is also a good way to detect early impairment. Direct assessment of lower limb power and performance in balance and gait tests should be done. The balance and gait functions would vary according to the severity and extent of the clinical factors. These performance-based functional

Table 7. Comparison with Previous Studies on the Incidences of Falls and Fallers

Country	Study design	Community-based surveys Incidence per 1000 person-years		Authors
		Incidence of falls (fall events)	Incidence of fallers (persons with falls)	
United Kingdom	R	224	153	Gabell A et al[1]
	R	677	na	Graham HJ et al[2]
	R	na	424	Downton JH et al[3]
	P	na	280	Vetter NJ et al[4]
	R	na	342	Blake AJ et al[5]
	P	668	203	Gryfe CI et al[6]
Finland	P	368 in men 611 in women	300	Luukinen H et al[7]
New Zealand	P	682	361	Campbell AJ et al[8]
United States	P	300	190	Lach HW et al[9]
	R	625	375	Perry BC et al[10]
	P	809	321	Tinetti ME et al[11]
	R	na	279	Robbins AS et al[12]
	P	na	217	Teno J et al[13]
Hong Kong	R	316	180	Ho SC et al[14] (prevalence = 18%)
	P	270 (all)	198	Present study (n = 1517; prospective 1 year follow-up)
	Age (y)			
	65-69	167	132	
	70-74	248	173	
	75-79	363	254	
	80-84	387	285	
	≥85	468	351	

na: data not available for calculation; P: prospective study; R: retrospective study

Table 8. Comparison of the Sex and Age Distribution of the Present Study Sample with the Elderly Population (65+) in the 2001 Hong Kong Population Census

	Men		Women		Total	
Age (y)	2001 HK elderly population (%)	Present study (%)	2001 HK elderly population (%)	Present study (%)	2001 HK elderly population % (n)	Present study % (n)
65-69	17.0	19.9	16.2	14.0	33.2 (250,300)	33.9 (514)
70-74	13.6	15.2	14.3	13.8	27.9 (210,400)	29.1 (441)
75-79	8.5	9.2	10.7	10.0	19.2 (14,100)	19.2 (291)
80-84	4.5	4.6	6.9	7.8	11.4 (86,200)	12.5 (189)
85+	2.6	1.8	5.7	3.6	8.3 (62,600)	5.4 (82)
Total, % (n)	46.2 (348,300)	50.8 (771)	53.8 (405,300)	49.2 (746)	100 (753,600)	100 (1517)

assessment measures were potent predictors of falls and recurrent falls in this study. Similarly, we had previously reported that lower limb power and tandem walk test performance were independent risk factors for falls in the hospital.[18] Rehabilitation training to improve lower limb strength as well as balance and gait functions would be beneficial in decreasing the risk of falling in any fall-prone elderly person.[30,33-37]

Medication

The number of drugs was a risk factor for falls and recurrent falls. However, this was not an independent clinical predictor in the multivariate logistic regression models. Previous studies had shown that psychoactive drugs (e.g., sedatives, hypnotics, antidepressants) were risk factors for falls.[38-40] In our previous study on falls in the hospital, the use of psychoactive drugs was a significant

risk factor for falls.[18] To our surprise, the use of psychoactive drugs was not a significant risk factor for falls and recurrent falls in the present study. This might be a false negative finding and was probably related to the overall low prevalence of psychoactive drug use in the present study.

Limitations of the Study

This was a randomly sampled, population-based study on Chinese older adults. We compared our sample's sex-age structure with the Hong Kong elderly population in 2001. Our sample had a fairly similar sex and age distribution with only mild over-representation of males and under-representation of the very old population aged 85 years and over (Table 8).[31]

Conclusion

In the present random sample prospective cohort study in Hong Kong older adults, the prevalence and incidence of falls were found to be 19.3% per year and 270 per 1000 person-years, respectively. Recurrent falls occurred in 4.75% of Chinese older adults every year. Falls were more common in females than males and in the old-old than the young-old. The independent predictors of falls were previous history of falls, advanced age, Parkinson's disease, knee extension power and gait speed. The independent predictors of recurrent falls are previous history of falls, self-perceived mobility problem, the knee extension strength and the Total Mobility Score of the Tinetti Balance and Gait Evaluation. Effective fall prevention programmes targeted at improving these risk factors should be developed for the Chinese elderly in Hong Kong and Asia.

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