

Determination of Persons at a High Risk of Falling in a Population of Healthy Community-Dwelling Elderly Japanese

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1 Original Article

2 **Title:**

3 Determination of fall risk factors to screen high fall risk in the elderly among the
4 healthy community-dwelling Japanese population

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1 **Abstract**

2 **Background:** The problem of falling in the elderly is an important social issue. This
3 study aimed to determine useful risk factors for screening high fall risk in the elderly.

4 **Methods:** Participants included 965 healthy elderly individuals aged 60 years and over
5 (349 males and 616 females, mean age: 70.1 ± 7.1 yr). We assessed fall risk in the
6 elderly by using Demura's fall risk assessment scale (DFRA) which is composed of
7 previous fall experience and 50 other fall risk assessment items representing the five
8 risk factors regarding the "potential for falling," "physical function," "disease and
9 physical symptoms," "environment," and "behavior and character" (Demura et al.,
10 2010). Receiver-operating characteristics analysis was conducted using previous fall
11 experience (faller or non-faller) as a dependent variable and using each fall risk factor
12 score in the DFRA as an independent variable. **Results:** The potential for falling were
13 obtained in the highest area under the ROC curve (AUC) (AUC=.80, sensitivity=.87,
14 and specificity=.75). However, it was difficult to screen high fall risk in the elderly by
15 using other fall risk factor scores. **Conclusions:** These results suggest that the
16 potential for falling are a useful risk factor to screen high fall risk in the elderly.

17

18 **Keywords:** ROC analysis, cross-sectional study, prevention of falls, risk assessment

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20

1 Introduction

2 In an aging society, the problem of falling in the elderly is an important social
3 issue.¹⁾ As a result, researchers have closely examined fall risk assessment for the
4 prevention falls in the elderly. Several performance tests or questionnaires have been
5 reported, and cut-off values to predict falling in the future (or previous falls) have been
6 proposed.²⁻⁴⁾

7 In the screening of falls based on performance tests, screening criteria is
8 derived from the relationship between fall occurrence and fall-related physical
9 function, such as lower limb strength and walking ability. In these procedures, it is
10 reported that direct measurements of minimum physical function or performance
11 requirements for fall prevention give a relatively accurate prediction of falling. In
12 contrast, questionnaire-based fall risk assessment is marked by a simple and
13 comprehensive evaluation of many internal- and external-risk factors of falling.

14 Falls are caused by multiple factors, and a comprehensive assessment based
15 on these multiple risk factors is important. However, falls occur due to many different
16 reasons, and the causes tend to be highly individualized.⁵⁻⁸⁾ Especially when screening
17 the elderly population, it is not necessarily the case that there is a clear relationship
18 between the incidence of falls and the outcomes of assessing these risk factors. Indeed,
19 the score of a questionnaire, which comprehensively assesses fall risk factors, could
20 not always accurately predict falls in the future.⁹⁾

21 Both the screening assessment (discriminating high fall risk in the elderly
22 among the population, prediction of falls in the future) and the risk profile assessment
23 (identification of problems for individuals) are essential for fall risk assessment. In the
24 risk profile assessment, various risk factors should be comprehensively assessed. In
25 the screening assessment, however, there is no problem in conducting an assessment

1 by using a specific factor or variable which can accurately predict the incidence of
2 falling. In the case of questionnaire-based fall risk assessment, a more effective and
3 useful fall risk assessment is possible by discriminating the risk factors associated
4 with high fall risk in the elderly in creating a fall risk profile. .

5 This study aimed to determine which risk factors from Demura's fall risk
6 assessment scale (DFRA) to use to screen high fall risk in the elderly.

7

8 **Participants and Methods**

9 **Participants and data collection**

10 The participants participating in this study were healthy community-dwelling
11 elderly individuals aged 60 and over, living in the Akita, Kanagawa, Ishikawa, Fukui,
12 Nagano, Gifu, Aichi, Tottori and Fukuoka prefectures in Japan. Mail or field surveys
13 were sent to 1770 elderly participants from which there were 1317 respondents.
14 Among these, 965 elderly (70.3 +/- 7.1yr) showing missing values of less than 10
15 percent were used for data analysis in this study. This pool of participants was
16 composed of 349 males (70.4 +/- 7.1 yr) and 616 females (69.9 +/- 7.1yr) with 160 of them
17 (16.6%) having experienced a fall in the last twelve months. There were no particular
18 gender- and age-specific biases between response participant and non-response
19 participant. The results of this study were generalized under the limitation of this
20 study sample.

21

22 **Fall risk assessment**

23 Demura's fall risk assessment chart (DFRA) is composed of previous fall
24 experience and 50 fall risk assessment items representing the five risk factors
25 regarding the "potential for falling," "physical function," "disease and physical

1 symptoms,” “environment,” and “behavior and character”.¹⁰⁾ The “potential for falling”
2 that a fall is currently happening is a concept regarding the occurrence of precursors
3 that are related to falls, such as the act of stumbling. We assessed the potential for
4 falling by asking the participants to answer the following three questions: “Have you
5 often stumbled?” “In the past year, have you felt like you might fall down?” and “Have
6 you ever been told that you look like you might fall down?” Physical function was
7 assessed using 22 items selected from three categories (fundamental function,
8 advanced function, and gait) and eight elements (muscular strength, lower limb
9 strength, balancing ability, walking ability, going up and down stairs, changing and
10 holding posture, upper limb function, and gait). Diseases and physical symptoms were
11 assessed using thirteen items selected from six categories (dizziness and instances of
12 blackout, medication, sight/hearing and cognitive disorder, cerebral vascular, arthritic
13 and bone disease, and circulatory disease). The environment was assessed using four
14 items selected from two categories (surrounding environment, and clothing). Behavior
15 and character was assessed using eight items selected from four categories (inactivity,
16 frequent urination, fear of falling, and risky behavior).

17 The validity of the DFRA has been examined in the previous study⁹⁾, and it has
18 been confirmed that this fall risk scale has a greater discriminant ability for predicting
19 the previous fall experience compared with the existing fall risk scale which is used
20 widely in Japan. In the result of examining test-retest reliability of DFRA for 172
21 elderly, high intra-class correlations were obtained for total and each risk factor scores
22 as followed; total score (0.956), potential for fall score (0.904), physical function score
23 (0.957), diseases and physical symptoms score (0.925), behavior and character score
24 (0.923) and environment score (0.874).

25 All questions were responded to on a dichotomous scale (yes or no), and with 1

1 point being assigned to each response falling into the “high risk” category. A risk factor
2 score was calculated by summing the scores of structural items of each risk factor.

4 **Statistical analyses**

5 Receiver-operating-characteristic (ROC) analysis was used to compare
6 accuracy for screening high fall risk in the elderly among the fall risk factors. ROC
7 analysis is one of useful tools to statistically confirm accuracy among several screening
8 tests.^{11,12)}

9 Because of cross-sectional data setting in this study, ROC analysis was
10 conducted using previous fall experience (faller or non-faller) as a dependent variable
11 and using each fall risk factor score in the DFRA as an independent variable. We
12 performed the ROC analysis on all of the trial models, and determined the area under
13 the ROC curve (AUC) and calculated a positive likelihood ratio, 95% confidence
14 interval, and cut-off points for maximizing the sensitivity and specificity for each score.
15 A cut-off point was defined as a point with farthest plots of sensitivity and specificity
16 from the bottom-right corner.

18 **Results**

19 Table 1 and Figure 1 show the results of ROC analyses and ROC curves for
20 each fall risk factor. The “precursor of falling” showed the highest AUC (.80;
21 95%CI: .76 - .83) and sensitivity (.87) values. The AUC values of the other risk factors
22 were less than .70. Especially, it is difficult to distinguish high fall risk elderly by
23 “environment” which showed the lowest AUC value (.54).

25 **Discussion**

1 This study aimed to determine useful fall risk factors to screen high fall risk in
2 the elderly through ROC analysis. The ROC analysis is a useful statistical tool to
3 determine the most useful screening test from several tests, and to set a criterion
4 (cut-off point) for screening. The AUC, which is calculated in ROC analysis, is an
5 indicator of discriminant power, and it is interpreted by the following guidelines:
6 non-informative test equal to chance ($AUC = 0.5$), less accurate ($0.5 < AUC < 0.7$),
7 moderately accurate ($0.7 < AUC < 0.9$), highly accurate ($0.9 < AUC < 1.0$), and perfect
8 discriminatory test ($AUC = 1.0$).^{13,14} In previous studies, an AUC of 0.8 has been
9 stated to represent a reasonably powerful model.¹⁵⁾

10 Among the fall risk factors, in this study, a sufficient AUC value was only
11 found in “potential for falling” (.80), and lower AUC values were found in other fall risk
12 factors (physical function: .63; diseases and physical symptoms: .63; environment: .54;
13 behavior and character: .67). A similar trend has been reported in a previous study,
14 which attempted to determine high fall risk in the elderly based on discriminant
15 analysis.⁹⁾ Thus, the highest discriminant probability was obtained in potential for
16 falling, and it was difficult to discriminate high fall risk in the elderly by using the
17 other four risk factors (physical function, disease and physical symptoms, environment,
18 and behavior and character).

19 In this study, the sensitivity coefficient of the potential for falling (.87) was
20 higher than those of other risk factors, but the specificity value of the potential for
21 falling was not very high (.66). Sensitivity (“positivity in disease”) refers to the
22 proportion of subjects who have the target condition (reference standard positive) and
23 give positive test results. Specificity (“negativity in health”) is the proportion of
24 subjects without the target condition and which gives negative test results.¹¹⁾ In the
25 assessment of fall risk among the elderly population, high sensitivity corresponds to

1 high negative predictive value (proportion of “true negative”/ (“false negative” + “true
2 negative”), and it should be given high priority, comparing with high specificity. Thus,
3 moderate specificity should be considered within an allowance in fall risk assessment.

4 Falling is a multifactoral problem, and the causes of falling are highly
5 individualized.⁵⁻⁸⁾ Therefore, in the questionnaire-based fall risk screening among the
6 elderly population, the clear relationships may be invisible between experience of
7 falling and risk factor scores. However, “potential for falling” means the likelihood of
8 falling, and they indicate a high relationship with fall experience regardless of the
9 cause of being at a high fall risk. It is considered to be a useful measure for screening
10 high fall risk in the elderly. Although the assessment of potential for falling provides
11 information concerning the likelihood of falling, it cannot provide information about
12 the causes of falling or countermeasures to prevent falls in the future. To prevent falls,
13 both assessments of risk level (screening) and a risk profile are essential. Therefore, a
14 fall risk profile assessment that contains comprehensive internal- and external fall
15 risk factors is also important in concert with screening the elderly with high fall risk.

16

17 **Summary**

18 Assessment based on the score of potential for falling is useful to screen high
19 fall risk elderly, although it is difficult to screen them with the scores of other risk
20 factors. However, the assessment of potential for falling provides useful information to
21 determine fall risk level but not to determine its causes and countermeasures. It is
22 important to both screen for high fall risk in the elderly and to make assessments
23 based on an individualized risk profile.

24

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2 Japan Ministry of Education, Science, Sports and Culture [grant number 21240064].

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18

Table 1 Summary of ROC analyses for each fall risk factor

Risk factors	AUC	p	AUC (95%CI)	Sensitivity	Specificity	Cut-off value
Potential for falling	0.80	0.00	.76~.83	0.87	0.66	1
Physical function	0.63	0.00	.58~.68	0.40	0.81	10
Diseases and Physical symptoms	0.63	0.00	.586~.67	0.30	0.87	5
Behavior and Character	0.67	0.00	.63~.72	0.53	0.75	3
Environment	0.54	0.12	.49~.59	0.78	0.27	1

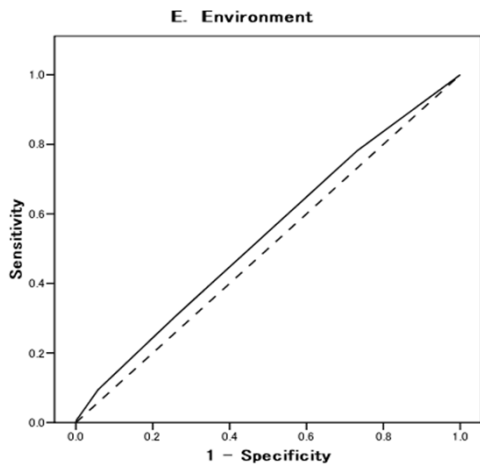
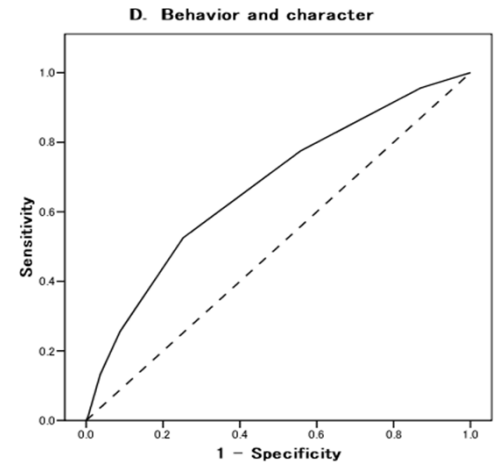
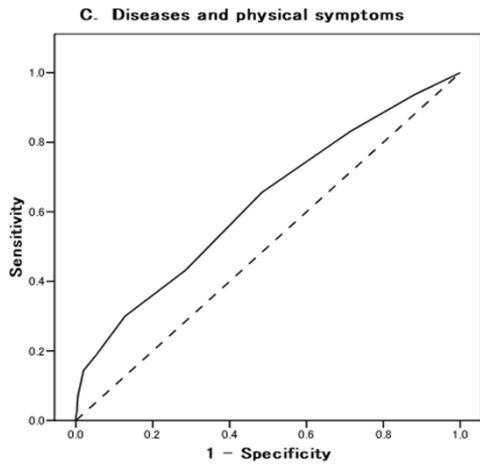
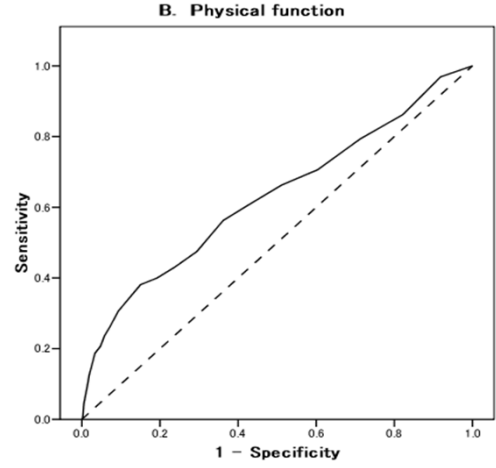
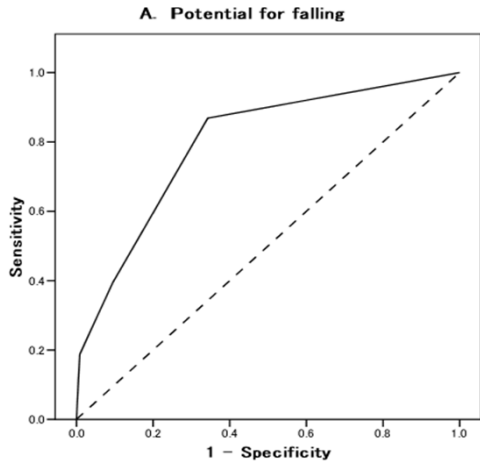


Figure1. ROC curves of each fall risk factor