History and Mobility Exam Index to Identify Community-Dwelling Elderly Persons at Risk of Falling

Kenneth E. Covinsky,1,2 Eva Kahana,3 Boaz Kahana,4 Kyle Kercher,3 John G. Schumacher,3 and Amy C. Justice5,6

1Division of Geriatrics and Department of Medicine, University of California, San Francisco.  
2The San Francisco VA Medical Center, California.  
3Department of Sociology, Case Western Reserve University, Cleveland, Ohio.  
4Department of Psychology, Cleveland State University, Ohio.  
5Division of General Internal Medicine and the Department of Medicine, University of Pittsburgh, Pennsylvania.  
6The VA Pittsburgh Healthcare System, Pennsylvania.

Background. Falls are common in community-dwelling elderly persons and are a frequent source of morbidity. Simple indices to prospectively stratify people into categories at different fall-risk would be useful to health care practitioners. Our goal was to develop a fall-risk index that discriminated between people at high and low risk of falling.

Methods. We evaluated the risk of falling over a one-year period in 557 elderly persons (mean age 81.6) living in a retirement community. On the baseline interview, we asked subjects if they had fallen in the previous year and evaluated risk factors in six additional conceptual categories. On the follow-up interview one year later, we again asked subjects if they had fallen in the prior year. We evaluated risk factors in the different conceptual categories and used logistic regression to determine the independent predictors of falling over a one-year period. We used these independent predictors to create a fall-risk index. We compared the ability of a prior falls history with other risk factors and with the combination of a falls history and other risk factors to discriminate fallers from nonfallers.

Results. A fall in the previous year (OR = 2.42, 95% CI = 1.49–3.93), a symptom of either balance difficulty or dizziness (OR = 1.83, 95% CI = 1.16–2.89), or an abnormal mobility exam (OR = 2.64, 95% CI = 1.64–4.26) were independent predictors of falling over the subsequent year. These three risk factors together (c statistic = .71) discriminated fallers from nonfallers better than previous history of falls alone (c statistic = .61) or the symptomatic and exam risk factors alone (c statistic = .68). When combined into a risk index, the three independent risk factors stratify people into groups whose risk for falling over the subsequent year ranges from 10% to 51%.

Conclusion. A history of falling over the prior year, a risk factor that can be obtained from a clinical history (balance difficulty or dizziness), and a risk factor that can be obtained from a physical exam (mobility difficulty) stratify people into groups at low and high risk of falling over the subsequent year. This risk index may provide a simple method of assessing fall risk in community-dwelling elderly persons. However, it requires validation in other subjects before it can be recommended for widespread use.

Falls are common in community-dwelling elderly persons, and those who fall are at higher risk for a number of adverse outcomes (1–5). For example, Tinetti (3) recently reported that even one noninjurious fall during a one-year period is associated with a three-fold greater risk of nursing home placement. Falls are responsible for most hip fractures in older people and are the leading cause of accidental death in people over age 65 (1,6). Falls are also associated with increased health care costs and frequently precipitate visits to the emergency room and hospital admission (7). Even seemingly minor, noninjurious falls can be disabling by leading to a fear of future falling, which in turn can result in decreased activity levels (8) and diminished quality of life.

There is evidence that simple interventions may reduce the risk of falling in high-risk elders (9–11). However, most intervention programs require at least moderate resources and provider time. These resources could be used most efficiently if they were targeted at elderly persons who are at the highest risk of falling. Thus, a simple risk stratification tool that discriminated between patients at high risk of falling (those most likely to benefit from an intervention) and patients at low risk of falling (those least likely to benefit from an intervention) would be of use to physicians and other health care providers.

While a number of studies have determined risk factors for falling (2,4,12–24), only a limited number of fall-risk indices have been published, and few published indices have focused on community-dwelling elderly persons (2,4,12–20). Some of these indices have been restricted either to injurious or recurrent falls (4,12,14,17,20). Most published indices document the importance of mobility and balance impairments in identifying patients at high risk for falling. For example, Lord (17) demonstrated that performance on tasks of static and dynamic balance successfully stratified patients into groups with different risk of falling. Likewise, Maki (19) demonstrated that postural balance was associated with
fall risk. Similarly, Studenski (18) demonstrated that a stratification system based on mobility impairment discriminated between patients with a 5% and 23% risk of falling. Environmental characteristics further discriminated between low-risk and high-risk patients. While a prior history of falls was an independent risk factor in patients with high mobility risk, prior falls was not specifically incorporated into the risk index. Robbins (13) has further demonstrated that risk factors identified from a comprehensive history and a physical exam identified patients at high risk of falling; however, this study did not assess the role of a prior falls history. Tinetti (2) demonstrated the importance of considering multiple domains of risk factors by showing that sedative use, cognitive impairment, poor lower extremity function, balance abnormalities, and foot problems all contributed to an index predicting falls. While a prior falls history was also predictive of falls, the developed index did not specifically consider a falls history. Subsequent work demonstrated that this index could be used to identify patients who would successfully respond to an intervention to reduce the incidence of falls (9). Tinetti and colleagues (16) have also recently demonstrated that an index that includes upper-extremity, lower-extremity, sensory, and affective impairments discriminates fallers from nonfallers. Furthermore, this study demonstrated that the risk factors for falls may also be risk factors for other geriatric syndromes, such as functional dependence and incontinence.

The goal of this study was to develop a simple prediction index to stratify community-dwelling elderly persons into groups at different risk for falling over the subsequent year. First, we examined the relationship between risk factors in seven different conceptual categories and subsequent falling. These categories included recent falls history, demographic characteristics, psychosocial characteristics, health status, physical activity, symptomatic risk factors (trouble with balance or dizziness), and physical-exam–related risk factors (mobility impairment). We selected these conceptual categories because each has been demonstrated to be strongly associated with falls or other health outcomes (25–31). Next, we used logistic regression to determine independent risk factors for falling. In developing these models, we were particularly interested in examining the relative ability of a previous falls history compared with other risk factors that can be obtained from a patient history and physical exam to discriminate subsequent fallers from nonfallers. Finally, we combined independent risk factors into a risk score to stratify subjects into low- and high-risk groups for subsequent falls.

Our hypotheses were (i) multiple domains of risk are required to predict falls; (ii) an index considering both a prior falls history and other risk factors will predict falls better than a falls history or other risk factors alone; and (iii) using the domains outlined above, it will be possible to stratify patients into groups at high and low risk for falling.

**METHODS**

**Study Population**

Subjects in this analysis were participants in a longitudinal study of functional change and adaptation among older people living in retirement communities in Clearwater, Florida (32–34). The cohort of 1000 subjects was assembled from January through June 1990 via a random selection of members from the retirement communities. Inclusion criteria at initial enrollment required that the subject be at least 70 years old and independent in basic activities of daily living (ADL). The fourth annual interview (January–June 1993) was the baseline interview for the falls analysis. A total of 667 subjects remained enrolled in the study at this time. Of the 333 respondents no longer in the study, 131 had died, and 202 had discontinued participation. Of the remaining 667 respondents interviewed during the fourth annual interview, 557 (84%) were interviewed during the fifth annual interview (January–June 1994) and thus had available data about falls in the subsequent year. Of the 110 excluded persons, 50 died prior to the Year 5 interview, and 60 discontinued participation in the study. The mean age of the 557 subjects in these analyses was 81.6 ± 4.4 years, and 66.4% were women.

**Dependent Variable**

The major dependent variable was whether or not the patient reported falling during the previous year on the Year 5 (outcome) interview. A fall was defined as unintentionally coming to rest on the ground.

**Independent Variables**

Predictor variables included characteristics measured on the Year 4 (baseline) interview that were potential risk factors for falling. We grouped risk factors for falling into seven conceptual categories:

(i) Recent fall history was determined by asking respondents during the baseline interview if they experienced any falls in the past year.

(ii) Demographic characteristics including age and gender were determined from respondents’ self-report.

(iii) Psychosocial characteristics included measures of social support (e.g., marital status, availability of companionship, and living arrangements) and psychological characteristics (e.g., spirituality, mastery, and depression). We measured availability of companionship by asking subjects how often they have a companion to call on when they want to be with someone. We classified responses as often or greater versus occasionally or less. We assessed spirituality by asking subjects how often they use spiritual coping when they have problems or difficulties. Religious or spiritual coping style has been shown to serve a protective role in ameliorating adverse effects of stressful life situations on the health of older adults (35). We classified subjects as coping in spiritual ways often or greater versus sometimes or less. We measured mastery with the seven-item Pearlin scale (36). We divided subjects into three categories on the basis of the response distribution. Depression was measured with the 10-item version of the Center for Epidemiologic Studies—Depression Scale (37). We divided respondents into three categories on the basis of response distribution.

(iv) Health status measures included independence in ADLs, independence in instrumental activities of daily living.
(IADLs), difficulty walking, self-assessed health, and comorbid conditions. We measured ADLs using a scale developed by Katz and colleagues (38) and classified respondents as independent in all ADLs versus needing assistance in at least one ADL. We measured IADLs using the scale developed by Lawton (39) and classified respondents as independent in all IADLs versus needing assistance in at least one IADL. Self-assessed health was classified as either excellent or very good versus fair or poor. We calculated a comorbidity score by asking subjects about the presence and severity of 12 conditions (arthritis, asthma, chronic obstructive pulmonary disease, hypertension, coronary artery disease, peripheral vascular disease, diabetes, liver disease, kidney disease, cancer, stroke, and Parkinson’s disease) and assigning one point for each condition that they reported as present but not severe and two points for each condition reported as at least somewhat severe. Respondents were classified as either having minimal comorbidity (range, 0–1), moderate comorbidity (range, 2–4), or severe comorbidity (≥5).

(v) Physical activity level was measured by asking respondents how many hours per week they spent in seven different aerobic activities (walking, swimming, golfing, running, aerobics, dancing, and bicycling). Subjects were classified as spending a total of 0, 1 to 7, or 8 or more hours per week in aerobic activities.

(vi) Symptomatic risk factors were determined by asking the subjects whether they had had trouble with either dizziness or balance during the past year.

(vii) Physical-exam–related risk factors were measured by determining whether the subject could complete, without difficulty, four tasks important to normal mobility (40): getting up from an armless chair, sitting down in an armless chair, raising feet while walking, and turning 180 degrees. We scored each task as normal, completed with difficulty, or unable to do. Subjects were categorized as having a normal mobility exam (normal on all four items), a borderline mobility exam (normal on 3 items, difficulty on one item), or an abnormal mobility exam (difficulty on two or more items, or unable to do one or more items).

Analyses

We used chi-square tests, modified for trend when appropriate, to measure the association between each risk factor and falls over the subsequent year.

Our goals for the multivariate analyses were to determine independent risk factors for falling and to compare the relative utility of a history of falling, other risk factors, and a combination of a falls history and other risk factors in predicting subsequent falls. Our first model was a logistic regression model that considered only a history of falling. Our second model was a stepwise logistic regression model that considered all risk factors that were associated with falls in the univariate analysis (entry criteria, \( p < .20 \); retention criteria, \( p < .05 \)) other than a falls history. Forward and backward selection models produced the same results. The third model was identical to the second model, except that it also considered falls history for entry. We used the \( c \) statistic to measured the ability of each model to predict falling. The \( c \) statistic, a commonly used measure of discrimination for predictive models, is the probability that given any random pair of patients, one of whom fell and one of whom did not fall during the subsequent year, the patient who fell would have a higher assigned risk than the patient who did not fall (41).

Clinical Utility of Risk Factors

To examine the clinical utility of the risk factors in our final model, we assigned a risk score to each patient on the basis of the presence or absence of each risk factor. A point value was assigned to each risk factor on the basis of the relative Beta weight of each risk factor in the final model. We then calculated fall rates as a function of the risk score. Finally, we compared the sensitivity, specificity, positive predictive value, and negative predictive values of three alternative indices using different cutpoints. The first “index” considered only whether or not the patient fell in the prior year. The second index considered only whether the patient described a history of balance difficulty or dizziness or had an abnormal mobility exam (independent risk factors from Model 2). The third index considered falls history, history of balance difficulty or dizziness, and abnormal mobility exam.

RESULTS

Predictors of Falling: Bivariate Analysis

Overall, 22% of patients reported falls. People who fell during the prior year were more than twice as likely to fall in the subsequent year (Table 1). Among the psychosocial characteristics, only depressive symptoms were significantly associated with falling. However, there was a consistent trend among these variables toward an association with falling. All the measures of health status were associated with falling. The associations were statistically significant (\( p < .05 \)) for IADL dependence, walking difficulty, and comorbidity. Lower levels of aerobic activity were associated with higher rates of falling. Symptomatic risk factors (balance difficulty or dizziness) and a physical exam demonstrating abnormal mobility were associated with falling.

Most variables strongly associated with falling on bivariate analysis were strongly associated with each other. For example, people with abnormal mobility exams were more likely than those with normal mobility exams to be in the highest comorbidity category (29% vs 16%), to be dependent in at least one IADL (81% vs 24%), and to be in the highest depression symptom category (39% vs 22%) (\( p < .05 \) for each comparison).

Predictors of Falling: Multivariate Analyses

While a history of falling in the previous year was associated with falling in the subsequent year (Table 2), a model considering only a falls history was only moderately effective in discriminating persons who fell from those who did not fall in the subsequent year (Model 1, \( c \) statistic = .61). In a stepwise logistic regression model considering all risk factors other than a falls history, an abnormal mobility exam or a history of balance difficulty or dizziness were independently associated with falling. These risk factors discriminated fallers from nonfallers...
more effectively (p < .001) than a history of falling (Model 2, c-statistic = .68). A model that considered all of these risk factors (Model 3) discriminated fallers from nonfallers better (p < .02) than either model alone (c-statistic = .71).

**Clinical Utility of Risk Factors**
To assess the potential clinical utility of these risk factors, we assigned a risk score to each patient on the basis of the presence or absence of each risk factor. On the basis of the relative Beta weights of each risk factor in the regression model, we assigned two points for a history of falling, two points for a mobility impairment on physical exam, and one point for a history of balance difficulty or dizziness. This risk score stratified subjects into categories with a fall risk ranging from 10.2% to 51.4% (Table 3). The c-statistic for the risk score was .70. Table 4 describes the sensitivity, specificity, and predictive values of different cutpoints for three alternative indices: an index considering only a falls history, an index considering only a history of balance difficulty or dizziness and an abnormal mobility exam, and an index considering all three of these risk factors.

**DISCUSSION**
We found that three easily obtained risk factors identify subjects at high risk for falling over the subsequent year. These include a fall during the previous year, a symptom suggesting a high risk of falling (balance difficulty or dizziness), and a finding of abnormal mobility through a physical exam. Considering a previous fall history along with symptoms and examination abnormalities discriminated fallers from nonfallers better than considering only a previous fall history or only symptomatic- and examination-based risk factors. Combining all of these risk factors into a risk index stratified subjects into groups whose risk of subsequent falling varied from 10% to 51%. The utility of such a stratification system depends, in part, on the particular needs of the patient or clinician. However, if validated, we suspect most clinicians would find our system useful because it is easy to use and readily differentiates between patients with 5-fold different rates of falling. In terms of targeting intervention strategies, we suspect that most clinicians would consider a 51% risk of falling high enough to justify additional evalu-
Our risk index, like any risk index developed with multivariate techniques, should be viewed as a parsimonious method of identifying persons at risk for an adverse outcome rather than as a method for identifying the mechanism or important determinants of that outcome. The risk factors we identified in our multivariate model likely represent distal events in the causal chain that leads to falling in elderly persons. However, a number of potentially important causes of falling are not included in the final model because they are predictors of the more distal predictors of falling that were included in our final model. For example, because functional dependence is closely associated with, and may in part cause, abnormal performance on a mobility exam, it is unlikely to be associated with falling after controlling for an abnormal mobility exam. However, preventing functional dependence and treating potential causes of functional dependence such as depressive symptoms may be a more useful long-term method of preventing falls than waiting for people to develop an abnormal mobility exam (28). Similarly, higher levels of physical activity may improve mobility and balance performance. As a result, physical activity levels may not be associated with falling after controlling for mobility and balance. However, increasing levels of physical fitness may still play an important role in preventing falls (11,31).

While we found that a history of falling in the prior year predicts falling in the subsequent year, we found that a history of balance difficulty or dizziness, together with an abnormal mobility exam, are better discriminators of future fallers than a falls history. Furthermore, all these factors together discriminate fallers from nonfallers better than any single risk factor alone. Our results differ from a recent report in nursing home patients that a falls history is by far the single strongest predictor of future falling (42). This report utilized data from the minimum data set (MDS) and may reflect the possibility that falls are more reliably included in the MDS than are specific risk factors for falling. It is also likely that a prior falls history is a stronger predictor of future falls in a highly dependent nursing home population than in a mostly independent community-dwelling population. Other community-based studies have demonstrated that a prior history of falling is a risk factor for future falling (12,19,21). However, we are not aware of community-based studies that explicitly compare the utility of indices that include falls history with indices that include other risk factors for predicting subsequent falls.

Most published fall risk indices differ somewhat from each other because they consider different risk factors in their development (2,4,12–20). For example, not all risk indices consider a previous fall as a risk factor, while others consider risk factors we did not measure, such as specific medications. Virtually all community-based studies have found some measure of mobility or stability to be an important risk factor for falling, although the specific measures used vary between studies (2,4,12–20). For example, Maki (19) demonstrated that measures of postural balance were strongly associated with subsequent falls, while Tinetti (23) demonstrated that simple performance-based tests of balance and mobility predicted subsequent falls. The use of different variables in different studies makes it difficult to compare different indices. While our risk index has fewer variables than other indices, it has the advantage of being conceptually simple and easy to administer. The three variables in the index can be obtained easily during the course of a routine clinical history and examination.

An important limitation of our risk index, along with virtually all other published fall-risk indices, is that the index has not been validated in a patient population that differs from the development sample. As described by Justice (41), the development of a risk index is akin to the development of any scientific hypothesis. Like any scientific hypothesis, a risk index needs to be subjected to the scrutiny of repeated testing. Before recommending a risk index for widespread clinical use, its stability and generalizability should be tested in populations that differ from the development sample. Ideally, these validations should test the generalizability of the index in people with at least moderately different characteristics from those in the development sample, across different intervals of time, and using somewhat different methods of data collection by different investigators (41). We are aware of only one fall risk index, which was developed for use in older hospital inpatients, that has been validated in a patient population that differs from the development sample.
validated in a population distinct from the development sample (24).

Several limitations of our study should be considered in interpreting our results. First, because we asked respondents to recall falls over a full year, it is possible that they did not recall all their falls. Cummings (43) has previously reported that 13% of patients with documented falls during a 12-month period failed to recall falls when interviewed. This recall bias probably caused us to underestimate the discriminative ability of our risk index. Second, it is possible that some respondents had difficulty distinguishing balance difficulties from actual fall occurrences. Third, our sample was homogeneous in terms of ethnicity, potentially limiting the generalizability of our results. Fourth, we were unable to obtain data on falls among respondents who either died during the index year or who were lost to follow-up.

In conclusion, a simple risk index that includes a history of falling in the prior year, symptoms of dizziness or balance difficulty, and an abnormal mobility exam stratifies people into groups at markedly differing risks of falling over the subsequent year. The discriminative ability of this index is considerably better than an index that just considers people into groups at markedly differing risks of falling in the prior year or who were lost to follow-up.

Acknowledgments

This study was funded in part by the National Institute on Aging Grants AG-10738 (Buffers of Impairment/Disability Cascade Among the Old-Old) and AG-07823 (Adaptation to Frailty Among Dispersed Elderly).

This project was supported by a merit award from the National Institute on Aging to Dr. Kahana. Dr. Covinsky (a Paul Beeson Faculty Scholar in Aging Research) was supported in part by a clinical investigator award from the National Institute on Aging (K23AG00714) and an Independent Scientist Award from the Agency for Healthcare Research and Quality (K02HS00060-01). Dr. Kahana was supported in part by a Merit Award from the National Institute on Aging. Dr. Justice (a Robert Wood Johnson Generalist Physician Faculty Scholar) was supported in part by a clinical investigator award from the National Institute on Aging (AG 00826-03).

Dr. Schumacher is now with the Gerontology Program, Bowling Green State University, Bowling Green, OH.

Address correspondence to Dr. Kenneth E. Covinsky, Division of Geriatrics, San Francisco VAMC (111G), 4150 Clement, San Francisco, CA 94121. E-mail: covinsky@medicine.ucsf.edu

References


