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A Two-Year Longitudinal Study of Falls in 482 Community-Dwelling Elderly Adults

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Background. Falls are a common occurrence in elderly persons, including relatively healthy, community-dwelling men and women. A significant percentage of falls result in soft-tissue injuries. Although some risk factors for falls have been identified, more research is needed on risk factors for injurious falls. In addition, there is little information from prospective studies on the long-term consequences of falls other than injury.

Methods. Risk factors and consequences of falls were analyzed in a 24-month prospective study of 482 elderly (mean age 74 ± 6.7 years) men and women living independently in the community. Falls and injurious falls were ascertained by telephone and by a bimonthly postcard follow-up. Predictor variables were obtained from a baseline assessment and follow-up questionnaire. Outcomes were defined as rates of falls and injurious falls, circumstances surrounding the fall, and the long-term correlates of falls.

Results. Sixty-one percent of the participants (53.7% of men and 65.7% of women) reported one or more falls during the 2-year follow-up. The crude rates of injurious falls were 11.17 per 1000 person-months in women and 7.23 per 1000 person-months in men. Age, history of fracture, low physical health, and low or high mobility level were risk factors for injurious falls in both sexes. The inability to balance unsupported on one leg was associated with injurious falls in women (rate ratio [RR] = 3.0; 95% confidence interval 1.9–4.7). Self-reported cognitive, physical health, and mobility impairments were greater in female fallers compared to the nonfallers.

Conclusions. Falls and injurious falls without fracture are frequent events for healthy elderly people and may be associated with morbid changes in cognitive status, physical health, and mobility.

INJURIOUS falls and the restriction of activity due to falls are some of the most important factors underlying morbidity in the elderly population (1–4). It has been estimated that 25-35% of community-dwelling elderly persons older than 65 years fall at least once each year, and about 40–50% of fallers experience two or more falls (5). These estimates refer generally to the proportions or prevalences of fallers in the community. Because risk factors identified for fallers may differ from those for falls, there is interest in quantifying rates of falls over time (6). Until recently, most data for rates of falls were based on cross-sectional or retrospective data for self-reported and recalled falls, which may underestimate the actual frequency of falls. Few prospective studies have estimated rates of falls in community-dwelling elderly adults over follow-up periods longer than 12 months (5,7,8).

There is little information on risk factors for injurious falls (8). Risk factors for injurious falls may differ substantially from those for noninjurious falls. Theoretically, injurious falls may involve more "intrinsic," or personal, than "extrinsic," or environmental, factors (9). Estimated rates of injurious falls may vary widely depending on the definition of injury. Approximately 5–10% of falls are reported to result in serious injuries such as fractures, head trauma, or joint dislocation requiring hospitalization (10). These injuries are clearly associated with increased morbidity and mortality in the elderly population. However, many falls result in less severe injuries such as cuts, bruises, or abrasions that may require medical attention but not hospitalization. Rates for these less severe falls are not well established. Nevitt et al. (10) reported that 55% of falls in 325 elderly community-dwelling persons followed over 1 year resulted in minor soft-tissue injury. In a recent prospective study of community-dwelling elderly persons in Montreal, about 43% of reported falls resulted in a minor injury (8).

Prospective studies of falls and injurious falls need to describe better the long-term consequences of these events. Falls and especially injurious falls may produce a "post-fall syndrome" in some elderly persons that may include fear of falling, social withdrawal, depression, and other psychological sequelae; restriction of daily activities; increased dependence; and a generalized decline in function and in health (1–4,8–10). However, there is little information from prospective studies on the consequences of falls other than injury (10). These data are needed to help design interventional studies to prevent the post-fall syndrome in community-dwelling elderly populations.

In this article we present data from the first 2 years of follow-up of an ongoing longitudinal study of falls in 482 community-dwelling elderly persons. The aims of this

study are: (i) to provide more information on risk factors for falls and injurious falls in elderly persons living at home; and (ii) to better understand the long-term consequences of falls in this population.

METHODS

Subjects

The Albuquerque Falls Study (AFS) was initiated in 1990, and the general characteristics of the study population have been described in previous publications (11,12). Participants were recruited from two longitudinal studies based in Albuquerque, NM: the New Mexico Aging Process Study (NMAPS) and the Study of Blood Donation in the Elderly (13). Entrance criteria for these studies limited the sample to persons older than 60 years of age and excluded those with diagnosed major medical conditions such as noninsulin dependent diabetes, coronary heart disease, and uncontrolled hypertension. All subjects were volunteers, and the study cohort does not represent a population-based sample. The mean age was 74.1 ± 6.6 years at baseline (in 1990). Fifty-nine percent of the cohort was female and 41% was male. The study was not limited to any ethnic group, but 96% were White, 3% Hispanic, and 1% other. For the most part, the subjects' perceptions of their health status were good to excellent: 27% had one or more diagnosed chronic conditions. Ninety percent of the subjects could walk without help and could do their own shopping upon entry into the study. The mean number of prescribed drugs was 1.51 per person. The cognitive status of this population was generally good (mean Mini-Mental State Examination [MMSE] score = 29 ± 2.1 in 1990). Sixty-one percent of the study participants were married, and 49% had college degrees.

Baseline Examination

All participants underwent annual exams to assess physical and cognitive status as well as functional assessments of balance and gait. In addition, all participants completed a self-administered questionnaire that assessed their own sense of well-being. The battery of tests used in this study are described below.

Physical examination.—Each subject completed a medical history questionnaire and interview (topics included drug prescription and consumption) and underwent a general physical examination by a nurse practitioner or physician assistant, which included measurement of blood pressure, height, and weight.

Balance and gait assessment.—Balance and gait performance were assessed by using the instrument developed by Tinetti (14) and administered by a trained nurse practitioner. In the Tinetti instrument, balance was assessed with regard to 13 position changes. The assessment of gait included 9 observations: initiation of gait, step height, step length, step symmetry, step continuity, path deviation, trunk stability, walk stance, and turning while walking. Each of the 13 position changes and 9 gait observations was scored as either normal or abnormal.

Interview.—The Iowa Self-Assessment Inventory (ISAI) was administered to each subject in 1990 and again in 1993 after 2 years of follow-up. The ISAI is a 56-item self-administered questionnaire and appears to be a reliable and valid instrument to assess the volunteers' own sense of well-being (15,16). Seven scales make up the inventory; they are economic resources, emotional balance, physical health, trusting others, mobility, cognitive status, and social support. Scores can range from 8 to 32, with higher scores indicating favorable, positive, or healthy assessments. It is important to remember that the ratings of the items in the inventory are the respondent's perceptions of his or her own status.

Ascertainment and Assessment of Falls

Participants were instructed to report any event they considered to be a fall by calling the study coordinator. To ascertain unreported falls, all participants were sent a stamped postcard bimonthly (12). If a response was not received in 15 days, a second card was sent. People who did not respond to more than two postcards were generally considered to be lost to follow-up. A fall was defined according to the World Health Organization (WHO) Work Group on the Prevention of Falls by the Elderly as, "an event which results in a person coming to rest inadvertently on the ground or other lower level and other than as a consequence of the following: sustaining a violent blow; loss of consciousness; sudden onset of paralysis, as in a stroke and an epileptic seizure" (4). Each subject was interviewed as soon as possible after each reported fall to review the circumstances of the incident and determine whether the incident reported by the participant met the study definition of a fall.

If the event met the study definition of a fall, a WHO falls questionnaire was completed by the study coordinator when interviewing the subject via telephone (4). This questionnaire elicits detailed information about the context and circumstances of a fall; for example, questions address the living situation before the fall, the description of the fall, environmental factors associated with the fall, consequences of the fall, how assistance was obtained, care provided, and associated morbidity. In particular, the questionnaire includes information on the types and causes of falls, whether a fall required first aid or medical attention, the type and severity of any injuries sustained, and the length of lie following the fall. In addition, information about the living situation, activities, and functional status of the faller was obtained.

Statistical Analyses

This article presents results for the first 2 years (1991–1992) of follow-up in the AFS. Following the recommendation of Cumming et al. (6), the analyses focused primarily on risk factors for falls and injurious falls rather than for fallers. From a public health perspective, risk factors that affect the rates of falls and injurious falls are more important than, and not necessarily the same as, those that identify fallers. Consequently, in the present study all falls and injurious falls reported during 1991–1992 were the primary outcome variables. Predictor variables were those assessments made at the subjects' baseline visit in 1990. The predictor variables (risk factors) of interest included: age;

MMSE score; body mass index (BMI; weight [kg]/stature^2 [m]^2); balance and gait abnormalities; number of medications; specific use of cardiac, sedative, and hypnotic medications; replacement estrogen use in women; physical health and mobility scores from the ISAI; living status (alone vs with another person); self-reported difficulties with balance; walking and standing; a fall in the year prior to 1990; and self-reported previous fracture due to a fall.

The rates of falls and injurious falls for any defined category of the predictor variables (R_j) were calculated as the number of falls recorded (F_j) divided by the sum of the lengths of follow-up time contributed by each individual (Δt_i) in that category, or $R_j = F_j/[\Sigma(\Delta t_i)]_j$, where $i = 1$, N_j = subjects, $j = 1$, and k = categories of each predictor variable. Rates of falls calculated by this formula were expressed in terms of 1000 person-months. These rates are not the same as "incidence densities" because they include repeated falls in some individuals. The calculated rates included data for individuals who were lost to follow-up (failed to return more than two postcards) and contributed only partial follow-up time. The possibility that subjects lost to follow-up differed from those who completed the 24 months of follow-up in terms of the frequency of falls was examined in two ways. First, the number of falls reported per postcard was plotted against the number of postcards returned. Second, the rate of falls per 1000 person-months in those contributing <18 months of follow-up was compared to the rate in those who contributed ≥18 months and were still active participants in 1993.

Ratios of rates were calculated for each predictor variable by using the category presumed to convey the lowest risk as the referent rate. Categories of continuous predictor variables (e.g., age, BMI) were defined according to tertiles or quartiles of their distributions. Rate ratios (RRs), which are interpretable as "relative risks," were calculated for all falls and separately for falls that resulted in injury. Injurious falls were defined as any fall for which the subject reported an immediate need for first aid or, in most cases, the attention of a nurse or physician. Self-reported need for first aid was used in conjunction with information on the type of injury to exclude falls resulting in trivial soft tissue injuries that did not require any form of treatment. This approach was developed in the attempt to reduce self-reporting biases (subjects either minimizing or dramatizing the severity of injuries) and to obtain a more objective definition of injurious falls. Even with this constraint, injurious falls included a broad range of trauma, from fractures requiring hospitalization to minor cuts, contusions, or abrasions requiring simple medications or bandages.

Univariate and multivariate analyses were calculated for the RRs or relative risks. Multiple logistic regression was used in the multivariate analyses. Analyses were first made that included only clinically observed variables. Self-reported variables (i.e., ISAI) were then added to the analyses. Models were analyzed for the combined sexes and separately for each sex for falls and injurious falls.

Although 96 of the 536 falls recorded over the 2 years of follow-up required immediate care, an important point is that even if a fall did not result in physical injury, it could have led to other serious consequences. The shock of falling, if the elderly patient is unable to get up, may generate a fear of falling again, which may lead to anxiety, loss of confidence, social withdrawal, and restriction in daily activities. It has been reported that nearly 50% of elderly persons who fall report "fear of falling," and that 25% modify their behavior as a result of this fear (17). To examine this possibility, fallers without fracture were compared with nonfallers for changes in scores between baseline in 1990 and 1993 for the various components of the ISAI. The mean changes in each group for physical health and mobility scores were tested for whether they were statistically significantly different from zero ($p < .05$). These findings were restricted to 405 individuals for whom ISAI questionnaires were available in 1990 and 1993 and who contributed 18 or more months of follow-up for falls. In addition, the numbers of fallers and nonfallers reporting the need for a cane, help in shopping, help getting around town, or help walking in 1993, who did not report these needs in 1990, were counted for each sex. These new self-reported cases of needs for assistance in mobility were expressed as percentages of the number of subjects in each group who responded to both the 1990 and 1993 ISAI questionnaires and who did not report any of these needs at baseline. The fallers and nonfallers were then compared by computing the ratio of these percentage rates for each sex. As noted by Cumming et al. (6), a problem in comparing fallers with nonfallers is the certainty with which the two groups can be accurately identified. Typically, fallers are identified by whether they report having fallen over some defined period; for example, the previous year. Some individuals, however, who have experienced multiple falls over a longer period may not fall during the fall ascertainment period, whereas other individuals who rarely fall may experience a fall during this period. The extent of misclassification of fallers and nonfallers is therefore conditional upon the length of the period over which falls are ascertained. Thus, it is important to note that, in the above comparisons, the group of nonfallers included those individuals who did not report a fall during the full 2 years of follow-up.

The Statistical Analysis System (SAS Institute, Cary, NC) was used for all statistical analyses.

Results

Frequency and Description of Falls

Of the 482 subjects, 405 (84%) completed 24 months of follow-up. Some of these individuals, however, did not return all 12 bimonthly postcards and did not contribute a full 24 months of data, so the median length of follow-up time was 22 months. A total of 536 falls occurred over 10,010 person-months for an overall rate of 53.5 falls per 1000 person-months. Forty-eight of the 536 falls occurred in the 77 participants who were lost to follow-up but who contributed 752 person-months of follow-up time, for a crude rate of 63.8 falls per 1000 person-months. Thus, the rate of falls appeared to be somewhat higher in those who were lost to follow-up than in those who were active participants at the end of the study period. However, there was no association between the reported number of falls per postcard and the number of postcards returned.

A total of 352 falls occurred in the women, who contributed 6000 person-months of follow-up (rate = 58.7 falls per 1000 person-months). In the men, 184 falls occurred over 4010 person-months (rate = 45.9 falls per 1000 person-months). The crude rate of falls in the women was significantly greater than in the men: the RR was 1.28 with a 95% confidence interval (95% CI) from 1.07 to 1.53. Sixty-one percent of the participants (53.7% of the men and 65.7% of the women) reported one or more falls during 1991 or 1992. The number of repeated falls within individuals ranged from 2 to 11. Among those who fell, 49% of the women and 43% of the men reported two or more falls; 12% of the women and 13% of men had more than three falls.

Nineteen percent of the falls in the women (67/352) and 16% in the men (29/184) resulted in some injury requiring first aid or medical treatment. About 25% of injurious falls required hospitalization. The majority of injuries were contusions or abrasions, followed by sprains, lacerations, and other soft-tissue injuries. About 6.4% of the falls in the women and 2.5% in the men resulted in a fracture. Contusions and abrasions were reported in about 41% of falls not requiring first aid or medical care. Thus, our definition of injurious falls clearly did not include all self-reported injuries, but only those of sufficient severity to require some form of treatment. The crude rates of injurious falls were calculated to be 11.17 per 1000 person-months in the women and 7.23 per 1000 person-months in the men. Thus, the women were 1.54 (11.17/7.23) times more likely to have experienced an injurious fall than the men.

About 75% of the subjects stated that they were able to get up immediately after the fall. Approximately 20% required some assistance in getting to their feet. Ability to get up immediately after a fall was reduced markedly in injurious falls. Subjects reported being able to stand up immediately following only 36% of injurious falls, and slightly more than half required some assistance in getting up. The "length of lie" following a fall also was increased in injurious compared to noninjurious falls. Subjects required more than a minute to get up following 64% of injurious falls versus 20% of noninjurious falls: eight subjects with injurious falls had long lies of ≥1 h.

Circumstances of Falls

The nature of the falls was "accidental" in more than 90% of cases. "Feelings of faintness" were reported for less than 3% of all falls. Most people were engaged in an activity such as standing or walking prior to the fall and tripped or stumbled. Nearly half of the falls occurred when a person encountered an object that caused an unexpected displacement for which they lacked the capacity to correct in the available time. The highest percentage of falls in women occurred at home (56%), whereas for men most falls occurred outside in a public place. Nearly 80% of falls occurred during the day, and these were evenly distributed between morning and afternoon; only 20% of falls occurred during twilight. About 50% of the falls were in a forward direction. The part of the body receiving the main impact of a fall, in order of frequency, was as follows: hands, buttocks, head, knees, and arms (see Figure 1).

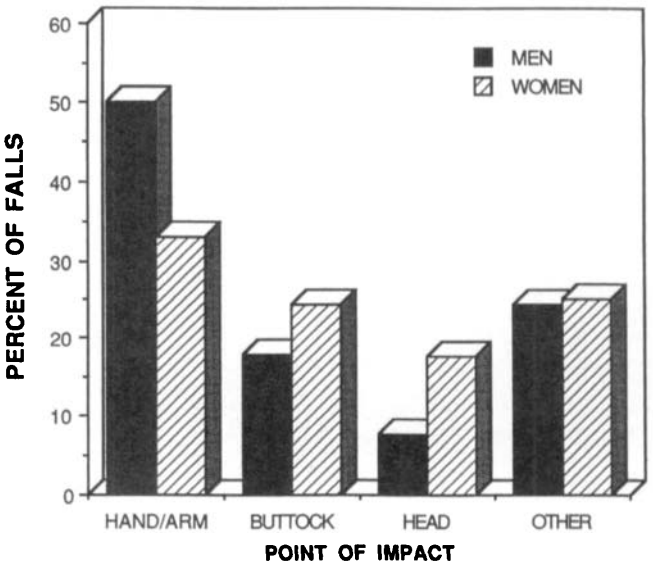

Figure 1. Percent of falls by parts of the body sustaining the main impact of each fall for men and women. AFS, 1990–1993.

Risk Factors for Falls and Injurious Falls

Tables 1 and 2 show crude rates and RRs with 95% CIs for falls and injurious falls for the predictor variables from the univariate analyses. Rates for falls increased with age in both sexes, and RRs were significantly higher ($p < .05$) in the men [1.57 (95% CI, 1.05–2.36)] and the women [1.35 (1.03–1.77)] older than 75 years compared to those 63–69 years of age. The age-associated increase in injurious falls was somewhat greater than for noninjurious falls, and those older than 80 years of age were at least two to three times more likely to report an injurious fall than younger men and women 63–69 years of age [men, 10.2 (3.1–33.6); women, 3.5 (1.9–6.5)].

BMI was not related significantly to falls in either the men or the women. Neither excessive thinness, possibly associated with muscle loss, nor fatness appeared to alter the risk of falling. "Obesity," or a BMI greater than 27 kg/m^2, however, appeared to be a protective factor for injurious falls in the men [RR = 0.16 (0.04–0.61)]. It is possible that obese men were less active and decreased their exposure to factors leading to injurious falls.

The one-leg standing balance, defined as the ability to balance on one leg for 5 or more sec, and the total balance score were highly correlated ($r = 0.85$). The inability to balance unsupported on one leg was used in the analyses because it is easier to observe clinically and was the primary abnormality contributing to the total balance score in most individuals. In the univariate analyses, one leg standing balance was significantly related to increased risk for falls [RR = 2.0 (1.4–2.8)], but not injurious falls [RR = 1.8 (0.8–4.2)] in the men. The reverse, however, appeared to be true in the women in whom one-leg standing balance was significantly associated with increased risk for injurious falls [RR = 3.0 (1.9–4.7)], but not falls in general [RR = 1.1 (0.9–1.4)]. These sex differences may be due to a different pattern of response to loss of balance in the men than in the women. As shown in Figure 1,

Table 1. Crude Rates and RRs for Falls and Injurious Falls by Risk Factor in Community-Dwelling Elderly Women: AFS, 1990–1993

	Falls			Injurious Falls		
	Rate	RR	95% CI	Rate	RR	95% CI
Age Group (years)						
63–69	51.3	1.00		6.9	1.00	
70–74	44.4	.87	(.63–1.20)	5.6	.80	(.33–1.99)
75–79	69.4	1.35	(1.03–1.77)	11.5	1.66	(.83–3.31)
80+	72.6	1.41	(1.06–1.88)	24.5	3.54	(1.94–6.46)
BMI (kg/m²)						
≤ 22.4	54.0	1.00		10.4	1.00	
22.5–24.6	54.4	1.01	(.75–1.36)	8.6	.83	(.40–1.70)
24.7–27.2	66.9	1.24	(.93–1.65)	12.6	1.21	(.63–2.36)
≥ 27.3	60.7	1.12	(.84–1.50)	13.3	1.28	(.68–2.41)
One-Leg Standing Balance						
Normal/adaptive	56.6	1.00		7.8	1.00	
Abnormal	63.0	1.11	(.86–1.44)	23.2	2.97	(1.86–4.74)
Gait Abnormalities						
None	55.9	1.00		9.3	1.00	
One or more	80.6	1.44	(1.09–1.91)	23.6	2.53	(1.48–4.30)
Physical Health Score						
> 27 (high)	50.5	1.00		5.8	1.00	
≤ 27 (low)	66.3	1.31	(1.06–2.04)	15.3	2.65	(1.53–4.58)
Mobility Score						
> 30 (high)	57.1	1.00		9.5	1.00	
≤ 30 (low)	62.0	1.09	(.87–1.36)	13.8	1.45	(.88–2.40)
No. of Medications						
None	44.2	1.00		5.6	1.00	
1	46.6	1.05	(.72–1.54)	8.5	1.51	(.56–4.07)
2	70.0	1.59	(1.12–2.24)	12.7	2.25	(.91–5.56)
3 +	65.0	1.47	(1.06–2.04)	14.6	2.59	(1.12–5.98)
Estrogen Use						
No	56.5	1.00		11.1	1.00	
Yes	64.5	1.14	(.90–1.45)	11.7	1.05	(.61–1.82)
Live Alone						
No	56.2	1.00		11.0	1.00	
Yes	61.2	1.09	(.88–1.34)	11.1	1.02	(.63–1.65)
Difficulty Walking						
No	55.0	1.00		9.5	1.00	
Yes	83.3	1.52	(1.16–1.98)	21.5	2.27	(1.33–3.88)
Difficulty Standing						
No	58.1	1.00		9.5	1.00	
Yes	64.3	1.11	(.80–1.54)	24.1	2.53	(1.45–4.41)
Fall in Year Prior to 1990						
No	49.3	1.00		10.1	1.00	
Yes	82.3	1.67	(1.35–2.06)	13.4	1.33	(.80–2.20)
History of Fracture						
No	53.1	1.00		9.3	1.00	
Yes	7.9	1.34	(1.08–1.65)	14.8	1.59	(.98–2.58)

men reported the point-of-impact for falls to be the hand or arm more frequently than the women, whereas the women reported the point of impact to be the buttocks or head more often than the men. Thus, it is possible that the men were able to extend the arm, break the force of the fall, and avoid injury more often than the women. One or more gait abnormalities was a risk factor for falls in both sexes and for injurious falls in the women [RR = 2.5 (1.5–4.3)].

Low self-ratings (scores ≤ 27) for the physical health component of the ISAI were positively related to risk of falls and injurious falls, particularly in the women (RR = 1.3 for falls; RR = 2.6 for injurious falls). Low self-ratings (scores ≤ 30) for the mobility component of the ISAI, in contrast, appeared to be a protective factor in the men, especially for injurious falls [RR = 0.4 (0.2–0.9)].

Taking two or more medications was associated with

Table 2. Crude Rates and RRs for Falls and Injurious Falls by Risk Factor in Community-Dwelling Elderly Men: AFS, 1990–1993

	Falls			Injurious Falls		
	Rate	RR	95% CI	Rate	RR	95% CI
Age Group (years)						
63–69	37.0	1.00		1.6	1.00	
70–74	28.2	.76	(.49–1.20)	3.5	2.14	(.41–11.2)
75–79	58.3	1.57	(1.05–2.36)	10.9	6.64	(1.76–25.0)
80+	70.6	1.91	(1.30–2.79)	16.7	10.18	(3.08–33.6)
BMI (kg/m²)						
≤ 22.4	46.4	1.00		12.0	1.00	
22.5–24.6	59.1	1.27	(.82–1.98)	11.8	.98	(.40–2.44)
24.7–27.2	37.3	.80	(.50–1.30)	5.1	.42	(.15–1.22)
≥ 27.3	4.4	.87	(.54–1.41)	1.9	.16	(.04–.61)
One-Leg Standing Balance						
Normal/adaptive	39.8	1.00		6.5	1.00	
Abnormal	79.7	2.01	(1.45–2.77)	11.6	1.79	(.78–4.15)
Gait Abnormalities						
None	38.9	1.00		6.7	1.00	
One or more	76.3	1.96	(1.44–2.67)	9.5	1.41	(.61–3.30)
Physical Health Score						
> 27 (high)	37.2	1.00		6.0	1.00	
≤ 27 (low)	54.9	1.48	(1.09–1.99)	7.8	1.30	(.61–2.80)
Mobility Score						
> 30 (high)	53.9	1.00		11.4	1.00	
≤ 30 (low)	43.0	.80	(.59–1.08)	4.9	.43	(.21–.89)
No. of Medications						
None	57.9	1.00		6.6	1.00	
1	40.0	.69	(.46–1.03)	4.0	.60	(.18–2.03)
2	36.2	.62	(.41–.94)	8.3	1.24	(.45–3.42)
3+	48.5	.84	(.57–1.22)	10.1	1.52	(.58–3.96)
Live Alone						
No	45.7	1.00		6.5	1.00	
Yes	46.3	1.01	(.64–1.59)	13.2	2.04	(.84–4.91)
Difficulty Walking						
No	44.2	1.00		7.4	1.00	
Yes	57.9	1.31	(.87–1.97)	6.4	.87	(.26–2.89)
Difficulty Standing						
No	42.2	1.00		6.8	1.00	
Yes	90.6	2.15	(1.44–3.20)	13.4	1.99	(.71–5.59)
Fall in Year Prior to 1990						
No	34.9	1.00		6.7	1.00	
Yes	84.7	2.43	(1.82–3.23)	9.2	1.36	(.61–3.06)
History of Fracture						
No	44.1	1.00		6.1	1.00	
Yes	53.6	1.21	(.85–1.74)	13.0	2.16	(1.00–4.65)

increased risk for falls [RR = 1.59 (1.12–2.24)], and three or more medications was associated with risk for injurious falls [RR = 2.59 (1.12–5.98)] in the women but not in the men. These findings partially support those of other researchers, which suggest that multiple medication use by elderly patients may increase risk for falls (10) even in very healthy, noninstitutionalized elderly subjects as in the AFS. Approximately 25% of the women were taking estrogen replacements. Estrogen might be hypothesized to protect against falls. In the present analyses, however, estrogen use was not associated significantly with a decreased or increased risk for falls or injurious falls.

Whether or not the subject lived alone was not consistently associated with risk for falls or injurious falls. Self-reported difficulty walking and standing was associated with increased risk for injurious falls in the women (RRs of 2.3 and 2.5, respectively) but not in the men. This finding would appear to agree with the sex difference in risks for injurious falls associated with observed abnormalities in balance and gait.

Finally, men and women who reported falling in the year prior to 1990 were significantly more likely to sustain a fall in the subsequent 2 years of follow-up [men, RR= 2.4 (1.8–3.2); women, RR = 1.7 (1.4–2.1)]. Self-reported falls prior to baseline, however, did not predict injurious falls. A fracture prior to 1990 due to a fall was significantly related to risk for subsequent falls in the women [RR = 1.3 (1.1–1.6)] but not in the men. Previous fractures were significant predictors for subsequent injurious falls in the men [RR = 2.2 (1.0–4.6)]: a slight, but nonsignificant increased risk was observed in the women [RR = 1.6 (0.9–2.6)].

Results for Multivariate Analyses

Results of multivariate analyses for the combined sexes are shown in Tables 3 and 4 for falls and injurious falls; those for sex-specific analyses are reported in the text. Age, sex, gait abnormalities, and number of medications were significant risk factors for falls, whereas the use of sedative/hypnotic medications appeared to be a protective factor, after adjustment for all other clinically observed variables in a full multiple logistic regression model, as well as in a reduced model selected through stepwise backward elimination (Table 3). Thus, the risk for falls associated with being female remained the same or even increased slightly ($RR_{adjusted}$ = 1.33 vs RR_{crude} = 1.28) after controlling for age, sex, BMI, balance and gait abnormalities, and medication use. Similarly, the increased risk with age (about 2.2% per year, or 44% over 20 years of age) was not modified substantially by controlling for other clinically observed risk factors. In contrast, only age and number of medications used were associated significantly with injurious falls after controlling for the other, clinically observed risk factors.

Table 4 shows results of the multivariate analyses with self-reported variables included in the model. For total falls, old age (> 80 years), number of medications, self-reported problems with balance, and a fall in the year prior to baseline were statistically significant risk factors, although sex, gait abnormalities, low physical health score, and a previous history of fracture approached significance. It is important to note that the self-report of a fall in the year prior to baseline was one of the most potent risk factors predicting falls during the 24-month follow-up period (RR = 1.860, 95% CI = 1.52 – 2.276). Interestingly, falls in the year prior to baseline was not a significant risk factor for injurious falls. This finding suggests that, whereas the likelihood of a fall during any given period is conditional on whether one has fallen previously, the likelihood of sustaining an injury due to a fall may be independent to some extent of the frequency of falls. Old age (>80 years), number of medications, and low physical health score were the only signifi-

Table 3. Multivariate Analysis of RRs for Falls and Injurious Falls by Clinically Observed Variables in Community-Dwelling Elderly Men and Women: AFS, 1990–1993

	Falls		Injurious Falls	
Independent Variables	RR	95% CI	RR	95% CI
Age (RR/year)	1.022	(1.006–1.039)	1.071	(1.032–1.111)
Sex (female = 0, male = 1)	1.326	(1.089–1.614)	1.257	(.797–1.981)
Thin (BMI < 22 kg/m²)	.846	(.664–1.078)	1.042	(.624–1.742)
Obese (BMI > 27 kg/m²)	.936	(.746–1.171)	.839	(.487–1.448)
One-Leg Standing Balance	1.069	(.848–1.346)	1.272	(.766–2.113)
Gait Abnormalities	1.078	(1.005–1.156)	1.077	(.946–1.226)
No. of Medications	1.075	(1.020–1.133)	1.201	(1.099–1.311)
Cardiac Medications	.981	(.774–1.243)	.665	(.393–1.127)
Sedative/Hypnotics	.499	(.257– .969)	.454	(.130–1.589)

Table 4. Multivariate Analysis of RRs for Falls and Injurious Falls by Clinically Observed and Self-Reported Variables in Community-Dwelling Elderly Men and Women: AFS, 1990–1993

	Falls		Injurious Falls	
Independent Variables	RR	95% CI	RR	95% CI
Age > 80 Years	1.362	(1.022–1.815)	3.569	(1.817–7.009)
Sex	1.173	(.928–1.482)	1.139	(.864–2.963)
Gait Abnormalities	1.041	(.953–1.138)	1.039	(.868–1.245)
No. of Medications	1.054	(1.001–1.109)	1.135	(1.022–1.260)
Physical Health ≤ 27	1.244	(.951–1.627)	2.002	(1.108–3.618)
Mobility ≤ 30	.894	(.721–1.110)	.635	(.383–1.053)
Living Alone	1.016	(.818–1.262)	.955	(.581–1.570)
Difficulty Walking	1.058	(.756–1.480)	.764	(.450–1.295)
Difficulty Standing	.810	(.565–1.160)	1.208	(.834–1.750)
Problems With Balance	1.538	(1.168–2.026)	1.125	(.603–2.096)
Fall in Year Prior to 1990	1.860	(1.519–2.276)	1.244	(.758–2.040)
History of Fracture	1.159	(.939–1.431)	1.416	(.889–2.253)

cant risk factors for injurious falls. Sex-specific analyses revealed only slight differences in associated risk factors in men versus women. In the men, total falls were associated additionally with low physical health score (RR = 1.664, 95% CI 1.028–2.692), and low mobility score was a protective factor for injurious falls (RR = .252, 95%CI .104–.607).

Morbidity Associated With Falls

Table 5 compares nonfallers, fallers, and injurious fallers for self-reported changes between 1990 and 1993 for scores on specific items on the ISAI. Male fallers had small but statistically significant decreases on the ISAI physical health score (–1; $p < .05$) and on the cognitive status score (–1.2 ; $p < .05$). Where nonfallers had a similar small decrease on the physical health score (–1.4), there was no corresponding change in cognitive status scores. Males who reported injurious falls had a more substantial decrease in cognitive status (–2.6, $p < .05$) than nonfallers or fallers in general, but they did not have significant changes in physical health or mobility scores. In the women, the changes in physical health, mobility, and cognitive status associated with falls appeared to be somewhat greater. Women fallers had significant changes on ISAI physical (–1.6, $p < .05$), mobility (–1.1, $p < .05$), and cognitive (–1.5, $p < .05$) scores. In contrast, only changes in physical status scores (–1.1, $p < .05$) were significant in the female nonfallers. Moreover, the changes were statistically significant and slightly greater in the women who reported injurious falls compared to falls without injury: physical health, –2.6; cognitive status, –1.8; and mobility level, –1.8.

Table 6 compares nonfallers and fallers without fracture for percentages of new self-reports of needs for a cane, and help in shopping, walking, and getting around town during the 2-year follow-up for each sex. The increase in the numbers of women reporting these needs in 1993 who did not report them in 1990 was 1.6 to 4.9 times greater among the fallers than the nonfallers. The numbers of new self-reported needs for help were not increased in the male fallers compared to the nonfallers, with the exception of need for help in walking or getting around town. It is possible that the men were more reluctant than the women to admit these needs, or that the consequences of falls for mobility status were less severe in the men than in the women.

Table 5. Changes in ISAI Scores Between 1990 and 1993 in Nonfallers Versus Fallers and Fallers With Injuries: AFS, 1990–1993

	ISAI Score		
	Nonfallers	Fallers	Injurious Fallers
Women	$n = 57$	$n = 131$	$n = 37$
Physical health	–1.1*	–1.6*	–2.6*
Mobility	0.0	–1.1*	–1.8*
Cognitive status	–0.7	–1.5*	–1.8*
Men	$n = 54$	$n = 68$	$n = 17$
Physical health	–1.4	–1.1*	+0.5
Mobility	+0.5	–0.1	–0.6
Cognitive status	–0.2	–1.2*	–2.6*

*Change between 1990 and 1993 scores significantly different from zero.

Discussion

Our study has some limitations. First, the AFS is based on a group of volunteers and is not a population-based sample, so generalizations of the results to other elderly populations should be made with caution. It is therefore useful to compare our data with those from other studies to determine to what extent the findings may be specific to our particular study. Recently, we completed a survey of health and nutritional status of a representative population-based sample of elderly men and women in Bernalillo County (Albuquerque). This study, known as the New Mexico Elder Health Survey (NMEHS), has been described in detail elsewhere (18). In brief, a total of 1666 elderly subjects, divided equally between men and women and Hispanic and non-Hispanic white ethnic groups, was sampled randomly from Health Care Finance Authority (Medicare) listings. Of this total, 883 underwent an intensive 4-h interview and examination that included demographics, anthropometry, assessments of nutritional and functional status (including Tinetti balance and gait), self-reported morbidity, and falls in past year. There were distinct differences between the Hispanic and non-Hispanic whites for most variables; because the AFS is composed of mostly non-Hispanic whites, only a comparison with this ethnic group in the NMEHS is meaningful. The mean age of the non-Hispanic white participants in the NMEHS was 74.3 ± 6.2 years, the same as the baseline (1990) age of participants in the AFS (74.1 ± 6.6 years). There were no significant differences between the studies for mean weights, statures, BMI, or dietary intakes for either sex. However, the AFS volunteers were somewhat better educated than the participants in the NMEHS (approximately 49% vs 33% with college degrees) and more affluent (70% vs 66% with incomes >$20,000 per year). The baseline (1990) prevalence in the

Table 6. Percent of Nonfallers and Fallers Without Fracture Reporting Restriction of Activities Between 1990 and 1993: AFS, 1990–1993

Mobility Level	Nonfallers (%)	Fallers Without Fracture (%)	Ratio
Women	$n = 58$	$n = 119$	
Need a cane	1.79*	8.47	4.73
Need help for shopping	1.89	9.32	4.93
Walk with help	1.82	7.96	4.37
Getting around town is a problem	8.93	14.0	1.57
Men	$n = 56$	$n = 67$	
Need a cane	3.77	1.54	0.41
Need help for shopping	5.88	6.15	1.04
Walk with help	0	3.73	—
Getting around town is a problem	1.96	5.97	3.04

*Number of new cases in 1993 / (number of subjects – number of prevalent cases in 1990).

AFS of one or more balance abnormalities was lower (20%) than in the NMEHS (31%), as was the prevalence of one or more gait abnormalities (16% vs 27%). In contrast, 25% of the men and 28% of the women in the NMEHS reported one or more falls in the past year, which were lower than the annual incidence rates for falls in the AFS. Retrospective estimates of rates of falls, however, are known to be subject to recall bias and are less reliable than data collected prospectively, and the true frequency of falls in the NMEHS may be underestimated (6). In summary, the AFS is comparable in some ways to a representative population-based sample of elderly non-Hispanic white men and women from Albuquerque. In other ways, the data from the two studies are not strictly comparable, and it remains difficult to generalize results for falls in the AFS to the elderly population in Albuquerque.

The overall rate of falls in the AFS (53.5 per person-month) is intermediate to rates reported elsewhere (3,5,8,10). Nevitt et al. (10) reported rates for falls and injurious falls that are about 2.5 times greater, but their study sample was restricted to individuals who reported having fallen in the 12 months prior to follow-up. The rates for falls and injurious falls in the men and women who reported having fallen in the year prior to follow-up in the present study were 1.3 to 2.4 times greater than the overall rates, or closer to those reported by Nevitt. This finding clearly indicates that it is important to control for a previous history of falls when analyzing the effects of other risk factors; however, it may be preferable to stratify or statistically control for this factor in analyses rather than to restrict sample selection to those with a previous history of falls.

Age, sex, number of medications used, balance and gait abnormalities, and previous falls were factors that were associated consistently with falls in the AFS in both univariate and multivariate analyses. Multiple medication use and balance and gait abnormalities are common findings in other studies, but there may be some controversy regarding the significance of age and sex as risk factors, especially after other risk factors have been controlled (5,7,8,10). Early community-based studies of falls indicated that age and female sex were risk factors for falls (19,20). Campbell et al. (19) reported not only an increased risk for falls in women, but more risk factors associated with falls compared to men. Some recent follow-up studies, however, have reported no significant associations with either age or sex after controlling for other risk factors in multivariate analyses (7,8,10). The contrasting results in the present study could be due in part to control for a somewhat different set of risk factors. For example, in a study of community-dwelling elderly adults in Montreal, O'Laughlin et al. (8) found that age and sex were not associated significantly with falls after controlling for time-dependent variables such as daily alcohol consumption or days of limited activity, which were not included in the present analyses. However, our contrasting results also may be due to different age-trends for rates of falls and injurious falls between studies. The overall rates for falls and the age increases in these rates appear to be greater in both sexes in the AFS than in the O'Laughlin's study (8). In contrast, the rates for injurious falls were lower in the AFS but increased more rapidly with age. In addition, the age increases were best described as "J-shaped" or exponential in the AFS for both falls and injurious falls, whereas the trend was reported as linear in the men and "U-shaped" in the women in the Montreal study. These differences underscore the point that falls, and probably injurious falls, are determined by a complex mixture of intrinsic and extrinsic factors that can vary from one community to another. The higher rates of falls in the AFS could reflect the combination of a more active population and, perhaps, a more hazardous environment, whereas the lower rates of injurious falls may be due to either better health or a more conservative definition of injury.

Injurious falls were reported in 22% of fallers, totaling 17% of all falls. The present study differs from previous reports in that the definition of an injurious fall was a fall that required immediate first aid or medical attention. In most other studies, falls resulting in small abrasions and contusions not requiring first aid have been considered injurious falls (8,10). If we had selected all falls with self-reported contusion or abrasion, injurious falls would be nearly 40% of all falls. There are benefits as well as drawbacks to the approach taken in the present study to defining injurious falls. On the one hand, possible bias due to some individuals, for example those with poor health, exaggerating the consequences of falls is reduced. On the other hand, the overall rate of injurious falls may be underestimated. In elderly people, contusions or abrasions are likely to occur more often than injuries actually requiring first aid or medical attention. We felt that the more objective situation of sustaining injuries that required attention was a better criterion to use to classify injurious falls.

In the present study, old age, multiple medication use, and poor self-reported physical health were the only statistically significant risk factors for injurious falls. In contrast to falls in general, sex, gait and balance abnormalities, and a previous history of falls were not significant risk factors for injurious falls. This result suggests that the likelihood of injury during a fall may be governed more by factors that increase vulnerability to injury than factors that influence the frequency of falls. Old age, poor physical health, and gait and balance abnormalities are all generally considered to be "intrinsic" risk factors for falls. Our results suggest that only certain intrinsic factors, perhaps those most directly related to "frailty," such as extreme old age and poor physical health, influence whether falls result in injury.

Men tended to report falling on their hands and upper extremities more often than women, who reported falling on their buttocks or heads more frequently. We can only speculate as to the reason for this sex difference in the point of impact for falls. It suggests a sex difference in the dynamics of falls: men may be more likely to fall in a forward direction or they may react more quickly to break the impact of a fall with their hands than women. Women may be more likely to fall to one side. Overall, those people with balance problems may have an increased tendency to fall to one side, and falls to the side are more likely to result in injury than falls in other directions (21). Further study is needed of possible sex difference in fall dynamics.

Self-reported low mobility appeared to be a protective factor against injurious falls in the men in the AFS. This

result suggests that some men in our study, who may recognize their own poor physical health, avoid injurious falls by reducing their physical activity. This highlights a paradoxical problem in relating physical activity to risk for injurious falls. Generally, it is considered that physically active elderly individuals are better able to maintain good muscle strength, balance, reflexes, and psychosocial functioning than more sedentary elderly persons, which may reduce their risk of falls and post-fall syndrome. A high level of mobility or physical activity, however, may also increase risk for injurious falls in individuals who are very old or in poor physical health by exposing them to more environmental hazards. Although some individuals may avoid injurious falls by restricting their activities, restriction of physical activity is generally considered a part of the post-fall syndrome, which also includes a wide array of deleterious social, emotional, and physical changes that describe a downward spiral of health. Future studies need to address more rigorously how physical activity or mobility interacts with other risk factors in relation to injurious falls and post-falls syndrome.

The present study included analyses of clinically observed as well as self-reported and self-assessed risk factors. An interesting finding was that self-assessed problems with balance, as ascertained in the ISAI, were correlated highly with clinically assessed balance abnormalities, and these variables were interchangeable in multivariate analyses. The ISAI self-assessments of physical health and mobility also appeared as significant risk factors. This finding indicates that these items of the ISAI may be useful in large surveys of elderly populations in which clinical assessments may be too difficult or expensive to implement.

Our analyses also suggest that the brief observation of one-leg standing balance may have good clinical predictive value for falls in ambulatory elderly people. However, there are some clear limitations to this finding, which needs to be confirmed in other studies. Although relative risks for falls and injurious falls were increased in both sexes falls for abnormal one-leg standing balance, they were statistically significant for only injurious falls in women (RR = 2.97, 95% CI = 1.86–4.74) and for falls in men (RR = 2.01, 95% CI = 1.45–2.77). In addition, one-leg standing balance was not a statistically significant risk factor in the multivariate analyses controlling for other variables. These inconsistent results partly reflect instability of the estimates due to small numbers, as well as confounding with other factors such as age. Sixty percent of those older than 80 years of age in the present study were unable to balance on one leg for ≥5 sec versus 13% of those younger than 80 years of age. In addition, our definition of abnormal one-leg standing balance was dichotomized at 5 sec: stance time as a continuous variable might be a more sensitive predictor of falls. We have examined the predictive value of one-leg standing balance more intensively elsewhere (22). We reported that the sensitivity of abnormal one-leg balance for predicting injurious falls was about 36% and the positive predictive value was about 31%. There are likely to be other tests of balance that have greater sensitivity and predictive value, but the one-leg standing balance test is very straightforward and easy to observe in the clinical setting.

Because falls are a very frequent event for elders (61% of the population in the 2-year study period), interventions to prevent falls in large populations are likely to be inefficient and costly. It may be more cost-effective to try to prevent injurious falls because physical injuries probably account for most of the long-term consequences of falls (10). Future studies need to evaluate the practicality of different interventions designed to prevent injurious falls in elderly populations. For example, some interventions, such as exercise programs designed to increase muscle strength and improve balance and gait, will be applicable mainly to elderly people in relatively good physical health. Passive interventions, such as hip pads, may help prevent serious hip fractures but might not be effective in preventing minor injuries or other behavioral and psychological consequences associated with fear of falling. Our results suggest that reduced physical mobility is a protective factor for injurious falls in people with poor health status. However, it would be illogical to propose the prevention of injurious falls through the restriction of activity if such restriction is considered a deleterious part of the post-fall syndrome.

Previous publications have defined the post-fall syndrome as a decrease in mobility, leading to further decline in functional activities (1–4). These changes are often attributed to anxiety and fear of falling again. In the present study, only 30% of those who fell during the follow-up period reported that they were afraid of falling again. About 13% of the women stated that the fall had significantly changed their life and had subsequently restricted their physical and social activities. Fallers who restricted their activities after a fall, however, were statistically more likely ($p < .05$) to report being afraid of falling again compared to fallers who did not restrict their activities.

In this study, we detected self-reported changes in physical health, mobility, and cognitive status associated with falls in a population of free-living elderly persons over a 2-year period. Because these changes were based on self-reports, it is possible that the results could be subject to differential reporting bias; that is, the fallers might have been more or less likely to report some changes than the nonfallers. It is unlikely that these changes could have been due to other diseases, however, because decreases in the ISAI physical health scores were slightly greater in the nonfallers than in the fallers. For example, in the women, the number of nonfallers reporting decreased physical health increased 11.9% during the follow-up period versus 6.3% in the fallers. In these analyses we kept only participants that returned the ISAI questionnaire in both 1990 and 1993. Participants who developed severe disease during the 2-year period dropped out of the study. Because these results were based on data for individuals who had completed the full 2 years of follow-up and ISAI questionnaires in both 1990 and 1993, it is possible that some fallers who dropped out due to more serious consequences of falls were not included. As a result, the actual changes in the fallers compared to the nonfallers may be somewhat underestimated. It is important to note that in the present study the changes observed in selected items on the ISAI are assumed to be consequences of falls. This may not be strictly true, because these changes occurred during the follow-up for falls.

These self-reported changes in cognitive status, physical health, and mobility could also be causes of falls. Due to the high frequency of falls, it would be very difficult to determine whether the changes preceded or followed falls or injurious falls. It would be necessary, for example, to administer the ISAI after every fall.

The long-term consequences of falls, other than those associated with fractures, have not been carefully studied. Future studies need to better establish the long-term consequences of injurious falls without fracture in elderly populations. It is possible that certain characteristics can be found that identify elderly persons who are more likely to respond to injurious falls with the morbid pattern identified in the post-falls syndrome. Tinetti et al. (2) recently identified risk factors for the inability to get up without help after a fall, which may influence the long-term consequences of falls. It may prove more economical and effective to direct efforts toward the detection of such predictors and to focus interventions on preventing injurious falls and the post-fall syndrome.

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