Setting the criterion for fall risk screening for healthy community-dwelling elderly

doi: 10.1016/j.archger.2011.04.010

M-2264(R)

Setting the criterion for fall risk screening for healthy community-dwelling elderly

Shinichi Demura[a], Susumu Sato[b,*], Sohee Shin[c], Masanobu Uchiyama[d]

[a]Graduate school of Natural Science and Technology, Kanazawa University, Kakuma, Kanazawa, Ishikawa, 920-1192, Japan

[b]Life-long Sports Core, Kanazawa Institute of Technology, Ohgigaoka 7-1, Nonoichi, Ishikawa, 921-8501, Japan

[c]Center for Innovation, Kanazawa University, Kakuma, Kanazawa, Ishikawa, 920-1192, Japan

[d]Akita Prefectural University, Akita, Akita, 010-0195, Japan

*Corresponding author:

Phone: +81 76-248-1100(ext.2386)

Fax: +81 76-294-6704.

E-mail: sssato@neptune.kanazawa-it.ac.jp

Abstract

This study aimed to develop a criterion for screening high risk elderly using Demura's fall risk assessment chart (DFRA), compared with the Tokyo Metropolitan Institute of gerontology (TMIG) fall risk assessment chart. Participants included 1122 healthy elderly individuals aged 60 years and over (380 males and 742 females) 15.8% of whom had experienced a fall. We assessed fall risk of the elderly by DFRA and TMIG. To develop a criterion for screening high fall risk subjects among community-dwelling elderly, receiver-operating-characteristic (ROC) analysis was conducted using fall experience (separated into the categories of faller and non-faller) and the following fall risk scale scores: (1) TMIG score, (2) DFRA score, and (3) potential for falling score according to the DFRA (summing the scores of three items). In ROC analyses, the area under the ROC curve (AUC) for evaluating the potential for falling gave a value of 0.797 (95% CI = 0.759-0.834) which proved better than the evaluation of the overall TMIG (0.654, 95% CI = 0.600-0.706) and DFRA scores (0.680, 95% CI = 0.633-0.727). Assessment of the potential for falling and fall experience are of benefit in screening for

elderly persons deemed to be at a high fall risk. Further examinations based on the prospective data setting will be required.

Keywords: ROC analysis, cross-sectional study, prevention of falls, risk profiles

1. Introduction

Prevention of falls for the elderly is an extremely important social issue (American Geriatrics Society, 2001; Perell et al., 2001; Chan et al., 2006; Russell et al., 2009). Various approaches to prevent these falls have been examined, one of which was fall risk assessment. The main objective of fall risk assessment is to connect the outcomes these assessments to prevent falls in the future. Thus, fall risk assessment should provide information concerning the prediction of the possibility of falling in the future and the determination of problems that lead to falls for individuals.

In the many cases, before a fall occurs, the “precursors” that a fall is about to happen appear as a stumble, slip, stagger, etc. However, because the causes of a fall are infinite in variety it is difficult to screen for high-fall risk subjects among the elderly population using only a composite index which summarizes the assessments regarding each fall risk factor. Furthermore, in the previous study it was reported that there is a limitation in the ability to predict fall experiences from an overall score consisting of several risk factors because of the diversity pattern of fall causes among individuals (Demura et al., 2010a). It may be recommended that the possibility of future falls (screening the high-fall risk elderly) be checked by the assessment of precursors for a fall, and, next, a risk profile assessment is conducted for multi-factorial risk domains to determine problems that lead to falls for individuals. Based on these processes, the prevention measures for falls can be developed for the individual.

Several fall risk assessments have been reported which have been based on questionnaires and performance tests (Tinetti et al., 1988; Suzuki, 2000; Gates et al., 2008; Tiedemann et al., 2008). Fall risk assessments that are questionnaire-based are an inexpensive and simple method and are widely used for the general population. In Japan, the fall risk assessment chart developed by the TMIG is widely used for the community-dwelling elderly population (Suzuki, 2000). However, it has been suggested that this chart is unclear with respect to the selection process of the assessment items as well as the basis for criteria calculation for the screening of high risk elderly. Furthermore, it is difficult to determine a risk profile for specific individuals (Demura et al., 2010a,b). Considering these problems, we aim to develop a new fall risk assessment chart. We have examined a selection of useful assessment items (Demura et al., 2010b), and have examined useful risk factor to predict fall experience (Demura et al., 2010a). However, there is no criterion for the screening of high fall risk elderly based on objective evidence.

This study aims to develop a criterion for screening high-risk elderly with respect to DFRA chart and, subsequently, to compare these criteria with the TMIG fall risk chart.

2. Subjects and methods

2.1. Subjects and data collection

The subjects participating in this study were healthy community-dwelling elderly individuals aged 60 and over, living in the Akita, Kanagawa, Ishikawa, Fukui, Nagano, Gifu, Aichi, Tottori and Fukuoka prefectures in Japan. Mail or field surveys were sent to 1927 elderly subjects from which there were 1464 respondents. Among these, 1122 elderly (70.3 ± 7.1 years) showing missing values of less than 10% were used for data analysis in this study. This pool of subject was composed of 380 males (70.5 ± 7.0 years) and 742 females (70.4 ± 7.2 years) with 177 of them (15.8%) having had a fall experience in the last 12 months.

2.2. Fall risk assessment

The DFRA is composed of previous fall experience and 50 other fall risk assessment items representing the five risk factors regarding the “potential for falling,” “physical function,” “disease and physical symptoms,” “environment,” and “behavior and character” (Demura et al., 2010a,b). The “potential for falling” that a fall is currently happening and is a concept regarding the occurrence of precursors that are related to falls, such as the act of stumbling.

We assessed the potential for falling by asking the patients to answer the following three questions: “Have you often stumbled?” “In the past year, have you felt like you might fall down?” and “Have you ever been told that you look like you might fall down?” Physical function was assessed using 22 items selected from three categories (fundamental function, advanced function, and gait) and eight elements (muscular strength, lower limb strength, balancing ability, walking ability, going and down stairs, changing and holding posture, upper limb function, and gait). Diseases and physical symptoms were assessed using 13 items selected from six categories (dizziness and instances of blackout, medication, sight/hearing and cognitive disorder, cerebral vascular, arthritic and bone disease, and circulatory disease). The environment was assessed using four items selected from two categories (surrounding environment, and clothing). The behavior and character was assessed using eight items selected from four categories (inactivity, frequent urination, fear of falling, and risk behavior). All questions were responded to on a dichotomous scale (yes or no), and with 1 point being assigned to each response falling into the “high risk” category.

In addition, we also used the TMIG fall risk assessment chart. The TMIG assessment chart is composed of 15 items with each item assessed using a dichotomous scale (yes or no). The subject with an overall score of 5 or higher or with fall experience is considered to be at a high risk for a fall.

2.3. Analyses

To develop a criterion for screening high fall risk subjects among the community-dwelling elderly, ROC analysis was conducted using previous fall experience (faller or non-faller) and the followed fall risk scale scores; (1) TMIG score, (2) DFRA score, and (3) potential for falling score for the DFRA. We performed the ROC analysis on all of the trial models and determine the AUC of the ROC. Next, we calculated the positive likelihood ratio with a 95% confidence interval (95% CI) and set cut-off points in order to maximize the sensitivity and specificity for each score.

2.3.1. ROC analyses based on TMIG score

The TMIG score (TMIG-15) was calculated by summing all 15 items in the TMIG scale. As mentioned above, in the TMIG fall risk scale, a cut-off point for screening high fall risk subjects is recommended to be a score of 5 points without statistical procedures (Suzuki, 2000). To confirm the cut-off point of the TMIG for screening high fall risk person, we conducted ROC analysis using the TMIG-15 as a dependent variable.

The TMIG scale includes previous fall experience. However, we must use fall experience as a dependent variable in this study based on cross-sectional data. Therefore, we confirmed the accuracy of predictions made regarding the TMIG when excluding the influence of the previous fall experience. Thus, we calculated the TMIG score which summed over 14 TMIG item scores, excluding the “previous fall experience” (TMIG-14). Then the ROC analysis was conducted using the TMIIG-14 score as a dependent variable.

2.3.2. ROC analyses based on DFRA score

The DFRA score was calculated by summing over 50 fall risk item scores. This study conducted ROC analysis using the DFRA score as a dependent variable.

2.3.3. ROC analyses based on the score of the potential for falling in the DFRA scale

The potential for falling in the DFRA scale was calculated by summing over the scores for three items (PF-3). Next, ROC analyses were conducted using this score to confirm the accuracy of predictions regarding these precursors. In our previous study, we confirmed that the relationship between previous fall experiences and the potential for falling score was comparable to those with overall DFRA score. If the degree of fall risk in elderly subjects could be predicted from the score of potential for falling, simplifying as well as improving fall risk screening.

Furthermore, for comparison with the TMIG scale, a similar ROC analysis was also conducted using the scores of four items concerning previous fall experience combined with the three potential for falling (PF-4).

3. Results

3.1. ROC curve in TMIG

In ROC analysis using the TMIG-14 score (excluding fall experience) (Fig. 1a), the AUC was 0.654 (95% CI = 0.602-0.706). A cut-off point was set at 3 points and the sensitivity and specificity were 0.425 and 0.169, respectively. Fig. 1b shows the ROC curve using the TMIG-15 score (including fall experience). The AUC, cut-off point, sensitivity and specificity were 0.786 (95% CI = 0.747-0.825), 4-points, 0.594, and 0.831, respectively.

3.2. ROC curve in DFRA

In ROC analysis based on an overall score of DFRA (Fig. 2), the AUC was 0.680 (95% CI = 0.633-0.727). The cut-off point was set at 22 points, and the sensitivity and specificity were 0.306 and 0.072.

3.3. ROC curve in potential for falling DFRA score

In the ROC analysis using the PF-3 score (Fig. 3a), the AUC was 0.797 (95% CI = 0.759-0.834). The cut-off point was set at 1 point, and the sensitivity and specificity were 0.869 and 0.657. When using the PF-4 score (including previous fall experiences) (Fig. 3b), the AUC was 0.946 (95% CI = 0.931-0.960). The cut-off point was set at 2 points, and the sensitivity and specificity were 0.869 and 0.906. These results show effectiveness of fall risk prediction using the potential for falling.

4. Discussion

This study examined a criterion for screening high fall risk elderly based on the ROC analysis. The TMIG fall risk scale, which is widely used in Japan, recommends a score of 5 points as a criterion for high fall risk in elderly persons. However, there is no report regarding an objective basis for the calculation of this criterion. In fact, in the examination of the validity of the criterion in the TMIG based on our study sample, cut-off points for screening fallers (participants who had previous experienced episodes of falling) was different from the recommended value. This result indicates the importance of this statistical demonstration in the development of a criterion for screening.

Our previous study has reported that risk factor of the potential for falling are closely related to previous fall experience, compared with other fall risk factors of “physical function”, “disease and physical symptoms”, “environment”, and “character and behavior” (Demura et al., 2010a). Therefore, we examined the screening of high fall risk by potential for falling score, and proposed the criterion in this study.

In ROC analysis, the AUC evaluates the diagnostic accuracy of the test because the area is equal to the provability of accurately discriminating between a randomly chosen person with the outcome and a randomly chosen person without the outcome (Eisenmann et al., 2010; Wray et al., 2010). It has been suggested that the AUC be interpreted according to the following guidelines: non-informative/test equal to chance (AUC = 0.5), less accurate (0.5 < AUC < 0.7), moderately accurate (0.7 < AUC < 0.9), highly accurate (0.9 < AUC < 1.0), and perfect discriminatory test (AUC = 1.0) (Swets, 1988; Eisenmann et al., 2010). An AUC of 0.8 has been stated to represent a reasonably powerful model. In this study, the AUC for evaluating the potential for falling score (3 items) gave a value of 0.80 and it was better than for evaluating the overall scores of the TMIG (15 items) and the DFRA (50 items). Furthermore, this value was better than those reported in previous studies examining the validity of performance tests for the screening of high fall risk (Muir et al., 2008). It indicates the availability of screening by the potential for falling.

The potential for recurrent falls or multiple falls is high, and “previous fall experience” is one of the important assessment items in a fall risk assessment (American Geriatrics Society, 2001). Therefore, although this study examined cut-off points using the potential for falling score, a fall risk assessment which takes into account previous fall experience in the three items in the potential for falling may prove effective in improving the accuracy of predicting future instances of falling.

On the other hand, the criterion proposed in this study has a limitation. Fall risk is defined as the possibility of a fall occurring in the future. Therefore, essentially, it is preferable that validity of a criterion for screening high fall risk is examined by falls in the future based on the prospective study setting. However, because this study is based on a cross-sectional data setting, we have to analyze our results using previous fall experiences. In further examinations, the accuracy of predictions regarding future instances of falling should be examined based on the prospective study.

According to the results in this study, the assessment of the potential for falling may be useful to screen high fall risk subjects, but it cannot propose information concerning the specific risk profile for individuals. Comprehensive assessment based on several risk factors is essential for taking measures to prevent falls in the future. Fall risk assessment is not an end in itself, and the outcomes will be incorporated into the prevention of falls. Therefore, it is very important to determine problems for specific individuals in addition to comprehensive screening for patients who are at a high risk for falling. The results of this study support that idea that the potential for falling and previous fall experience provide useful information for the screening of high fall risk subjects. However, we do not deny the significance of the assessment of other risk factors. Further research will be required to develop an assessment of the fall risk profile for individuals based on multiple risk factors.

5. Conclusion

This study examined a criterion for screening high fall risk elderly subjects and proposed a cut-off point based on the potential for falling score. In addition, in examinations based on our study sample, a cut-off point for screening using the TMIG fall risk scale differed from the previously recommended cut-off value for screening high fall risk elderly. Assessment of the potential for falling and previous fall experience is beneficial for screening high fall risk elderly. In addition, further research examining the accuracy of predictions regarding future instances of falling will be required based on the prospective data setting.

Conflict of interest statement: None.

Acknowledgment

This work was supported by A Grant-in-Aid for Science Research, the Japan Ministry of Education, Science, Sports and Culture (grant number: 21240064).

References

American Geriatrics Society, British Geriatrics Society, and American Academy of Orthopaedic Surgeons Panel on falls prevention., 2001. Guideline for the prevention of falls in older persons. J. Am. Geriatr. Soc. 49, 664-672.

Chan, B.K.S., Marshall, L.M., Winters, K.M., Faulkner, K.A., Schwartz, A.V., Orwoll, E.S., 2006. Incident fall risk and physical activity and physical performance among older men. Am. J. Epidemiol. 165, 696-703.

Demura, S., Sato, S., Yamaji, S., Kasuga, K., Nagasawa, Y., 2010a. Examination of validity of fall risk assessment items for screening high fall risk elderly among the healthy community-dwelling Japanese population. Arch. Gerontol. Geriatr., **Doi:10.1016/j.archger.2010.10.010** [Epub a head of print].

Demura, S., Sato, S., Yokoya, T., Sato, T., 2010b. Examination of useful items in the assessment of fall risk in the community-dwelling elderly Japanese population. Environ. Health. Prev. Med. 15, 169-179.

Eisenmann, J.C., Laurson, K.R., DuBose, K.D., Smith, B.K., Donnelly, J.E., 2010. Construct validity of a continuous metabolic syndrome score in children. Diabeteology and Metabolic Syndrome, 2-8, http://www.dmsjournal.com/content/2/1/8.

Gates, S., Smith, L.A., Fisher, J.D., Lamb, S.E., 2008. Systematic review of accuracy of screening instruments for predicting fall risk among independently living older adults. J. Rehabil. Res. Developm. 45, 1105-1116.

Muir, S.W., Berg, K., Chesworth, B., Speechley, M., 2008. Use of the Berg balance scale for predicting multiple falls in community-dwelling elderly people: a prospective study. Phys Ther 88, 449-459.

Perell, K.L., Nelson, A., Goldman, R.L., Luther, S.L., Prieto-Lewis, N., Rubenstein, L.Z., 2001. Fall risk assessment measures: an analytic review. J. Gerontol. A: Biol. Sci. Med. Sci. 56, M761-M766.

Russell, M. A., Hill, K. D., Day, L. M., Blackberry, I., Gurrin, L. C., Dharmage, S. C., 2009. Development of the falls risk for older people in the community (FROP-Com) screening tool. Age Ageing. 38, 40-6.

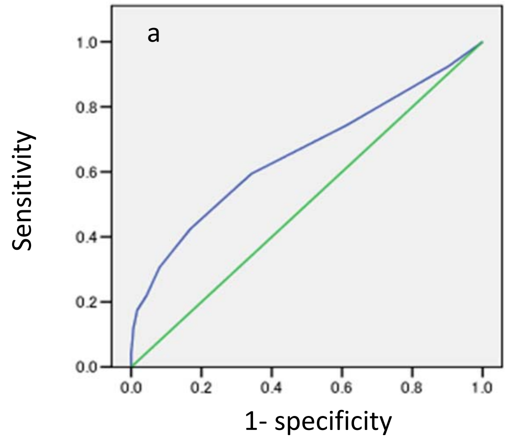
Suzuki, T., 2000. Questionnaire for falls assessment of elderly people and its application. In: Health Assessment Manual. Kosei Kagaku Kenkyusho, Tokyo, pp. 142-163 (In Japanese).

Swets, J, A., 1988. Measuring the accuracy of diagnostic systems. Science 240, 1285-1293.

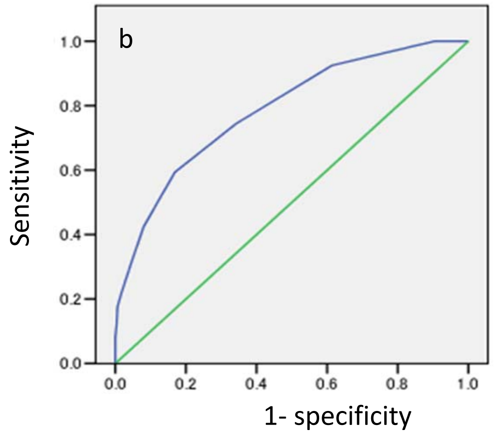
Tiedemann, A., Shimada, H., Sherrington, C., Murray, S., Lord, S., 2008. The comparative ability of eight functional mobility tests for predicting falls in community-dwelling older people. Age Ageing 37, 430-435.

Tinetti, M.E., Speechley, M., Ginter, S.F., 1988. Risk factors for falls among elderly persons living in the community. N. Enngl. J. Med. 319, 1701-1707.

Wray, N.R., Yang, J., Goddard, M.E., Visscher, P. M., 2010. The genetic interpretation of area under the ROC curve in genomic profiling. PLoS Genet. 26, 6-2, :e1000864.

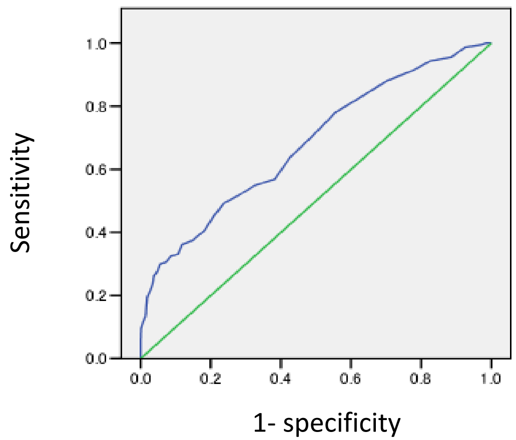


AUC	AUC (95%CI)	Sensitivity	Specificity	Cut-off value
0.654	0.602- 0.706	0.425	0.169	3



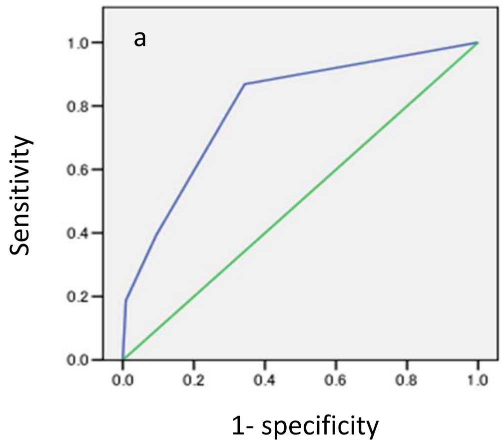
AUC	AUC (95%CI)	Sensitivity	Specificity	Cut-off value
0.786	0.747-0.825	0.594	0.831	4

Fig. 1. The result of ROC analysis based on the TMIG score: (a) ROC curve when using the TMIG-14 score; (b) ROC curve when using the TMIG-15 score

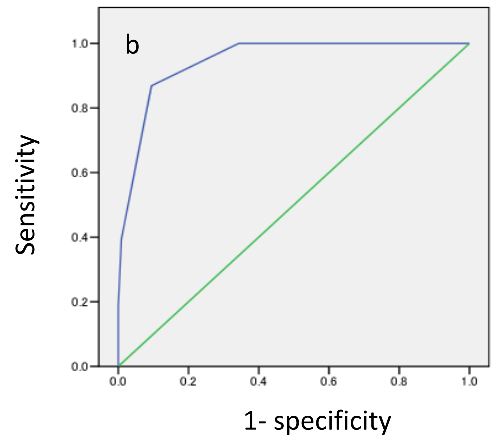


AUC	AUC (95%CI)	Sensitivity	Specificity	Cut-off value
0.680	0.633- 0.727	0.306	0.072	22

Fig. 2. The result of ROC analysis based on the DFRA score



AUC	AUC (95%CI)	Sensitivity	Specificity	Cut-off value
0.797	0.759- 0.834	0.869	0.657	1



AUC	AUC (95%CI)	Sensitivity	Specificity	Cut-off value
0.946	0.931-0.960	0.869	0.906	2

Figure 3. The result of ROC analysis using the score of potential for falling in the DFRA: (a) ROC curve when using the PF-3 score; (b) ROC curve when using the PS-4 score