"Fall Risk Index" Helps Clinicians Identify High-risk Individuals

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Abstract

Introduction Hip fractures are the third most important medical condition among bed-ridden patients in Japan. More than 80% of hip fractures are caused by falls; however, there is no simple screening test for falls for the community-dwelling elderly. Thus the aim of this study was to develop a portable risk index for falls.

Methods Risk factors were chosen from previously established factors and several environmental factors were then added to the risk index.

Subjects The questionnaire sheet was completed by 2,439 community-dwelling elderly subjects (aged 76.3±7.4). The frequency of each item in the Fall Risk Index for fallers (history of falls within one year) and non-fallers was compared. Multiple regression analysis was performed to identify independent risk factors for future falls of 1,378 subjects for whom falls were longitudinally recorded.

Results Except for "barrier," "step use," and "steep slope around home," all items in the Fall Risk Index were more frequent for fallers.

Multivariate analysis revealed that "history of falls," "decrease in walking speed," "cane use," "bent back," and "prescribed more than 4 medications" were independent risk factors for falls.

These 5 selected items were weighted using odds ratios and further analyzed as predictors. The maximum sum of sensitivity and specificity was reached at the cut-off point of 6/7 (sensitivity 0.67, specificity 0.71) on the receiver operating curve.

Conclusion The portable Fall Risk Index is useful in clinical settings for identifying high-risk individuals.

Key words Falls, Community-dwelling people, Intrinsic factors, Environment, Fall index

Introduction

Falls and fractures are the third leading cause of a bedridden state in aged individuals. Over 90% of femoral neck fractures, the most serious form of osteoporotic fractures, are caused by falling.[1] Repeated episodes of falls, even if not complicated with fracture, lower the patient's motivation and ability to perform activities of daily living (ADL).[2] As an ADL-dependent risk factor among community-dwelling individuals, falls are associated with a two-fold risk of being bedridden.[2] Fall prevention is essential to the prevention of bedridden condition.

Fall risk factors have been analyzed in cross-sectional and longitudinal studies targeted at specific fields. Although these studies identified some common risk factors such as physical weakness and lowered walking function, the results concerning dizziness, dementia (cognitive impairment), and other potential risk factors have been inconsistent.[2] Falling is understood as a complex syndrome resulting endogenously from physical

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Table 1 Fall risk factors and assessment techniques classified by the ease of assessment

Questionnaires and other simple methods
• Decrease in Tokyo Metropolitan Institute of Gerontology Index of Competence (13 items covering instrumental ADL, intellectual activeness, and social roles)
• Past history of falls
• Environmental factors: Poor lighting, barriers, level differences, inappropriate footwear, etc. (involving difficulty in quantification)
Special tests requiring special equipment, assessment personnel, interviews and examination by physicians, etc.
• Gait/motor system (arthropathy, sarcopenia, etc.)
Reduced gait speed: timed up & go test, 10-m walking time
Poor balance: one-leg standing test, tandem gait (tandem foot position), stabilometry/gravicoder
Reduced leg muscle power: step test, grip power (a surrogate measure), DXA (muscle mass)
General gait abnormality: gait examination, 3-dimensional gait analyzer
• Cardiovascular disorders (arrhythmia, orthostatic hypotension, etc.): ECG, autonomic nerve tests
• Nervous system disorders (dementia, parkinsonism, etc.): Neurological examination
• Medications (sedatives, hypnotics, antiallergic drugs, antihypotensive drugs, etc.): Medication compliance check

(Quoted from Toba K. Journal of Joint Surgery. 2006;25:720–724.)

Table 2 The Fall Risk Index

Question item	Percentage of positive answers (%)			Significance (*P*)
	Total	Non-fallers	Fallers	
1) The number of persons with the history of falls in the past 12 months: 708 in 2,395 responding participants (4.7±1.0 episodes/year)	29.6			
2) I stumble sometimes.	56.5	45.3	83.3	<0.0001
3) I cannot go up and down stairs without holding on handrails.	50.6	40.5	63.8	<0.0001
4) My walking speed has become slower.	65.2	59.2	79.6	<0.0001
5) I cannot cross a road while the traffic light is green.	17.05	12.7	27.5	<0.0001
6) I cannot walk 1 km at a time.	35.8	30.5	48.5	<0.0001
7) I cannot stand on one foot for 5 seconds.	38.6	32.5	53.2	<0.0001
8) I use a cane.	28.3	22.0	43.7	<0.0001
9) I cannot squeeze a towel tightly.	16.8	12.2	28.2	<0.0001
10) I have dizziness or staggering.	32.4	24.7	50.6	<0.0001
11) My back has become bended.	44.9	40.3	55.8	<0.0001
12) I have pain in the knees.	47.3	41.1	62.3	<0.0001
13) I have difficulty in vision.	53.1	48.4	64.3	<0.0001
14) I have difficulty in hearing.	42.5	39.1	50.7	<0.0001
15) I am troubled with forgetfulness.	63.7	59.4	74.0	<0.0001
16) I fear about falling.	45.8	37.0	64.8	<0.0001
17) I take 5 or more different medicines every day.	31.2	27.2	40.8	<0.0001
18) I feel my sight is dim while walking in the house.	11.4	8.5	18.3	<0.0001
19) There is a barrier (walking hazard) in the hallway, living room, or entrance.	20.8	17.1	29.6	<0.0001
20) There are some level differences in the house.	69.1	68.9	69.5	0.79 (ns)
21) I have to use stairs.	27.7	27.5	28.2	0.74 (ns)
22) I walk on a steep slope near my house in daily life.	33.3	33.6	32.5	0.60 (ns)

(Quoted from Toba K, et al. Journal of the Japan Geriatrics Society. 2005;42:346–352.)

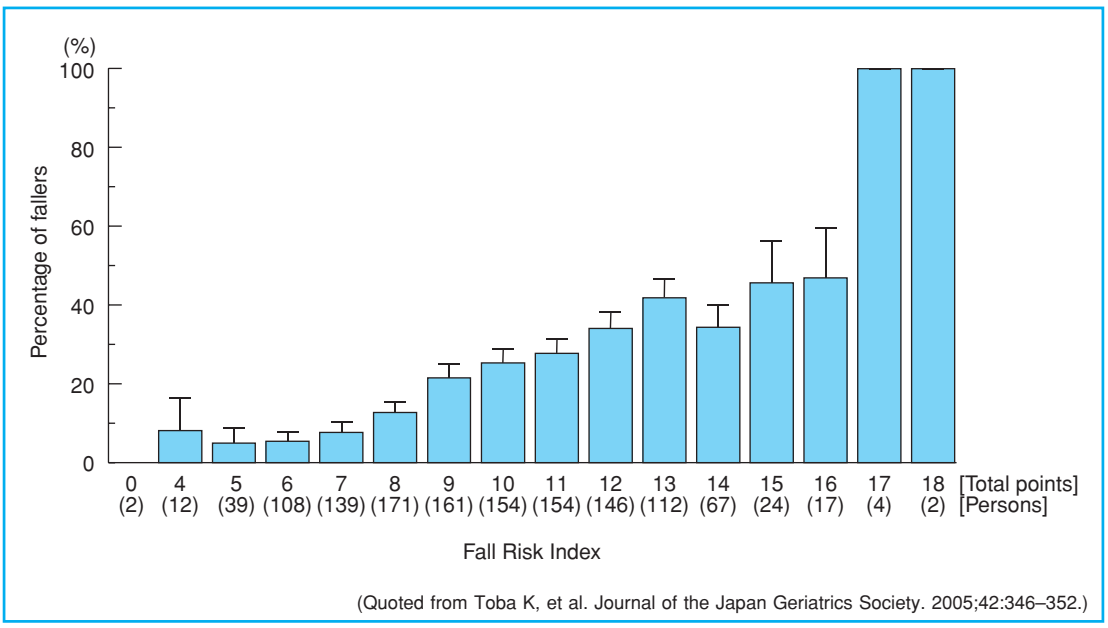

Fig. 1 Total points of positive answers to 21 items in the Fall Risk Index (out of 21 points) and percentage of fallers (past 12 months)

factors and exogenously from environmental factors. The latter may vary greatly depending on geographical region, culture, lifestyle, etc.

There are various means for assessing fall risk factors, including medical history taking, evaluation of present illness, blood tests, ADL ability tests, and other simple examinations, as well as measurements performed by specially trained examiners and investigations using special equipment; however, these have been performed in an unsystematic manner without sufficient consideration of the usefulness in general health checkups (Table 1). This article, based on the reviews in Japanese and international literature, describes the Fall Risk Index, which is a portable fall risk prediction table developed by the Working Group on the Development of Method for Early Detection of High Fall Risk Individuals, and discusses its validity and effectiveness.

Background and Methodology of Development of the Fall Risk Index

The development of the Fall Risk Index dates back to a joint discussion held by the Fall and Fracture Group under the Clinical Research Project to Establish and Promote Effective Medical Techniques, a Scientific Research Grant Program of the Ministry of Health, Labour and Welfare in Fiscal 2002,[1,3] where the group identified lowered muscle power, poor balance, gait impairment, visual impairment, locomotion impairment, cognitive impairment, ADL impairment, orthostatic hypotension, aging, past history of falls, chronic disease, medication use, and level differences as the essential factors contributing to falls. A questionnaire sheet for assessing these items was developed through repeated discussion, ensuring that patients would accurately understand questions by simply reading the questionnaire and that the meaning of each factor would not be altered or obscured (Table 2). The questionnaire has undergone basic performance assessments including reproducibility of repeated measurements and seasonal variations, and satisfactory results have been reported.[3]

Assessment of the Fall Risk Index in Japan and Analysis of Sub-items

We surveyed 2,439 community-dwelling individuals (932 males and 1,507 females, aged 76.3 ±7.4) of 7 regions in Japan from April 2004 to March 2005. After receiving an explanation of

Table 3 Portable "Fall Risk Check Sheet"

Please check the items that apply to you.	
☐ I experienced falls in the past 12 months.	5 points
☐ My back has become bended.	2 points
☐ My walking speed has become slower.	2 points
☐ I use a cane.	2 points
☐ I take 5 or more different medicines every day.	2 points
Total ____ points	

A total score of 7 points or more is a warning sign.

(Quoted from Toba K, et al. Journal of the Japan Geriatrics Society. 2005;42:346–352.)

the questionnaire and giving consent to participate in the study, the participants filled in the questionnaire. In the case of those who were unable to write, researchers heard and recorded their answers.

To analyze the results, we performed (1) a multivariate analysis in which the dependent variable was the history of falls in the past 12 months, and (2) a multivariate analysis in which the dependent variable was the history of falls in the observation period and the independent variables were the question items including the history of falls in the past 12 months. Age and gender were put into the analysis as mandatory data.

A P-value less than 0.05 was considered statistically significant. Items with $P<0.1$ were also noted as showing a tendency toward significance.

Principal Results

The frequency of Positive Answers to Respective Items: The number of persons with a history of falls in the past 12 months was 708 (229 males and 479 females; mean age 77.5 ± 7.4), the percentage of the fallers was 29.6%, and the percentage of those who experienced falls during the observation period was 25%. Fracture occurred in 1.8%. Table 2 lists the question items and the "frequency of positive answers" for fallers (past 12 months) and non-fallers, based on which we identified the sub-items associated with a risk.

Figure 1 shows the percentage of fallers in relation to the total points of positive answers in items 2 through 22. It shows that the percentage of fallers increases with the point.

The 1,378 cases we could assess falls in the observation period were subjected to a logistic regression analysis in which the dependent variable was the falls in the observation period, and the magnitude of fall risk (odds ratio) was calculated for each sub-item identified as an independent risk factor.[4]

The significant independent risk factors identified in this analysis were the history of falls in the past 12 months ($P<0.0001$), decrease in walking speed ($P=0.04$), use of a cane ($P=0.02$), bent back ($P=0.02$), and use of 5 or more types of medications ($P=0.03$). The odds ratio from the logistic regression analysis was the highest with falls in the past 12 months (OR 4.5), followed by decrease in walking speed (1.9), use of a cane (1.8), bent back (1.8), and use of 5 or more types of medications (1.7).

Using these items, we produced a portable Fall Risk Check Sheet, in which each item was weighted with the odds ratio, and rounded to a whole number (Table 3). By examining the predictive validity of falls during the observation period based on the total points, we obtained a practically acceptable performance with the sensitivity of 68% and the specificity of 71% when the cutoff point was set between 6 and 7.

Discussion

Fall is a multiple risk factor syndrome involving several intrinsic and extrinsic factors.[1]

Rubinstein conducted a review of large-scale studies on falls, and found that lowered muscle power, poor balancing, gait impairment, locomotion impairment, and ADL impairment were the common risk factors shared by almost all studies, while visual impairment and cognitive impairment were not significant as risk factors in one-half of the studies, and orthostatic hypotension

was significant only in 2 of the 7 studies.[5] As suggested by this finding, the weight of each risk factor may vary among different populations even in the case of intrinsic factors, which are considered to involve relatively race and geographic variations.

The development of fall risk assessment tables has been conducted mainly at nursing care institutions[6] and hospitals.[7–9] In such endeavors, history of falls, cognitive function, sensory function, mobility and gait function, medication use, dizziness on standing up, and chronic disease have been identified as risk factors. However, despite the fact that a great majority of falls take place in homes and more than a half occur in living rooms and other indoor spaces, there have been few attempts at standardizing risk factors related to extrinsic factors. While many studies have been conducted to identify fall risk factors in communities,[10–14] most functional assessments have been performed by specially trained persons, as no questionnaires have been sufficiently effective in such assessment. In addition, there have been no studies that objectively compared intrinsic and extrinsic factors and examined their importance as fall risk factors, and there are no risk factor assessment tables available for convenient in communities covering extrinsic factors. The intrinsic factors used in our Fall Risk Index were selected based on past results[1,2,4] and the findings of the Fall Risk Assessment Table Working Group. The extrinsic factors were selected focusing on extrinsic factors related to lowered muscle power, poor balancing, gait impairment, locomotion impairment, and ADL impairment. In addition, we also listed sub-items including barriers, level differences, stairs, slopes, and other factors from the standpoint of barrier-free environment. In relation to visual impairment, we also added the dimness of vision in the room.

In the comparison between fallers and non-fallers, almost all items in the Fall Risk Index showed significant differences, whereas no significant differences were found regarding level differences, stairs, and slopes. This result for the first time demonstrated the wrongness of over-simplification equating fall prevention with a barrier-free environment.

The percentage of fallers increased with the total points of positive answers. To assess the practical value of this index, Matsubayashi, et al. compared this index with other assessment methods in a Town, Hokkaido. When falls were used as the dependent variable, the cutoff level predicting a fall risk was 10 points or more in the Fall Risk Index, and both sensitivity and specificity exceeded 70%. Their results also showed that our method was superior to conventional methods including timed up & go test, gait speed, and functional reach in terms of the sensitivity and specificity of fall prediction [Kozo Matsubayashi: Report of "Longitudinal Study Concerning Persistent Improvement of ADL Function through Development of Efficient Fall Prediction Technique and Intervention for Fall Prevention," a Comprehensive Research Project in Longevity Science under the Ministry of Health, Labour and Welfare Scientific Research Grant in Fiscal 2006 (Chief Researcher: Kenji Toba)]. Kikuchi, et al., at their clinic for memory disorders, compared our Fall Risk Index with one-leg standing, tandem gait, timed up & go test, functional reach, grasp power, and other methods, and showed that only the Fall Risk Index provided an independent risk prediction factor in the multivariate analysis (submitted for publication).

The sub-items of the Fall Risk Index identified by the multivariate analysis in this study were lowered muscle power (decrease in gait speed), osteoporosis (kyphosis), lowered muscle power plus osteoporosis plus anxiety about falling (use of a cane), and multiple diseases (use of 5 or more types of medications). Other fall risk factors that are not included in the above are considered to have been subsumed in the past history of falls.

An important finding in this study is that physical weakness and multiple diseases (intrinsic factors) are more important contributors to falls than environmental factors among community-dwelling individuals. Finding ways to reduce medication use as a fall risk factor is an important challenge for physicians from the standpoint of "patient safety."

Conclusion

In the practice of fall prevention programs, the conventional method to identify high-risk individuals combining questionnaires concerning environmental factors and leg muscle power tests (gait speed, one-leg standing time, etc.) is time-consuming. Our study suggests that a more portable and useful method would be to conduct sufficient history taking about past falls and to

make use of the Fall Risk Index to obtain information regarding the physical aspects (osteoporosis and lowered muscle power).

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