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# The Effect of Falls and Fall Injuries on Functioning in Community-Dwelling Older Persons

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***Background.*** Several preventive strategies have proven effective at reducing the occurrence and rate of falling. It remains to be determined, however, whether, and to what extent, falls and/or fall injuries are independent determinants of adverse functional outcomes in older persons.

***Methods.*** A probability sample of 1,103 community-dwelling persons over age 71 years was followed for 3 years. The 957 cohort members (87%) who participated in at least one follow-up interview while residing in the community were included in this study. Outcome measures included one and three year change in basic and instrumental activities of daily living (BADLs-IADLs), social activities, and physical activities. Based on daily calendars and hospital surveillance, participants were placed into one of four levels of fall status: no falls, one fall without serious injury, at least two falls without serious injury, and one or more falls with serious injury. Hierarchical linear regression models, sequentially adding six domains of covariates, were constructed to examine fall status as a risk factor for change in function.

***Results.*** One noninjurious fall ($\beta = -.437$; $p < .01$), at least two noninjurious falls ($\beta = -.877$; $p < .001$); and at least one injurious fall ($\beta = -1.254$; $p < .001$) were each associated with decline in BADL-IADL function over 3 years after adjusting for covariates (model $R^2 = .2617$). Experiencing two or more noninjurious falls ($\beta = -.538$; $p < .05$) was associated with decline in social activities (model $R^2 = .2779$) while experiencing at least one injurious fall ($\beta = -.580$; $p < .01$) was associated with decline in physical activity (model $R^2 = .4231$).

***Conclusions.*** Falls and fall injuries appear to be independent determinants of functional decline in community-dwelling older persons. Falling is a health condition meeting all criteria for prevention: high frequency, evidence of preventability, and high burden of morbidity.

At least 30% of persons over 65 years of age fall each year; this proportion increases to 40% after age 75 years (1,2). Serious nonfatal injuries occur with 10–15% of falls (1–7). Over 40% of persons seen in an emergency room for a fall injury report continued pain or restriction in activity 2 months after the fall (8). Fear of falling is another increasingly recognized entity that may affect function either independent of, or in conjunction with, falls and their physical sequelae (9,10).

Falling has been associated with an increased risk of functional decline and of institutionalization among older persons (11–16). The question remains, however, as to whether falling is merely a marker for frailty and disability or a direct contributor (14). In a recent longitudinal study, for example, the strength of the association between falling and institutionalization was lessened after adjusting for level of dependence in activities of daily living (ADLs) (16). Previous studies, however, have not differentiated injurious from noninjurious falls, have relied solely on retrospective ascertainment of falls, and have included a limited spectrum of potential factors confounding the relationship between falls and function (12,14,16).

The contribution of falls and fall sequelae to adverse functional outcomes is of particular clinical and public health relevance as several interventions have proven effective at reducing the occurrence and rate of falling (17–19). The aims of this study, therefore, were to determine whether, and to what extent, falls and/or fall injuries are independent determinants of adverse functional outcomes in older persons. To determine whether the relationship varied by type of functional outcome, we explored a spectrum of outcomes including new onset or increased disability in basic ADLs (BADLs) and instrumental ADLs (IADLs), social activities, and advanced physical activities.

## Methods

### *Participants*

Participants represented a probability sample of community-dwelling residents of New Haven, Connecticut who were over 71 years of age. The assembly of this sample has been described (7,9). Briefly, all 2,483 age-restricted elderly housing units were censused. Next, every 62nd non-age-restricted housing unit was sampled with the next 12 addresses identified as a cluster to be included in the study. A total of 1,436 age-eligible persons not enrolled in another longitudinal study of older persons were identified in the enumerated households during baseline interviews from October 1989 through August 1990. Forty-four of these persons (3%) were ineligible because they did not speak English, Spanish, or Italian; could not follow simple commands; or were not ambulatory within their own household. Among the 1,392 eligible participants, 1,103 (79%) agreed to be enrolled in the study. The present analyses are limited to the 957 (87%), who completed at least one follow-up interview while residing in the community. Of the 146 participants not included in these analyses, 82 died before follow-up interview; 37 were residing in skilled nursing facilities (SNF) at the time of the follow-up interview and 27 refused both the 1- and 3-year follow-up interviews. Participants residing in SNFs were excluded because of limited opportunity to perform the IADLs, social tasks, and higher level physical activities that constituted our outcome measures. Compared with those included, excluded cohort members were significantly older, had greater visual and hearing impairments, and received lower mental status, physical performance, BADL, IADL, social activities, and physical activities scores at baseline.

*Data*

Baseline interviews and assessments were completed in participants' homes by a trained research nurse. Information on age, gender, race, housing type (public age-restricted, private age-restricted, community), and past fall and fall injury history was obtained. Chronic conditions were ascertained by self-report of whether a doctor had ever told the participant that he/she had experienced any of a myocardial infarction, stroke, cancer, diabetes mellitus, arthritis, hip fracture, other fracture since age 50 years, amputation, or Parkinson's syndrome. Medications were recorded directly from containers. The Folstein Mini-Mental Status Examination (MMSE) (20), the Center for Epidemiologic Study-Depression (CES-D) (21), and the Spielberger State-Trait Anxiety Index (STAI) (22) were administered to assess mental status, depressive symptoms, and anxiety symptoms, respectively. Corrected near visual acuity was assessed with the Rosenbaum card; percent visual impairment was calculated (23). Hearing was assessed by the Whisper Test (24). Body mass index was calculated as self-reported weight in kilograms divided by self-reported height squared in meters. A battery of six timed physical performance tasks, including foot taps, three chair stands, turning a full circle, bending over, completing a 20-foot rapid pace walk, and signing name, was completed by each participant. For use in the present analyses, these measures were rescaled and summed using a strategy similar to that developed for the MacArthur Battery (25). First, because the ranges varied widely among the items, times were rescaled to a range of 1.0 (fastest time) to 0 (slowest time) by dividing each participant's raw score by the maximum time allowed for that test. Next, the scores for the six subscales were summed so that final physical performance battery score ranged from 0 to 6.

A second face-to-face interview, during which the questionnaires and physical assessments were repeated, was completed a median of 12 months (95% range 11–18 months, with a few outliers up to 26 months) after the baseline interview. A telephone follow-up, during which the questionnaire components were repeated was completed a median of 37 months (range 36–40) months after the baseline interview.

*Fall-related measures.*—Fall events, defined as unintentional changes in position to the floor or ground, were ascertained with a "fall calendar" described in detail elsewhere (7,26). Participants were instructed to complete the calendar and to mail it to us at the end of each month. They were contacted by telephone monthly if no calendar was returned, the calendar was completed incorrectly, or at least one fall was recorded during the month. Proxies were contacted if the participants seemed confused or unreliable or could not be reached after five attempts during a 1-week period. Using this system, 99% follow-up of participants for the duration of the study has been achieved. Serious fall injuries included all fractures and joint dislocations; head injuries resulting in loss of consciousness and hospitalization; joint injuries other than dislocations resulting in hospitalization or in decreased mobility or activity for at least the three days following the fall; and internal injuries resulting in hospitalization. These injuries were ascertained from a combination of hospital records, emergency department records, and self-report using a previously described algorithm (7). Self-report was used only when the data were not available from the two acute hospitals and emergency departments under constant surveillance. As previously reported, the Kappa statistic—a measure of the extent of agreement beyond that expected by chance—for the injury events for which self-report and medical record data were available was .76, suggesting good to excellent agreement (7). The four levels of fall status included no falls, one fall without serious injury; at least two falls without serious injury; and one or more falls with serious injury. Participants were assigned to the highest level for which they met criteria for the time period of the analysis.

*Functional outcome measures.*—BADL-IADLs, social activities, and physical activities were ascertained during the baseline, 1-year, and 3-year follow-up interviews. These outcome measures were ascertained by proxy for five persons at the 1-year interview and 64 persons in the 3-year interview. Fourteen self-reported BADLs and IADLs were ascertained using questions adapted from Branch et al. (27) and Lawton and Brody (28), respectively. Eating, grooming, bathing, dressing, transferring from bed to chair, toileting, walking across a room, transportation, and shopping were each scored as able (1) or unable (0) to perform without human help while light housekeeping, heavy housekeeping, light yard work, heavy yard work, and home repairs were scored as performed at least once per month (1) or less than once per month (0). Composite BADL-IADL scores ranged from 0 to 14. Combining BADLs and IADLs is justified by the hierarchical relationship among them (29). Social activity score, as described, was the sum of the frequency ratings (not at all, 0; one to four times per month, 1; more than once per week, 2) for each of eight groups of activities (attending events, trips, paid work, volunteering, visiting friends, attending religious services, participating in groups, and going to museums or shows (9). The range of social activity scores was 0–16. Physical activity was assessed using a modification of the Yale Physical Activity Scale in which the number of blocks walked and the number of flights of stairs climbed per day were translated into a scale based on estimated kilocalories expended (30). A log transformation of the scale resulted in a normal distribution of results.

*Statistical Analyses*

The covariates were selected based on their potential association with either the fall-related variables or with the functional outcomes described above. For modeling purposes, the covariates were categorized into demographic, health-related, cognitive performance, physical capability, or psychological domains. The demographic domain included age, gender, race (white, black, other), education (coded as 0–8, 9–12, or >12 years), marital status and housing type. The health-related domain included number of chronic conditions, body mass index (in tertiles), percent visual impairment, hearing deficit (defined as number of items missed on the Whisper Test), and number of noninjury hospitalizations during the follow-up period, ascertained by hospital surveillance. The MMSE was used to measure the cognitive domain, while the summed physical performance battery represented the physical capability domain. The psychological domain included the CES-D (coded as 0–15 vs 16+) and the STAI (coded as 0–31 vs 32+).

In order to examine the association between falling and change in functioning over short and long-term follow-up, we conducted two series of primary analyses. First, falls during the first year of follow-up were tested as a risk factor for decline in functioning between the baseline interview and the 1-year follow-up interview. Second, falls during the entire 3 years of follow-up were examined as a risk factor for decline between the baseline interview and the 3-year follow-up interview.

Each participant's fall and fall injury status was categorized for both short and long-term follow-up. Associations between the covariates and the four levels of fall status (no falls, one fall without serious injury, two or more falls without serious injury, and one or more falls with serious injury) were examined using $\chi^2$ tests for categorical variables and analysis of variance procedures for continuous variables. For all comparisons, participants with no falls during the relevant time period were the reference group.

For each of the three functional outcome measures, a hierarchical series of linear regressions models was constructed to examine fall status as a risk factor for change in function over each time period. In all models, change in the functional measure over the interval was the dependent variable, and the baseline value of the functional measure was included as a covariate. This approach permitted modeling of change adjusted for baseline function, also called "residualized change" (31). Six models were constructed for each functional measure, sequentially adding each domain of covariates. The first model in each series tested for the effect of the four level fall variable adjusting only for baseline function while the sixth model included the covariates from all five domains. Possible interactions between baseline function and fall status were also tested to ensure that the effect of falling on change in function was not dependent on level of function at baseline. In primary analyses, baseline values for all covariates were used except for noninjury hospitalizations, for which a variable was constructed to indicate the number of hospital admissions for causes other than injury during the relevant follow-up period. For the series of analyses examining falls during the three years of follow-up as a risk factor for decline between the baseline interview and the 3-year follow-up interview, the hierarchical models were rerun including both baseline and 1-year values for the covariates. As results for all outcomes were almost identical to results when only the baseline covariates were used, only the latter results are reported as this strategy allowed the retention of the greatest number of participants with the least amount of missing covariate data. For categorical covariates having missing data for >5% of participants, an additional category of "missing" was created so that the observations with partial missing data could be retained in the multivariate models. Body mass index, CES-D, and STAI were treated in this way.

We were concerned that decline in functional status might precede—and, indeed, contribute to—falling as opposed to falling resulting in a decline in function. While we were unable to examine this directly, we did address this issue in two ways. First, by including number of hospitalizations for reasons other than injury as a covariate in our models, we controlled for major intervening health events other than injurious falls that could have contributed to a decline in functional status. Second, we conducted an analysis in which we restricted the fall group to include fall events that occurred in the first year of follow-up while evaluating functional decline over the 3-year period, in order to maximize the likelihood that any change in function occurred after the fall events. Persons experiencing a first fall after the first year were excluded from these analyses. For this analysis all covariates were updated at 1 year so that all factors (other than hospitalizations) were ascertained within the same time frame.

## Results

The baseline characteristics of the participants by their one-year fall status are shown in Table 1. Of the 885 subjects included in the 1-year analyses, 617 (70%) had no falls in the first year, 149 (17%) had one noninjurious fall, 78 (9%) had two or more noninjurious falls, and 41 (4%) had at least one injurious fall. Participants who fell were older, had more chronic conditions, displayed more depressive symptoms, and had poorer physical performance than those who did not fall. Those with multiple falls or with at least one injurious fall performed worse on the Folstein MMSE. Women were more likely than men to sustain an injurious fall, but there was no gender difference for noninjurious falls. Hospitalizations for causes other than injury were more common among participants with one or more noninjurious falls but not among injurious fallers compared to nonfallers.

A total of 770 subjects had the 3-year follow-up interview in the community and were therefore included in the analysis for long-term follow-up. Of the 885 participants included in the 1-year analyses, 197 were lost to long-term follow-up because of death ($n$ = 114), SNF placement ($n$ = 55), and refusal ($n$ = 18). The proportion of persons lost between 1 and 3 years because of death was 12% among nonfallers, 14% among persons with one noninjurious fall, 21% among persons with at least two noninjurious falls, and 15% among persons with a serious fall injury. The comparable proportions lost because of admission to an SNF were 5%, 5%, 12%, and 17%, respectively. Participants ($n$ = 115) who had missed the 1-year interview were included in the long-term analysis. Among the 770 participants included in the 3-year analysis, 389 (50%) had no falls during the entire 3 years, 166 (22%) had one noninjurious fall, 135 (18%) had two or more noninjurious falls, and 80 (10%) had at least one injurious fall. Of the 80 seriously injured fallers, 14 experienced a hip fracture; 57 suffered fractures other than of the hip; and the remaining nine experienced a severe soft tissue injury resulting in decreased mobility or activity for at least 3 days. Similar results to those shown in Table 1 were found for the association between baseline characteristics and fall status over 3 years (data not shown).

The left panel of Table 2 shows the means of the functional outcome measures at baseline and the unadjusted change from baseline to the 1-year follow-up by fall status during the same period. Change was coded so that negative numbers indicate a decline in functioning. The right panel provides the same information for the 3-year follow-up period. Compared with nonfallers, fallers tended to have poorer functioning at the baseline interview and to experience greater decline in functioning, particularly for BADL-IADL and social activities.

Tables 3–5 show the regression coefficients for the effects of falls on change in BADL-IADL functioning, social activities, and physical activity, respectively. In each table the top panel presents the results for the baseline to 1-year (short-term) analysis and the bottom panel presents the results for the 3-year (long-term) analysis. Each panel presents the coefficients for the series of six hierarchial models for each

Table 1. Baseline Characteristics According to 1-Year Fall Status ($n$ = 885)

| Characteristic | No Falls ($n$ = 617) | 1 Fall, No Injury ($n$ = 149) | ≥2 Falls, No Injury ($n$ = 78) | ≥1 Fall, Serious Injury ($n$ = 41) |
|---|---|---|---|---|
| Age | 79.1 (5.0) | 79.6 (4.9) | 81.3 (5.8)** | 81.1 (6.3)* |
| Female | 71 | 71 | 72 | 88* |
| White | 83 | 86 | 81 | 81 |
| Housing type | | | | |
| Public | 12 | 10 | 9 | 2* |
| Private | 56 | 58 | 50 | 71 |
| Community | 32 | 32 | 41 | 27 |
| Education (0–8 yr) | 49 | 37* | 39 | 49 |
| Married | 26 | 19 | 19 | 15 |
| Folstein MMSE‡ | 24.7 (4.1) | 25.2 (4.2) | 23.5 (6.1)* | 23.3 (4.6)* |
| CES-Depression ≥ 16† | 18 | 30** | 30* | 26 |
| Anxiety (STAI) ≥ 32† | 46 | 55 | 53 | 43 |
| Body mass index <22.6† | 31 | 32 | 36 | 43 |
| Number of noninjury hospitalizations | 0.2 (.5) | 0.3 (.7)* | 0.3 (.5) | 0.1 (.3) |
| Number chronic conditions† | 1.3 (1.0) | 1.5 (1.1) | 1.7 (1.2)** | 1.6 (1.1)* |
| % Vision impairment† | 33.9 (32.9) | 38.1 (35.5) | 43.4 (35.2)* | 41.5 (35.8) |
| Physical performance† | 4.6 (.8) | 4.5 (.9) | 4.2 (1.0)*** | 4.1 (1.2)*** |

*Notes.* Percents are reported for categorical variables and means (± SDs) for continuous variables.
†See Methods for definition.
*$p$ < .05; **$p$ < .01; ***$p$ < .001 for comparison with nonfallers.

Table 2. Comparison of Change in Functional Measures by Fall Status

| | Baseline to 1 Year | | | | Baseline to 3 Years | | | |
|---|---|---|---|---|---|---|---|---|
| | Fall status over first year ($n$ = 885) | | | | Fall status over three years ($n$ = 770) | | | |
| Function* | No Falls ($n$ = 617) | 1 Fall, No Serious Injury ($n$ = 149) | ≥ 2 Falls, No Serious Injury ($n$ = 78) | ≥ 1 Fall, Serious Injury ($n$ = 41) | No Falls ($n$ = 389) | 1 Fall, No Serious Injury ($n$ = 166) | ≥2 Falls, No Serious Injury ($n$ = 135) | ≥1 Fall, Serious Injury ($n$ = 80) |
| ADL-IADLs | | | | | | | | |
| Baseline | 10.07 (1.62) | 9.96 (1.77) | 9.13 (1.81) | 9.46 (1.61) | 10.32 (1.43) | 10.08 (1.69) | 9.79 (1.61) | 9.74 (1.60) |
| Change | –.08 (1.30) | –.36 (1.42) | –.45 (1.39) | –1.37 (2.23) | –.27 (1.55) | –.72 (1.94) | –1.22 (2.29) | –1.45 (1.99) |
| Social activity scale | | | | | | | | |
| Baseline | 4.79 (2.58) | 4.72 (2.70) | 3.73 (2.62) | 4.37 (2.91) | 5.22 (2.56) | 4.83 (2.60) | 4.44 (2.78) | 4.90 (2.52) |
| Change | .02 (2.14) | –.12 (2.16) | –.46 (2.10) | –.87 (2.46) | –.49 (2.42) | –.55 (2.43) | –.90 (2.38) | –.94 (2.21) |
| Physical activity intensity | | | | | | | | |
| Baseline | 2.39 (1.95) | 1.97 (2.06) | 1.72 (1.92) | 2.03 (2.05) | 2.62 (1.89) | 2.20 (2.06) | 1.99 (2.02) | 2.52 (1.86) |
| Change | –.22 (1.71) | –.21 (1.97) | –.02 (1.99) | –.50 (1.99) | –.26 (1.90) | –.09 (2.07) | –.25 (2.10) | –1.02 (2.00) |

*See Methods for description of functional measures.

Table 3. Regression Coefficients for the Effects of Falling on Change in ADL-IADL Functioning

| Model Covariates | Model $R^2$ | 1 Fall, No Injury versus 0 Falls | ≥2 Falls, No Injury versus 0 Falls | ≥1 Fall, Injury versus 0 Falls |
|---|---|---|---|---|
| Baseline to 1 Year (*n* = 832) | | | | |
| I BA | .0806 | –.284** | –.469*** | –1.253**** |
| II BA + DEM | .1390 | –.280** | –.413** | –1.124**** |
| III BA + DEM + HR | .1757 | –.207* | –.378** | –1.183**** |
| IV BA + DEM + HR + COG | .1777 | –.208* | –.372** | –1.160**** |
| V BA + DEM + HR + COG + PRF | .1810 | –.199 | –.357** | –1.134**** |
| VI BA + DEM + HR + COG + PRF + PSY | .1864 | –.224* | –.380** | –1.149**** |
| Baseline to 3 Years (*n* = 696) | | | | |
| I BA | .1348 | –.492*** | –1.064**** | –1.445**** |
| II BA + DEM | .1883 | –.457*** | –.961**** | –1.360**** |
| III BA + DEM + HR | .2263 | –.454*** | –.899**** | –1.352**** |
| IV BA + DEM + HR + COG | .2537 | –.448*** | –.883**** | –1.263**** |
| V BA + DEM + HR + COG + PRF | .2595 | –.447*** | –.867**** | –1.257**** |
| VI BA + DEM + HR + COG + PRF + PSY | .2617 | –.437*** | –.877**** | –1.254**** |

*Note.* BA = Baseline value of outcome measure; DEM, demographics (age, gender, race, education, housing type, marital status); HR, health-related (number of chronic conditions, body mass index, % visual impairment, hearing impairment, number of noninjury hospitalizations); COG, cognitive (Folstein MMSE score); PRF, physical performance (timed battery—see Methods); PSY, psychological (CES-Depression; STAI score).
*$p < .1$; **$p < .05$; ***$p < .01$; ****$p < .001$.

Table 4. Regression Coefficients for the Effects of Falling on Change in Social Activity Scale

| Model Covariates | Model $R^2$ | 1 Fall, No Injury versus 0 Falls | ≥2 Falls , No Injury versus 0 Falls | ≥1 Fall, Injury versus 0 Falls |
|---|---|---|---|---|
| Baseline to 1 Year (*n* = 833) | | | | |
| I BA | .1039 | –.152 | –.792*** | –.802** |
| II BA + DEM | .1542 | –.183 | –.767*** | –.668* |
| III BA + DEM + HR | .1700 | –.113 | –.705*** | –.699** |
| IV BA + DEM + HR + COG | .1745 | –.117 | –.689*** | –.636* |
| V BA + DEM + HR + COG + PRF | .1785 | –.109 | –.653** | –.605* |
| VI BA + DEM + HR + COG + PRF + PSY | .1801 | –.096 | –.645** | –.596* |
| Baseline to 3 Years (*n* = 698) | | | | |
| I BA | .1847 | –.202 | –.771**** | –.447 |
| II BA + DEM | .2314 | –.193 | –.704*** | –.405 |
| III BA + DEM + HR | .2555 | –.157 | –.625*** | –.402 |
| IV BA + DEM + HR + COG | .2579 | –.155 | –.620*** | –.364 |
| V BA + DEM + HR + COG + PRF | .2682 | –.153 | –.596*** | –.368 |
| VI BA + DEM + HR + COG + PRF + PSY | .2779 | –.112 | –.538** | –.374 |

*Note.* BA = Baseline value of outcome measure; DEM, demographics (age, gender, race, education, housing type, marital status); HR, health-related (number of chronic conditions, body mass index, % visual impairment, hearing impairment, number of noninjury hospitalizations); COG, cognitive (Folstein MMSE score); PRF, physical performance (timed battery—see Methods); PSY, psychological (CES-Depression; STAI score).
*$p < .1$; **$p < .05$; ***$p < .01$; ****$p < .001$.

functional outcome. These coefficients can be interpreted as the decline in the mean level of functioning attributable to falls, after adjusting for the covariates in the model.

Falling had a strong effect on decline in BADL-IADL function over both time periods (Table 3). For both short and long-term follow-up, there was a graded effect with multiple fallers experiencing greater decline than one-time fallers and those individuals sustaining seriously injurious falls experiencing still greater decline in BADL-IADL functioning. The coefficients were notably greater for the longer time period, particularly for the noninjurious falls, and the effects were not greatly diminished by adjustments for demographic characteristics or the other domains of covariates.

For social activities (Table 4), no significant decline was seen among participants with only one noninjurious fall, but repetitive fallers and those with an injurious fall showed substantial declines. The adjustment for each domain of covariates reduced the magnitude of the fall coefficients slightly to the point that, for injurious falls the effects were of marginal statistical significance. Injurious falls were associated with greater declines in social activity for the short-term follow-up than the long-term follow-up, as indicated by the larger coefficients for the 1-year analysis compared to the 3-year analysis.

For the physical activity measure, no significant effect of fall status was observed for the 1-year analysis. However,

Table 5. Regression Coefficients for the Effects of Falling on Change in Physical Activity Scale

| Model Covariates | Model $R^2$ | 1 Fall, No Injury versus 0 Falls | ≥2 Falls, No Injury versus 0 Falls | ≥1 Fall, Injury versus 0 Falls |
|---|---|---|---|---|
| Baseline to 1 Year ($n$ = 833) | | | | |
| I BA | .2454 | −.159 | −.099 | −.309 |
| II BA + DEM | .3132 | −.226 | −.073 | −.133 |
| III BA + DEM + HR | .3255 | −.149 | .010 | −.096 |
| IV BA + DEM + HR + COG | .3262 | −.150 | .015 | −.078 |
| V BA + DEM + HR + COG + PRF | .3315 | −.148 | .050 | −.028 |
| VI BA + DEM + HR + COG + PRF + PSY | .3342 | −.173 | .027 | −.044 |
| Baseline to 3 Years ($n$ = 698) | | | | |
| I BA | .3382 | −.079 | −.333* | −.749**** |
| II BA + DEM | .3973 | −.087 | −.281* | −.636*** |
| III BA + DEM + HR | .4157 | −.066 | −.213 | −.619*** |
| IV BA + DEM + HR + COG | .4167 | −.064 | −.209 | −.598*** |
| V BA + DEM + HR + COG + PRF | .4196 | −.067 | −.198 | −.584*** |
| VI BA + DEM + HR + COG + PRF + PSY | .4231 | −.039 | −.176 | −.580*** |

*Note.* BA = Baseline value of outcome measure; DEM, demographics (age, gender, race, education, housing type, marital status); HR, health-related (number of chronic conditions, body mass index, % visual impairment, hearing impairment, number of noninjury hospitalizations); COG, cognitive (Folstein MMSE score); PRF, physical performance (timed battery—see Methods); PSY, psychological (CES-Depression; STAI score).

*$p < .1$; **$p < .05$; ***$p < .01$; ****$p < .001$.

over the longer follow-up period, there was a strong, independent effect of experiencing one or more seriously injurious falls. A marginally significant decline in physical activity among those with two or more falls was eliminated by adjustment for other covariates.

When the 3-year analysis was repeated assigning participants to their first year fall status, updating covariate values at one year, and excluding participants whose first fall event occurred after the first year, similar results were found for each of the three functional outcome measures. For example, one noninjurious fall ($\beta = -.717$; $p < .001$); at least two noninjurious falls ($\beta = -.799$; $p < .01$); and at least one injurious fall ($\beta = -1.021$; $p < .001$) during the first year were each associated with declining BADL-IADL function over three years after adjusting for all covariates ($R^2 = .2726$). The coefficients for each of the fall categories and the model $R^2$s were similar to those presented in Tables 4 and 5 for social and physical activities although statistical significance was lost in the fully adjusted models due in part to the smaller numbers.

Finally, to determine whether the relationship between fall injury and function held for injuries other than hip fracture, the models presented in Tables 3–5 were repeated excluding persons with a hip fracture from the category of serious fall injury. As expected, the results for noninjurious falls changed very little in any of the models. For injurious falls, the coefficients were somewhat reduced but remained highly significant ($p < .001$) for BADL-IADL over 1 and 3 years and were marginal ($p < .10$) for physical activity.

## Discussion

We found, in a representative cohort of community-dwelling older persons, a strong independent relationship between the occurrence of fall events and decline in BADL and IADL functioning. This relationship between fall events and functional decline was seen for both short (1 year) and long (3 year) periods of follow-up. In addition, we found evidence of a "dose-response" relationship between falling and decline in BADL and IADL functioning as the amount of decline increased while the number of falls increased and was greater among persons experiencing more, seriously injurious falls. Further, the relationship between fall status and decline held with sequential adjustment for the other factors known to be associated with any falls, serious fall injuries, or decline in BADL-IADL functioning. Indeed, there was little change in regression coefficients after adjusting for the multiple covariates, suggesting that the relationship between fall status and decline in function was largely independent of these other factors.

While there did not appear to be an increased risk of decline in social functioning among participants experiencing a single noninjurious fall, repetitive fallers experienced a decline in social functioning in both short- and long-term follow-up analyses. The relationship between repetitive falling and decline in social functioning remained after adjusting for each category of covariates. Experiencing a serious fall injury, on the other hand, was only marginally associated with decline in social functioning over the 1-year follow-up, and not at all over the 3-year follow-up. Preferential loss to follow-up of persons experiencing decline in social functioning between the 1- and 3-year follow-up interviews might at least partially explain the lack of relationship between injurious falls and change in social activities. Indeed, there was a trend toward persons lost to follow-up after 1-year because of nursing home placement, death, or refusal, to experience greater decline in social functioning from baseline to one year than persons not lost. As the relationship between decline in BADL-IADL function and loss to follow-up was stronger than for decline in social activities, however, preferential loss likely was not the entire explanation.

Injurious, but not noninjurious, falls were associated with experiencing decline in physical activities. The increased frequency and severity of injurious falls over the 3-year follow-up, compared with the 1- year follow-up may partially explain the difference in the effects of injurious falls on physical activity for the short-term versus the long-term follow-up. Compared with the 1 year follow-up, the participants with one or more serious fall injuries between baseline and 3 years were more likely to suffer a fracture (79% versus 68%) and have experienced more than one serious fall injury event (24% versus 12%). While previous investigators have identified decreased physical activity as a risk factor for injurious falls, our results suggest the relationship may be reciprocal (32,33). Of note, the relationship between serious fall injury and decline in BADL- IADL and physical activity remained after excluding hip fracture, suggesting that other serious injuries may have a lasting effect on functioning as well.

As is true for any observational study, we cannot establish a direct cause-effect relationship between falls or fall injuries and decline in functioning. We attempted, however, to adjust for potential confounders and biases through a series of planned analyses. Our hierarchial models adjusted for many—albeit likely not all—of the factors that might have confounded the relationship between fall status and functional decline. Temporal precedence—ensuring that the risk factor (fall) preceded the outcome (functional decline) —is difficult in a cohort study such as ours in which participants were not continuously observed. We cannot determine definitively that falls or fall injuries preceded decline in functioning as falls were ascertained on a daily basis, while function was ascertained only yearly. Finding that the relationship between falls and fall injuries and functional change over 3 years was maintained in analyses limited to persons experiencing their fall events during the first year of follow-up (during which there was less time for the occurrence of other events likely to cause functional decline to have occurred) suggests, but does not prove, temporal precedence.

Our results support earlier findings that falls are associated with decline in functioning (12,13). Unlike Dunn, we found that the relationship between fall status and functional decline was maintained after adjusting not only for baseline functioning, but for other known contributors to falls, fall injuries, and functional decline (14). Our dataset contained a more complete, prospective ascertainment of fall and fall injury events than the Longitudinal Study of Older Americans (14).

The present study was not designed to determine the mechanisms linking falls and functional decline. Most likely, however, falls contribute to functional decline both through loss of physical capability (e.g., worsening balance and gait) and through loss of confidence in performance of daily tasks. Indeed, we recently found that poor confidence or efficacy in performing common daily tasks was a potent determinant of decline in ADLs among persons who declined in performance on key balance and gait measures (34).

These results have important clinical and public health implications. Several epidemiologic studies have verified the high frequency of falls and serious fall injuries among older persons. Multiple risk factors—many of which are potentially modifiable—have been identified in these epidemiologic investigations. While there are as yet no data for serious fall injuries, several strategies have been proven effective at reducing the rate of falling in well designed, controlled trials (17–19). To these data we now add compelling evidence of the serious functional morbidity associated with falls and serious fall injuries. This combination of epidemiologic and clinical trial data strongly support the need to implement public health and clinical strategies aimed at reducing the rate of falls and fall injuries. Indeed, falling represents one of the few health conditions meeting all the criteria for prevention—high frequency, evidence of preventability, and heavy burden of morbidity.

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