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Research Article

Chronic Pain and Risk of Injurious Falls in Community-Dwelling Older Adults

Yurun Cai, PhD,[1,2,*] Suzanne G. Leveille, PhD, RN,[2,3,4] Ling Shi, PhD,[2] Ping Chen, PhD,[5] and Tongjian You, PhD[6]

[1]Department of Epidemiology, Johns Hopkins Bloomberg School of Public Health, Baltimore, Maryland. [2]Department of Nursing, University of Massachusetts Boston. [3]Division of General Medicine, Beth Israel Deaconess Medical Center, Boston, Massachusetts. [4]Department of Medicine, Harvard Medical School, Boston, Massachusetts. [5]Department of Computer Science and Engineering, University of Massachusetts Boston. [6]Department of Exercise and Health Sciences, University of Massachusetts Boston.

*Address correspondence to: Yurun Cai, PhD, Center on Aging and Health, Johns Hopkins University, 2024 E. Monument Street, Suite 2-207, Baltimore, MD 21205. E-mail: ycai28@jhu.edu

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Abstract

Background: Fall injuries are a leading cause of death in older adults. The potential impact of chronic pain characteristics on risk for injurious falls is not well understood. This prospective cohort study examined the relationship between chronic pain and risk for injurious falls in older adults.

Method: The MOBILIZE Boston Study enrolled 765 community-dwelling adults aged 70 years and older living in and around Boston, Massachusetts. Chronic pain characteristics, including pain severity, pain interference, and pain distribution, were measured at baseline using the Brief Pain Inventory subscales and a joint pain questionnaire. Occurrence of falls and fall-related injuries were recorded using monthly fall calendar postcards and fall follow-up interviews during the 4-year follow-up period.

Results: Negative binomial regression models showed that pain interference and pain distribution, but not pain severity, independently predicted injurious falls adjusting for potential confounders. Participants in the highest third of pain interference scores had a 61% greater risk of injurious falls compared to those reporting little or no pain interference. Compared to no pain, multisite pain was associated with a 57% greater risk of injurious falls. Stratified by gender, the association was only significant in women. In the short term, moderate-to-severe pain in a given month was associated with increased risk of injurious falls in the subsequent month.

Conclusions: Global pain measures are associated with increased risk of injurious falls in older adults. Pain assessment should be incorporated into fall risk assessments. Interventions are needed to prevent fall injuries among elders with chronic pain.

Keywords: Epidemiology, Falls, Mobility, Pain, Risk factors

Falls are a threat to the health of the older population and impair functional independence in everyday life. Falls often occur due to diminished physiological function and mobility decline in older adults, such as weakened lower limb strength, poor balance, slow gait speed, reduced peripheral sensation, and visual deficit (1–3). In addition to these functional risk factors, other factors such as changes in cognition, advanced age, chronic conditions (eg, diabetes, arthritis, Parkinson's disease), and medication use (eg, sedatives/hypnotics, benzodiazepines, antidepressants), are linked to increased risk of falls (2,4,5). Multifactorial interventions to reduce occurrence of falls have addressed many of these risk factors but have had only a modest impact on fall risk (6), suggesting that more needs to be done to understand and intervene on fall risk in older adults.

Over the past decade, studies have emerged showing characteristics of chronic pain associated with falls in community-dwelling older adults. Older adults with chronic multisite musculoskeletal pain or more severe global pain experience mobility decline and have a greater risk of falls compared to those without pain (7–9). Although this risk factor has been confirmed in multiple observational studies, mechanisms that underlie the relationship between pain and falls remain elusive. While ongoing research is examining potential explanations, evaluating other fall outcomes related to chronic pain may also shed light on this relationship. For example, it is important to consider the risk for fall injuries related to chronic pain in older adults. In addition, given the risk for serious injuries such as hip fracture and head injury due to falling, research identifying potentially modifiable risk factors for injurious falls is needed to inform prevention efforts related to fall-related injuries (10). Notably, previous studies have found the risk factors for injurious falls may differ from those for non-injurious falls (11,12). Although chronic pain has been linked to fall risk, little is known about whether chronic pain assessed using global measures contributes to injurious falls. Thus, the aim of this study was to examine the association between chronic pain characteristics, including pain severity, pain interference, and pain distribution, and risk of injurious falls in community-dwelling older adults.

Method

Study Design

The MOBILIZE Boston Study (MBS), a population-based cohort study, was designed to investigate fall risk factors related to physiological, physical, and cognitive function in community-dwelling older adults. The original cohort was recruited from the community in Boston and surrounding areas from 2005 to 2008. Following the extensive baseline assessment, participants were followed for 4 years for the occurrence of falls. Details of the study recruitment and procedures were published previously (13). The study protocol was approved by the Institutional Review Boards at Hebrew SeniorLife and the University of Massachusetts Boston.

Study Participants

A total of 765 community-dwelling older adults aged 70 years and older were recruited door-to-door based on random city/town lists of older adults living within a 5-mile radius of the Institute for Aging Research (IFAR) at Hebrew Rehabilitation Center (HRC) in Boston where the study was based. The inclusion criteria were as follows: (a) aged 70 years and older, (b) able to speak and understand English, (c) expected to live in the area for at least 2 years, and (d) able to walk 20 feet without personal assistance (walking aids permitted). Spouses aged 65 years and older of eligible participants who met the other eligibility criteria were also welcomed in the study. Older adults who had terminal disease, severe vision or hearing deficit, or moderate-to-severe cognitive impairment (Mini-Mental State Examination < 18) were excluded.

Data Collection

A 2-hour home interview was followed by a 3-hour clinical assessment at the IFAR clinic at baseline.

Fall ascertainment

A fall was defined as "unintentionally coming to rest on the ground or other lower level not as a result of a major intrinsic event (eg, myocardial infarction or stroke) or an overwhelming external hazard (eg, hit by a vehicle)" (14). In the home interview, participants were instructed to fill out the monthly fall calendar postcard to record the occurrence of falls each day and mail it back to the research center at the end of each month.

Injurious falls

Whenever a fall was reported on the monthly fall calendar, the research staff conducted a telephone interview with the participant or their proxy about the circumstances and outcomes of each fall. During the fall follow-up interview, participants were asked, "did you hurt yourself in any way when you fell?" If participants answered "yes," the fall was classified as an injurious fall; this was the main outcome of this study. In addition, details on the types of fall-related injuries and emergency department visits or hospitalizations as a result of falls were also recorded.

Chronic pain assessment

Global pain severity was assessed using the 4-item Brief Pain Inventory (BPI) subscale measuring chronic pain intensity in the previous week (15). Participants were asked to rate their pain in 4 conditions: (a) worst pain, (b) least pain, (c) pain on average, and (d) pain now. Each item has a 0–10 numeric rating response with "0" referring to no pain and "10" indicating "severe or excruciating pain, as bad as you can imagine" (15). The BPI scale has been validated to measure chronic nonmalignant pain, with a Cronbach's alpha of 0.85 for the severity subscale (16).

The BPI pain interference scale assessed level of pain interference with general activity, mood, walking, normal work including housework, relations with other people, sleep, and enjoyment of life, rated using a 7-item rating scale where "0" referred to "not at all interferes" and "10" indicated "completely interferes" (15). The BPI interference score was the average of the 7-item ratings (15). The test–retest reliability of pain interference ranged from 0.83 to 0.93 (17).

Chronic musculoskeletal pain location was assessed using the joint pain questionnaire, assessing pain lasting 3 or more months in the previous year and present in the past month at 6 locations: hands/wrists, shoulders, back, hip, knees, and feet (18). According to pain distribution, number of musculoskeletal pain sites was classified into 3 groups: (a) no pain, (b) single site pain: pain in a single site, and (c) multisite pain: pain in 2 or more musculoskeletal sites. This classification of pain distribution is strongly associated with disability and risk for falls in older adults (8,9).

During the follow-up period, participants rated their bodily pain in the past 4 weeks on the fall calendar postcards as "none," "very mild," "mild," "moderate," "severe," or "very severe," an item from the validated Short-Form Health Survey (SF-36) (19).

Covariates measurements

Sociodemographic characteristics including age, gender, education, and race were collected in the home interview. Height and weight were measured during the MBS clinic visit and body mass index (BMI) was calculated as weight in kilograms divided by height in squared meters. Chronic conditions including osteoarthritis, peripheral arterial disease, diabetes, and peripheral neuropathy were assessed using disease algorithms, described previously (13). Physician diagnosis of other chronic conditions including heart disease and stroke were self-reported. Presence of any mobility difficulty was based on 2 questions regarding ability to walk ¼ mile and ability to walk up stairs (20). Depressive symptoms were assessed using the Center for Epidemiologic Studies Depression Scale-Revised (CESD-R) questionnaire (21). Vision deficit was determined by the 10-foot distant vision test using the Good-Lite Chart (22). Medication use including opioid analgesic medications and psychiatric medications was determined using the brown bag method, where names and frequency of all medications used in the previous 2 weeks were recorded (9).

Statistical Analysis

The rates of falls and injurious falls (number of falls and injurious falls per 100 person-years [PY]) during follow-up period were calculated. The BPI pain severity score was classified into 4 groups according to clinical cutpoints: no pain (0), very mild pain (<2), mild pain (2–3.99), and moderate-to-severe pain (≥4) (23). The pain interference score was classified into tertiles according to the data distribution. We examined associations between sociodemographic characteristics, health conditions, and fall risk factors with fall outcomes to evaluate potential confounders. We performed a series of multivariable negative binomial regression models to compare the rate of injurious falls according to each pain characteristic (ie, pain severity groups, pain interference tertiles, and pain distribution). Initially, we performed the model without covariates, then a second model was adjusted for potential confounders (age, gender, race, education, BMI, peripheral neuropathy, peripheral artery disease, heart disease, and vision impairment). In a final step, we added measures that might be considered possible mediators of the association between pain and injurious falls (mobility difficulty, and opioid and psychiatric medications). We did not include depression in the multivariable models because it is very likely that both chronic pain and depression are on the same pathway leading to falls (24). We also used negative binomial regression models to test the trend for rates of injurious falls according to pain characteristics. We chose the negative binomial regression models instead of Poisson regression models due to the over-dispersion of the data. The distribution, outliers, and missing data for all the variables were evaluated and very few had missing values such that the full multivariable model had fewer than 5% missing. We repeated the analysis using our secondary outcome of serious injurious falls (those resulting in emergency department visits or hospitalizations).

The short-term relation between monthly pain ratings in a given month and risk of injurious falls in the subsequent month was examined using generalized estimating equation (GEE) models with logit link function, taking within-individual correlation into account using the autoregressive covariance structure. Two participants were excluded from this analysis for missing follow-up data. Due to the small number reporting “very severe” pain, we combined the “severe” and “very severe” categories (9). Women usually have more falls and injurious falls and report more pain than men, thus, all multivariable analyses were additionally stratified by gender (25–27). Tests for interaction between pain and gender were performed. The significance level α was set as 0.05. All analyses were conducted using SAS software 9.4 (SAS Institute Inc., Cary, NC).

Results

The mean age of the 765 participants was 78.1 (*SD* = 5.4) years at baseline, of which 63.9% were women and 77.6% were white. Nearly half (46.6%) of the participants were college graduates. The average and median length of the follow-up period were 2.78 (*SD* = 0.95) years and 2.85 years, respectively, with a range from 16 days to 4.32 years. Among the participants, 713 (93.2%) had at least 12 months of follow-up and 650 (85.0%) participants had over 24 months of follow-up. Nearly two-thirds (62.4%) had at least one fall and nearly half (47.5%) reported at least one injurious fall during the follow-up. The overall rate of injurious falls was 33.8/100 PY. Among women, the rate of injurious falls was 37.3/100 PY, and, among men, the rate was 27.6/100 PY. The rate of serious injurious falls, those resulting in visits to the emergency department or hospitalizations, was 7.0/100 PY for all participants, 7.7/100 PY for women, and 5.7/100 PY for men. The frequencies of different types of fall-related injuries reported by study participants are presented in Supplementary Table 1.

Sociodemographic factors associated with injurious falls included white race and having more years of education (Table 1). People who had injurious falls were more likely to have depressive symptoms compared to those who did not fall (10.5% and 3.1%, respectively). Also, a greater proportion of people with injurious falls were using psychiatric medication compared to people without falls (24.5% and 15.7%, respectively).

The mean scores of the BPI pain severity and pain interference subscales at baseline were 2.4 (*SD* = 2.1) and 1.7 (*SD* = 2.2), respectively. Pain severity, pain interference, and pain distribution at baseline were associated with increased rates of injurious falls (Table 2). For example, participants in the highest pain interference group had a higher rate of injurious falls compared to those in the lowest pain interference group (44.0/100 PY and 26.7/100 PY, respectively). Also, participants with multisite pain had a higher rate of injurious falls compared to those without pain (42.0/100 PY and 25.8/100 PY, respectively).

We found that pain interference and pain distribution, but not pain severity, independently predicted occurrence of injurious falls. The associations remained significant after adjusting for sociodemographic characteristics and multiple fall risk factors including BMI, chronic conditions, and vision impairment. Further adjusting for mobility difficulty and use of opioid analgesics and psychiatric medication had a modest impact on the associations (Table 2). Specifically, participants in the highest tertile of pain interference had an 80% increased risk for falls initially, but with additional adjustments, there was a 61% greater risk of injurious falls among those with greatest pain interference compared to those reporting the least pain interference (adj. RR = 1.61, 95% CI: 1.23, 2.13). Older adults with multisite pain had a 57% higher risk of injurious falls than those without pain, adjusted for all covariates (adj. RR = 1.57, 95% CI: 1.22, 2.01). Pain severity was associated with an increased risk for injurious falls initially, but this association diminished after adjusting for mobility difficulty and use of opioid and psychiatric medications.

Sex-stratified analysis showed that among women, every measure of pain independently predicted occurrence of injurious falls (Table 3). After adjusting for sociodemographic characteristics, BMI, chronic conditions, and vision impairment, women reporting the most pain interference had 2 times the risk of injurious falls compared to those with the least interference (adj. RR = 2.01, 95% CI: 1.48, 2.73) and results were similar for those with multisite pain, compared to women with no pain (adj. RR = 1.83, 95% CI: 1.36, 2.47). The associations remained significant after additionally adjusting for mobility difficulty and use of opioid and psychiatric medications, except for the pain severity measure. We did not find a significantly greater risk of injurious falls according to chronic pain in men. The test for interaction between gender and pain was not significant.

For the analysis of risk for serious injurious falls, baseline pain severity and pain interference, but not pain distribution, predicted this outcome during the follow-up period. Older adults with mild pain severity had a 92% greater risk of fall-related emergency department visits or hospitalization compared to those without pain (adj. RR = 1.92, 95% CI: 1.07, 3.46; Supplementary Table 2). No association with fall risk was observed in those with moderate-to-severe pain compared to those with no pain. Participants in the

Table 1. Baseline Sociodemographic Characteristics, Chronic Conditions, and Fall Risk Factors of Participants According to Occurrence of Any Non-injurious and Injurious Falls During Follow-up (*N* = 765)

		No Fall (*n* = 288)	Non-injurious Fall[a] (*n* = 114)	Injurious Fall[b] (*n* = 363)	
Characteristics	Total, *n* (%)	*n* (%)			*p*-Value[c]
Age in years					
≤74	234 (30.6)	89 (30.9)	40 (35.1)	105 (28.9)	
75–84	425 (55.6)	160 (55.6)	58 (50.9)	207 (57.0)	
≥85	106 (13.9)	39 (13.5)	16 (14.0)	51 (14.1)	.788
Gender					
Male	276 (36.1)	103 (35.8)	51 (44.7)	122 (33.6)	
Female	489 (63.9)	185 (64.2)	63 (55.3)	241 (66.4)	.096
Race					
White	593 (77.6)	201 (69.8)	88 (77.2)	304 (84.0)	
African American	123 (16.1)	66 (22.9)	20 (17.5)	37 (10.2)	
Other	48 (6.3)	21 (7.3)	6 (5.3)	21 (5.8)	**<.001**
Education					
Less than high school	85 (11.1)	42 (14.6)	14 (12.3)	29 (8.0)	
High school graduate	323 (42.3)	136 (47.4)	41 (36.0)	146 (40.2)	
College graduate	356 (46.6)	109 (38.0)	59 (51.8)	188 (51.8)	**.002**
Body mass index					
<25	222 (29.7)	79 (28.4)	36 (32.4)	107 (29.9)	
25–29	320 (42.8)	118 (42.5)	42 (37.8)	160 (44.7)	
≥30	205 (27.4)	81 (29.1)	33 (29.7)	91 (25.4)	.659
Mobility difficulty	272 (35.6)	100 (34.8)	43 (37.7)	129 (35.5)	.863
MMSE < 24	92 (12.0)	43 (14.9)	11 (9.7)	38 (10.5)	.154
Heart disease	319 (41.7)	109 (37.9)	51 (44.7)	159 (43.8)	.241
Diabetes	153 (20.0)	64 (22.2)	25 (21.9)	64 (17.6)	.297
Osteoarthritis					
Neither site	484 (63.4)	193 (67.3)	69 (60.5)	222 (61.2)	
Knee only	134 (17.5)	47 (16.4)	26 (22.8)	61 (16.8)	
Hand only	88 (11.5)	32 (11.2)	13 (11.4)	43 (11.9)	
Hand and knee	58 (7.6)	15 (5.2)	6 (5.3)	37 (10.2)	.149
Peripheral neuropathy	92 (12.2)	28 (9.9)	18 (15.8)	46 (12.9)	.238
Peripheral artery disease	73 (9.5)	29 (10.1)	13 (11.4)	31 (8.5)	.615
Stroke	76 (9.9)	28 (9.7)	12 (10.5)	36 (9.9)	.971
Depressive symptoms	56 (7.3)	9 (3.1)	9 (7.9)	38 (10.5)	**.002**
Vision impairment	189 (24.8)	82 (28.7)	29 (25.7)	78 (21.5)	.107
Opioid analgesic use	49 (6.4)	20 (7.0)	6 (5.3)	23 (6.3)	.763
Psychiatric medication use	158 (20.7)	45 (15.7)	24 (21.1)	89 (24.5)	**.022**

Notes: MMSE = Mini-Mental State Examination. The *p*-values marked in bold indicate statistically significant results ($p < .05$).
[a]Participants had at least one fall but did not have any injurious falls in the follow-up period. [b]Participants had at least one injurious fall in the follow-up period. [c]Chi-squared test, df = (r−1) (c−1).

highest pain interference group had a 76% greater risk for serious injurious falls compared to those reporting the least pain interference (adj. RR = 1.76, 95% CI: 1.09, 2.86). Additional adjustments for mobility difficulty and use of opioid and psychiatric medications diminished these associations.

Regarding fall risk in the short term, we found that participants who reported more bodily pain in any given month were at increased risk for an injurious fall in the subsequent month, compared to their counterparts reporting no pain (Table 4). For example, participants who rated their bodily pain as severe or very severe at the end of the month had a 61% greater risk of injurious falls in the subsequent month compared to those without pain, after adjusting for potential confounders (adj. OR = 1.61, 95% CI: 1.12, 2.31). When we examined the short-term impact of pain reports on fall risk according to gender, there was a strong graded association between pain severity at the end of one month with risk for injurious falls in the next month in women such that women who reported severe or very severe pain had a 76% increased risk for an injurious fall in the next month (adj. OR = 1.76, 95% CI: 1.15, 2.69). The findings were not as consistent in men; those reporting moderate levels of pain had an increased risk for injurious falls (adj. OR = 1.77, 95% CI: 1.14, 2.74) in the short term but no increased risk was observed in men reporting severe or very severe pain.

Discussion

This study found a significant association between chronic pain and risk of injurious falls in both short- and long-term follow-up periods among community-dwelling older adults. Specifically, more pain interference and multisite pain at baseline were each associated with increased risk of injurious falls over the 4-year follow-up after controlling for potential confounders. Pain severity and pain interference were significantly associated with risk of injurious falls leading to emergency department visits or hospitalizations. Monthly pain severity ratings predicted occurrence of injurious falls in the subsequent month. In general, these associations were more evident

Table 2. Rate Ratio for Injurious Falls During the 4.3 y of Follow-up According to Pain Characteristics (*N* = 765)

Pain Characteristics	*n*	No. of Injurious Falls	No. of PYs	Rate of Injurious Falls (/100 PY)	Model 1[a]	Model 2[b]	Model 3[c]
					Adj. RR (95% CI)		
Pain severity							
No pain	163	134	437.4	30.6	1.0	1.0	1.0
Very mild pain	210	188	624.0	30.1	0.99 (0.73, 1.34)	0.95 (0.70, 1.28)	0.93 (0.69, 1.25)
Mild pain	200	198	551.9	35.9	1.18 (0.87, 1.60)	1.14 (0.84, 1.55)	1.05 (0.78, 1.43)
Moderate-to-severe pain	189	197	506.6	38.9*	1.34 (0.99, 1.82)	**1.47 (1.07, 2.03)**	1.24 (0.88, 1.74)
Pain interference							
1st tertile	288	212	793.0	26.7	1.0	1.0	1.0
2nd tertile	219	209	655.1	31.9	1.21 (0.93, 1.56)	1.13 (0.88, 1.46)	1.10 (0.85, 1.42)
3rd tertile	255	296	672.4	44.0**	**1.69 (1.32, 2.15)**	**1.80 (1.40, 2.31)**	**1.61 (1.23, 2.13)**
Pain site							
No pain	274	197	764.6	25.8	1.0	1.0	1.0
Single site pain	186	167	519.0	32.2	1.24 (0.94, 1.63)	1.19 (0.90, 1.57)	1.19 (0.91, 1.57)
Multisite pain	304	354	842.7	42.0**	**1.65 (1.30, 2.09)**	**1.68 (1.32, 2.14)**	**1.57 (1.22, 2.01)**

Notes: Adj. RR = adjusted rate ratio; CI = confidence interval; PY = person-years. The values in bold indicate statistically significant results ($p < .05$).

[a]Model 1 estimated unadjusted rate ratio from negative binomial models. [b]Model 2 was adjusted for age, gender, race, education, body mass index, peripheral neuropathy, peripheral arterial disease, heart disease, and vision impairment. [c]Model 3 was additionally adjusted for mobility difficulty, opioid analgesic use, and psychiatric medications use.

*Test for trend, p-value <.05, **p-value < .001.

in women than in men. To our knowledge, this is among the first injurious falls studies to examine multiple characteristics of chronic pain and also to determine both the short- and long-term impact of chronic pain on injurious fall risk in older adults.

Because the mechanism underlying the now well-recognized association between chronic pain and fall risk remains unclear, it is worthwhile to consider whether pain is similarly predictive of other fall outcomes, in this case, injurious falls. The seminal work on the topic of pain as a predictor of all falls in older adults was conducted with the MOBILIZE Boston cohort data (9). Our study of the same cohort, found the rate ratio of injurious falls to be similar, if not a little stronger, to the risk for all falls among older adults with chronic pain (9). Notably, our final estimate of pain-related risk for injurious falls may be somewhat conservative as the additional risk factors of mobility difficulty and medications could represent an over-adjustment for factors that are on the pathway from pain to falls. Thus, we also presented risk ratios from models that did not include these potential mediators. In the years since the original MOBILIZE study of multisite pain and all falls, several others have examined this broader question, as reported in a recent meta-analysis of 18 studies by Welsh and colleagues, finding that older adults with multisite pain had a 2-fold increased risk of falls, unadjusted for other fall risk factors (28). While our study shows that a number of pain characteristics are associated with risk for injurious falls, further studies of pain as a predictor of fall outcomes such as recurrent falls and fall-related fractures or head injuries, could shed further light on ways in which pain contributes to fall risk and also inform fall-prevention interventions.

Older adults with pain may be unable to effectively prevent a fall in the face of a hazard and, further, to adequately protect themselves from getting injured during a fall. Recent studies have examined possible pathways related to local pathology due to osteoarthritis, neuromuscular effects of pain on muscle weakness and gait alteration, and poor executive function and decreased attentional resources (9,29–31). Other studies found that declines in physical function and impaired motor control as a result of low back pain and knee pain can lead to falls (32–34). The impacts of low back pain on neuromuscular and motor control are associated with decreased ability to respond quickly to postural perturbations (35). However, as mounting evidence points to the global effects of chronic pain on falls, measured by multisite pain regardless of the pain location, further research is needed to understand the impacts of chronic pain on whole body functioning which is likely to be a multifactorial process (9,28,36).

Although a number of studies have demonstrated the pain–fall relationship, research considering the potential impact of chronic pain on risk for injurious falls is limited. A longitudinal cohort study in Sweden reported that pain characteristics (number of sites, severity, and pain-related disability) were associated with injurious falls in men but not women (37). The sex difference was explained by more pain and fear of falling in women who are more likely to intentionally avoid hazardous activities leading to injurious falls (37). To the contrary, in our current study, we only observed a significant association between chronic pain and injurious falls in women. Women may be more vulnerable to the impact of chronic pain on their abilities to effectively respond to balance perturbation to prevent a fall (38). Previous studies also found the pain-related disability is more prevalent in women than men (39). Another explanation is that pain-related fear, which was found to be more disabling than pain itself (40). Women may be more likely to restrict activities due to more fear of falling than men, which in the long run may increase the risk of falls (41). Evidence in studies of injurious fall risk points to a significant role of functional limitations and disability in predicting injurious falls (42–44). People who have more functional limitations may be less able to brace themselves or quickly protect themselves to avoid injury when falling.

Our results related to sex differences in the month-to-month relationship between pain severity and injurious falls were somewhat inconsistent. In women, there was a strong graded effect, where more severe pain in a given month was associated with a greater risk of injurious falls in the subsequent month. In men, however, moderate pain but not severe or very severe pain was associated with an increased risk for injurious falls. Older women are generally more likely to suffer from chronic pain and showed higher pain sensitivity

Table 3. Adjusted Rate Ratio for Injurious Falls During the 4.3 y of Follow-up According to Pain Characteristics by Sex (*N* = 765)

Pain Characteristics	*n*	Rate of Injurious Falls (/100 PY)	Model 1[a] Adj. RR (95% CI)	Model 2[b]	Model 3[c]
Women (*n* = 489)					
Pain severity					
No pain	87	31.4	1.0	1.0	1.0
Very mild pain	119	35.2	1.13 (0.76, 1.69)	1.04 (0.70, 1.56)	1.02 (0.69, 1.51)
Mild pain	134	39.6	1.26 (0.85, 1.87)	1.38 (0.93, 2.06)	1.27 (0.85, 1.88)
Moderate-to-severe pain	147	40.9	1.36 (0.92, 2.01)	**1.59 (1.07, 2.37)**	1.34 (0.88, 2.04)
Pain interference					
1st tertile	169	26.9	1.0	1.0	1.0
2nd tertile	139	39.8	**1.51 (1.09, 2.07)**	**1.43 (1.04, 1.96)**	**1.40 (1.02, 1.92)**
3rd tertile	179	45.5**	**1.72 (1.27, 2.33)**	**2.01 (1.48, 2.73)**	**1.80 (1.28, 2.54)**
Pain site					
No pain	162	26.8	1.0	1.0	1.0
Single site pain	111	36.2	1.34 (0.94, 1.90)	1.30 (0.92, 1.85)	1.34 (0.95, 1.89)
Multisite pain	216	45.6**	**1.72 (1.28, 2.30)**	**1.83 (1.36, 2.47)**	**1.72 (1.27, 2.33)**
Men (*n* = 276)					
Pain severity					
No pain	76	29.7	1.0	1.0	1.0
Very mild pain	91	22.9	0.78 (0.49, 1.23)	0.84 (0.54, 1.31)	0.84 (0.54, 1.31)
Mild pain	66	28.6	0.98 (0.61, 1.59)	0.83 (0.51, 1.35)	0.79 (0.49, 1.28)
Moderate-to-severe pain	42	31.1	1.15 (0.66, 2.02)	1.45 (0.80, 2.66)	1.26 (0.68, 2.33)
Pain interference					
1st tertile	119	26.5	1.0	1.0	1.0
2nd tertile	80	18.3	0.69 (0.45, 1.08)	0.69 (0.45, 1.06)	0.68 (0.44, 1.04)
3rd tertile	76	40.3*	**1.58 (1.06, 2.37)**	1.46 (0.96, 2.24)	1.36 (0.86, 2.13)
Pain site					
No pain	112	24.3	1.0	1.0	1.0
Single site pain	75	26.1	1.07 (0.69, 1.67)	0.97 (0.62,1.50)	0.94 (0.61, 1.45)
Multisite pain	88	32.8	1.38 (0.91, 2.09)	1.30 (0.85,1.99)	1.20 (0.77, 1.87)

Notes: Adj. RR = adjusted rate ratio; CI = confidence interval; PY = person-years. The values in bold indicate statistically significant results ($p < .05$).

[a]Model 1 estimated unadjusted rate ratio from negative binomial models. [b]Model 2 was adjusted for age, gender, race, education, body mass index, peripheral neuropathy, peripheral arterial disease, heart disease, and vision impairment. [c]Model 3 was additionally adjusted for mobility difficulty, opioid analgesic use, and psychiatric medications use.

*Test for trend, *p*-value < .05, ***p*-value < .001. Test for interaction between each pain measure and sex, *p*-value > .05.

Table 4. Adjusted Odds Ratio for Injurious Falls in the Subsequent Month According to Monthly Pain Ratings (*N* = 763)[a]

	All Participants (*N* = 763)		Women (*n* = 488)		Men (*n* = 275)	
Monthly Pain Ratings	Rate of Injurious Falls (/100 PY)	Adj. OR (95% CI)	Rate of Injurious Falls (/100 PY)	Adj. OR (95% CI)	Rate of Injurious Falls (/100 PY)	Adj. OR (95% CI)
None	27.0	1.0	30.2	1.0	23.2	1.0
Very mild	31.1	1.04 (0.80, 1.37)	34.3	1.05 (0.75, 1.47)	26.0	1.08 (0.67, 1.74)
Mild	36.3	1.20 (0.92, 1.58)	39.5	1.19 (0.84, 1.68)	30.2	1.26 (0.80, 1.99)
Moderate	43.8	**1.40 (1.07, 1.83)**	42.5	1.30 (0.92, 1.84)	47.1	**1.77 (1.14, 2.74)**
Severe or very severe	50.7	**1.61 (1.12, 2.31)**	56.3	**1.76 (1.15, 2.69)**	33.4	1.31 (0.65, 2.62)

Notes: Adj. OR = adjusted odds ratio; CI = confidence interval; PY = person-years. Generalized estimating equation (GEE) models with logit link function, adjusted for age, race, education, body mass index, chronic conditions, vision impairment, mobility difficulty, opioid analgesic use, and psychiatric medications use; first model also adjusted for gender. The dependent variable was occurrence of an injurious fall in the month immediately following each monthly pain rating during the 4-y follow-up. Test for interaction between each pain measure and sex, *p*-value > .05. The values in bold indicate statistically significant results ($p < .05$).

[a]Excluded one participant with only 1 mo of follow-up and another who was missing all monthly pain ratings.

than men which may explain sex differences in the report of chronic pain (39). The differences in study results between women and men may be attributed to the reports of more severe pain in women (45). Comparing the results of baseline pain and injurious falls in follow-up, we posit that the impact of chronic pain on increased risk of injurious falls may be both short-term and long-term, and may disproportionately affect older women.

Strengths of this study include the large sample size, the representativeness of the population-based study sample, and the generalizability of study findings. Another strength is that participants were followed for 4 years using monthly fall calendars, a gold standard method to record falls (46). The MBS collected data on monthly pain ratings, providing a unique opportunity to examine the short-term impact of pain ratings on injurious fall risk. There are also some limitations to this research. The follow-up time varied among study participants and occasionally monthly calendars were missing when participants failed to return the calendars and could not be reached for a telephone follow-up, resulting in possible underreporting of falls. In our sample, college graduates had higher rates of injurious falls but also fewer missing fall calendar days than those who did not complete high school. Thus, it is possible that those with less education, comprising 11% of the population, may have underreported injurious falls. We found older adults who reported mild and moderate-to-severe pain had shorter follow-up time compared to those with very mild or no pain. Participants in the highest pain interference group also had shorter follow-up time than those in the middle pain interference group. These differences may also impact study results. Fall injuries may have been over- or underreported and it is unclear whether participants with chronic pain may have been more or less likely to report injuries.

In conclusion, this study demonstrated that older adults with chronic pain, whether measured by pain severity, pain interference, or multisite pain, had increased risk of injurious falls, and this increased risk was most evident in women. Pain ratings in a given month increase the risk of injurious falls in the subsequent month in both women and men. Further studies are needed to understand the underlying mechanisms in the relationship between pain and injurious falls and sex differences in impacts of chronic pain on mobility in older adults. Given the stronger impact of pain on risk of injurious falls in women, tailored fall-prevention programs are needed for older adults especially women living with chronic pain in order to reduce occurrence of fall-related injuries.

Supplementary Material

Supplementary data are available at *The Journals of Gerontology, Series A: Biological Sciences and Medical Sciences* online.

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Conflict of Interest

None declared.

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