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Chronic Musculoskeletal Pain and the Occurrence of Falls in an Older Population

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Abstract

Context—Chronic pain is a major contributor to disability in older adults, however, the potential role of chronic pain as a risk factor for falls is poorly understood.

Objective—To determine whether chronic musculoskeletal pain is associated with an increased occurrence of falls in a cohort of community-living older adults.

Design, Setting, Participants—The MOBILIZE Boston Study is a population-based longitudinal study of falls in 749 adults aged 70 and older living in the Boston area. Participants were enrolled from September, 2005 through January, 2008.

Main Outcome Measure—Participants recorded falls on monthly calendar postcards mailed to the study center during an 18-month period.

Results—There were 1029 falls reported during the follow-up. Report of 2 or more locations of musculoskeletal pain at baseline was associated with greater occurrence of falls. The age-adjusted fall rates were: 1.18 (95%CI 1.13–1.23) falls per person-year(PPY), for participants with ≥2 sites of joint pain (n=300), 0.90 (95%CI 0.87–0.92) falls PPY for those with single site pain (n=181), and 0.78 (95%CI 0.74–0.81) falls PPY for persons reporting no joint pain (n=267). Similarly, more severe or disabling pain at baseline was associated with higher fall rates ($p<0.05$). The association persisted after adjusting for multiple confounders and fall risk factors. The greatest risk for falls was observed in persons who had ≥2 pain sites (adj. rate ratio (RR) =1.53, 95%CI 1.17–1.99), and those in the highest tertiles of pain severity (adj. RR=1.53, 95%CI 1.12–2.08) and pain interference with activities (adj. RR=1.53, 95%CI 1.15–2.05), compared to their peers with no pain or those in the lowest tertiles of pain subscales.

Conclusions—Chronic pain measured according to number of locations, severity or pain interference with daily activities was associated with greater risk for falls in older adults. A randomized controlled trial is needed to confirm whether improved pain control could reduce fall risk in older persons who have chronic pain.

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Falls rank among the 10 leading causes of death in older adults in the U.S., resulting in over $19 billion in health care costs annually.[1, 2] Despite a growing body of scientific evidence supporting associations between a number of risk factors and falls,[3] efforts to translate these findings into effective fall prevention strategies have been limited.[4] Perhaps one contributing factor to the limited success of multifactorial fall prevention efforts may be that some major causes of falls in older persons continue to elude us.

Few reports have examined chronic pain as a risk for falls in older adults[5–7] and none have prospectively examined multiple pain sites in relation to fall risk in the general population of older adults living in the community. Pain contributes to functional decline and muscle weakness, and is associated with mobility limitations that could predispose to falls.[8–10] In addition, neurocognitive deficits observed in elderly fallers[11] are not unlike the mild cognitive deficits observed in older adults with chronic back pain,[12] supporting the possibility of a central-mediated pathway whereby pain contributes to falls. Given the high prevalence of chronic pain coupled with the problem of under-treatment of chronic pain in older patients,[13] it is reasonable to surmise that chronic pain could be an important contributor to falls. The MOBILIZE (Maintenance of Balance, Independent Living, Intellect, and Zest in the Elderly) Boston Study (MBS) used a longitudinal cohort design to explore a set of risk factors for falls that are generally more challenging to measure, in hopes of identifying new targets for fall prevention.

METHODS

Study participants were women and men aged 70 and older, living in the community in Boston and nearby suburbs. Recruitment and enrollment took place from September, 2005 to January, 2008, within a defined geographic area bounded by a 5-mile radius from the Institute for Aging Research at the Hebrew Rehabilitation Center (HRC) in Boston. The sampling area was chosen to capture a diverse urban and suburban population, to increase likelihood of recognition of the study center, and to minimize transportation burden. Details of the study methods were published previously.[14, 15]

Initial eligibility was based on age 70 years or older, ability to walk 20 feet without personal assistance, able to communicate in English, and the expectation of staying in the area for 2 years. Following the initial recruitment visit, study staff contacted prospective enrollees by telephone to confirm eligibility and schedule the baseline home and clinic visits. During the home visit, informed consent was obtained and participants were screened for moderate or severe cognitive impairment using the Mini-Mental State Examination (MMSE, score of <18).[16, 17] All protocols for the study and consent procedures were approved by the Institutional Review Boards of the HRC and collaborating institutions.

Falls Assessments

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 (e.g. myocardial infarction, stroke, or seizure) or an overwhelming external hazard (e.g. hit by a vehicle).[18] During the home visit, participants were instructed to complete and return monthly falls calendar postcards. On the postcards, participants were to record an “F” for each fall on the day it occurred and an “N” on days when no fall occurred. This approach has been well-validated for use in epidemiologic cohort studies.[19] Research staff monitored the return of the calendars and on any given month, approximately one-third of participants were called for missing or incomplete calendars. Falls were assessed for up to 18 months through April, 2009.

Chronic Pain Assessment

Pain was assessed according to location, overall pain severity and pain interference with daily activities, encompassing key dimensions for pain assessment recommended by the American Geriatrics Society.[20] We used a 13-item joint pain questionnaire (JPQ) to assess chronic musculoskeletal pain in hands/wrists, shoulders, back, chest, hips, knees, and feet.[21] This measure was previously associated with decline in physical function in older women.[10, 22] Chronic pain in each site was based on participant's report that pain was present in the previous month and present for at least 3 months in the previous year. Chest pain associated with angina was excluded, based on an algorithm used to classify angina from the Rose questionnaire[23] and use of nitrates. We classified chronic joint pain as follows: (1) pain in 2 or more locations (referred to as polyarticular pain), (2) pain in a single location, and (3) no pain. We also developed a second set of pain location measures according to each specific joint site. For example, knee pain was classified as (1) pain in the knee(s) as well as 1 or more other joint locations, (2) pain in the knee(s) only, and (3) no knee pain. We used two subscales of the Brief Pain Inventory (BPI), the 4-item pain severity subscale and the 7-item BPI pain interference scale.[24] The BPI, which measures pain in general without reference to location, was originally developed for use in cancer patients but has been validated for use in non-malignant pain.[25, 26]

Pain was also assessed monthly during follow-up using a single pain-rating question on the monthly fall postcards. The question, from the well-validated SF-36, was stated as follows, "In the past month, how much bodily pain have you had?" and response options were, "none, very mild, mild, moderate, severe, and very severe."[27]

Sociodemographics, Chronic Conditions, and Fall Risk Factors

Sociodemographic characteristics assessed in the home interview included age, sex, race (self-identified), and years of education. Race was included because our prior work found Black race associated with polyarticular pain.[22] Cognitive status was assessed using the MMSE, scored 0–30.[17] We used the validated Physical Activity Scale for the Elderly (PASE) to measure physical activity in the previous week.[28] Participants were asked about doctor-diagnosed major medical conditions. Heart disease included report of heart attack, congestive heart failure, angina, pacemaker or cardiac arrhythmia. Other self-reported diagnoses included stroke, Parkinson's Disease, rheumatoid arthritis, and spinal stenosis/ disc disease. Peripheral neuropathy was assessed using Semmes-Weinstein monofilament testing.[29] Peripheral arterial disease was defined using an algorithm, based on an ankle-arm index <0.90 and the Rose Intermittent Claudication questionnaire.[23] Diabetes was defined using an algorithm based on self-reported diabetes, use of antidiabetic medications, and laboratory measures from the baseline clinic visit including random glucose (≥200mg/dl) and hemoglobin A1c (>7%). American College of Rheumatology (ACR) clinical criteria for osteoarthritis(OA) of the hand and knee[30, 31] were assessed in the clinic examination by experienced nurses trained by the study rheumatologist (R.H.S.). Depression was assessed using Eaton's method based on a modification of the 20-item Centers for Epidemiologic Studies Depression (CESD) scale.[32, 33] Distant vision was measured at 10-feet using a letter chart, the Good-Lite Chart Model 600A. Body mass index (BMI, height in cm^2/weight in kilograms) was calculated from measured height and weight. Standing balance was scored using 4 timed tests (side-by-side, semi-tandem, tandem and one-leg stands).[34] For the timed chair stands test, participants were asked to fold their arms across their chest and stand up and down from a chair 5 times as quickly as possible.[34] Gait speed was based on the shortest time of 2 trials of a usual-paced 4-meter walk.

Medications

During the home visit, the interviewer recorded use of all prescription and over-the-counter medications taken in the previous 2 weeks. Active ingredients of medications were coded according to the Iowa Drug Information System (IDIS) ingredient codes.[35] Analgesic medications included opioid and non-opioid analgesics and daily use was determined from dose and frequency information. Daily or less than daily use of 325mg or less of aspirin, probable anti-thrombotic therapy, was not included as an analgesic. Psychotherapeutic agents, including sedative, hypnotic, anxiolytic, antidepressant, and antipsychotic medications, were categorized as use of 2 or more daily, 1 daily, non-daily use, no use.

Analysis

We planned to enroll 800 participants in order to have 648 evaluable subjects at the end of follow-up, accounting for possible attrition. Assuming the annual occurrence of falls, estimated at 30%,[36] follows a Poisson process, we expected to have 85% power to detect a difference as small as 20% between those with polyarticular pain compared to those with no pain, using a chi-square test with continuity correction and significance level 0.05.

In our analyses, we tested both the association between baseline pain measures and risk of falls over the 18-month follow-up and the short-term relationship between pain measured each month and risk for falls in the subsequent month. We used descriptive statistics and chi-square tests (1 d.f.) to describe prevalence of baseline characteristics and fall risk factors according to musculoskeletal pain categories (none, single site, polyarticular). Age-adjusted fall rates and 95% confidence intervals (CI) were calculated using the direct method, applying the crude age-specific rates to the age distribution of the cohort.[37]

Statistical models were performed using total number of falls (as a count variable) per total follow-up time for each participant, yielding multivariable-adjusted rate ratios (RR) and 95% CI. Using the Poisson distribution for fall counts assumes that the mean equals the variance and this assumption typically does not hold as the variance is often much higher than the mean. To correct for this overdispersion, which can result in underestimates of standard errors and overestimates of chi-square statistics, we used negative binomial regression models with an offset variable for log total years of follow-up. We examined 3 domains of baseline chronic pain in relation to fall risk: pain location (none, single joint site, polyarticular), severity (tertiles of the BPI pain severity subscale) and interference (tertiles of the BPI pain interference subscale). In addition, we performed a similar analysis using site-specific pain measures. There was very little missing information in the baseline measures and no single covariate had more than 2.4% missing. In the fully adjusted models that included all covariates, only 5.6% of records (n=42) were excluded for missing information. Analyses were performed using SAS version 9.1 (Cary, N.C.).

To evaluate the association between monthly pain ratings and risk for falls in the subsequent month during the 18-month follow-up, we performed pooled logistic regression models. Using an approach described previously, each month of follow-up for each subject is a separate observation in the dataset, which assumes within-subject observations are independent and risk for falls in relation to pain is unchanged over time.[38, 39] The logistic regression models, generating odds ratios, were adjusted for baseline covariates used in the fully adjusted negative binomial models previously described. Because of the small numbers who reported very severe pain on the monthly pain rating, we grouped severe and very severe pain ratings.

RESULTS

From a random sample comprising 5,655 households within the target area, recruitment staff confirmed that 4,319 persons aged 70 years and older resided at the sampled addresses. Of these, 1,610 were ineligible, 1,916 were of unknown eligibility (including refusal to complete screening), 44 persons were eligible but did not complete the interview, and 749 persons were eligible and completed the baseline home interview and clinic examination. Ineligibility was most commonly related to language, poor health, mobility, and cognitive status.

To determine the response rate among those eligible to participate, which was 53%, we applied our observed eligibility rate (33%) to estimate the proportion of those we contacted whose eligibility was unknown would have been eligible to participate (American Association of Public Opinion Research[40]). Participants were younger than non-participants [mean in years (SD), 78 (5) and 79 (7) respectively, $P < 0.001$] and more likely to be white, non-Hispanic (81% vs. 77%, $P = 0.02$) but no more likely to be women (63% vs 64%, $P = 0.81$).

At baseline, 40% of participants reported chronic polyarticular pain. Another 24% reported chronic pain in only one joint area. The number of musculoskeletal pain locations was highly correlated with the tertile classifications of both BPI pain severity and pain interference ($r = 0.55$ for each). The two BPI subscales also were highly correlated ($r = 0.70$). Older adults who had polyarticular pain were more likely to be women, have fewer years of education, to be obese, have fallen in the previous year, and have poorer performance in tests of balance and mobility (Table 1). Medical conditions associated with chronic musculoskeletal pain included spinal stenosis/disc disease, hand and knee osteoarthritis, rheumatoid arthritis, depression, peripheral arterial disease, and heart disease (Table 2).

Overall, 76% of participants completed 18 monthly calendars, 90% completed 15 or more monthly calendars and 94% completed at least 12 monthly calendars. On average, 98% of falls calendar information was completed each month either by returned postcards or by telephone; specifically, the proportions of completed calendars at 6, 9, 12, and 18 months were 97%, 97%, 98% and 98%, respectively, among persons currently enrolled at each time point. A total of 1,029 falls were reported by the 749 participants on the monthly fall calendars during up to 18 months of follow-up. More than half of participants (n=409; 55%) fell at least once during the follow-up. Older persons who had chronic pain, whether measured by location, severity, or pain interference with activities, had higher rates of falls during follow-up compared to those who had no pain ($p<0.05$, Figure 1). After multivariable adjustment for chronic conditions and fall risk factors, each measure of chronic pain continued to be independently associated with increased occurrence of falls (Table 3). Adjustment for balance and mobility performance, use of psychotherapeutic medications, and, in subsequent models, adjustment for use of analgesics and clinical criteria for osteoarthritis of the hand and knee had little influence on the rate ratios (RR). When we adjusted for history of falls, the association with each pain measure was attenuated but remained significant (eTable 1 online). We found no evidence of an interaction between musculoskeletal pain and use of daily analgesics in relation to falls (test for interaction, $p=0.78$).

We considered individual musculoskeletal sites alone or in combination with other sites of pain in relation to falls. For each site of joint pain, risk for falls increased only when polyarticular pain was present (Table 4). The one exception was back pain, which was not associated with an increased rates of falls compared to persons without pain.

In about one-third of the monthly postcards, participants rated their pain on average for the month as moderate to very severe. We observed a strong graded relationship in the short term between pain severity ratings each month with risk for falls in the subsequent month (Table 5). For example, among persons who reported severe or very severe pain for any given month on their calendar postcard, there was a 77% increased likelihood for a fall in the subsequent month, compared to those who reported no pain (multivariable adj. OR 1.77, 95%CI 1.32 – 2.38). Persons reporting even very mild pain also had an elevated risk for falls in any given month (adj. OR 1.36, 95%CI 1.08 – 1.71). Further adjustment for baseline pain status led to only a modest attenuation of the association with no change in the significance of the findings.

COMMENT

Both chronic pain and falls were very common in our study population. Our results provide strong and consistent evidence that chronic musculoskeletal pain, regardless of the measure used, is associated with increased risk for falls in a general population of community-living older adults. The effect was observed using chronic pain assessed at baseline predicting falls over 18 months and, more immediately, in monthly pain ratings predicting falls in the subsequent month. Pain may be a marker for underlying pathology or treatments that could contribute to falls, such as spinal stenosis, osteoarthritis with deformities, or sedating medications. However, when we adjusted for these potentially confounding factors, pain remained a strong independent risk factor for falls.

Possible underlying mechanisms for the pain-falls relationship can be grouped into three categories, local joint pathology, neuromuscular effects of pain, and central mechanisms whereby pain interferes with cognition or executive function. Osteoarthritis is the main disease process contributing to joint pain in older adults. Polyarticular pain, as defined in our study, may represent a generalized arthritic process. Findings regarding risk for falls from arthritis are generally weak or inconclusive, possibly related to varying definitions of arthritis.[41] Knee pain but not clinically diagnosed knee OA, was associated with increased fall risk in older trial participants.[7] In our analyses, the association between pain and falls was independent of clinically assessed hand and knee OA, as well as mobility performance. However, we cannot be certain that unmeasured joint pathology could be a contributing factor to the observed associations.

Neuromuscular effects of pain could lead to leg muscle weakness or slowed neuromuscular responses to an impending fall. Muscle weakness could arise from lack of physical activity or from a direct effect of pain on muscle, referred to as reflex muscle inhibition.[42] Another factor may be gait alterations or adaptations to chronic pain that lead to instability and subsequent balance impairments.

Chronic pain may serve as a distractor or, in some way, interfere with cognitive activity needed to prevent a fall. Successful avoidance or interruptions of a fall typically requires a cognitively-mediated physical maneuver. Recent imaging studies provide evidence that chronic pain patients exhibit changes in both structure and function of the brain consistent with changes observed through neuropsychological testing.[43, 44] Patients with chronic pain show poorer executive function and decreased attentional resources compared to healthy controls.[45] Attention has also been associated with gait changes and fall risk.[46–48] A cognitively-mediated pathway would be consistent with our finding of similar fall risk with pain in the upper or lower extremities.

We did not observe a lower rate of falls among analgesic users, contrary to our previous study which found that analgesic users had lower fall risk than non-users among women

with pain.[6] Benefits of analgesic use may have been more evident among disabled women than in the higher functioning MBS cohort. Analgesic use is sometimes thought to contribute to falls, however, underuse of analgesics also could contribute to falls. This question deserves further study using an experimental design.

Mobility limitations and history of falls are among the strongest predictors of falls.[3] The observed association between pain and falls was independent of mobility function. Including falls that occurred in the year before baseline in our models was likely an over-adjustment for chronic pain defined also in reference to the past year (lasting 3 or more months in the past year). Thus, according to our hypothesis, chronic pain in the previous year would likely contribute to falls in the previous year. We did not control for depression because pain and depression were highly correlated in the MOBILIZE Boston cohort, similar to other cohorts.[12, 22] Nonetheless, this may be an important consideration for future investigations.

Although we studied fall risk prospectively, we cannot exclude the possibilities that baseline pain was a consequence of previous falls or that pain-related pathology was the underlying cause of the falls. We adjusted our models for comorbid conditions including clinical evidence of osteoarthritis without any substantive change in the pain-falls relationship. Strengths of this study include the population-based design, the extensive assessment of fall risk factors and possible confounders, the monthly falls ascertainment with little missing information, and the assessment of pain in several complimentary ways. Our results are likely generalizable to the population of mobile older adults living independently in the community without significant cognitive difficulties.

The findings provide evidence suggesting that the common complaint of the aches and pains of old age is related to a greater hazard than previously thought. Daily discomfort may accompany not only difficulties in performing daily activities but equally as important, may be a risk for falls and possibly fall-related injuries in the older population. The significance of this work is in the identification of chronic pain as an overlooked and potentially important risk factor for falls in older adults. A randomized controlled trial is needed to determine whether improved pain control could reduce risk for falls among older patients with chronic pain.

Supplementary Material

Refer to Web version on PubMed Central for supplementary material.

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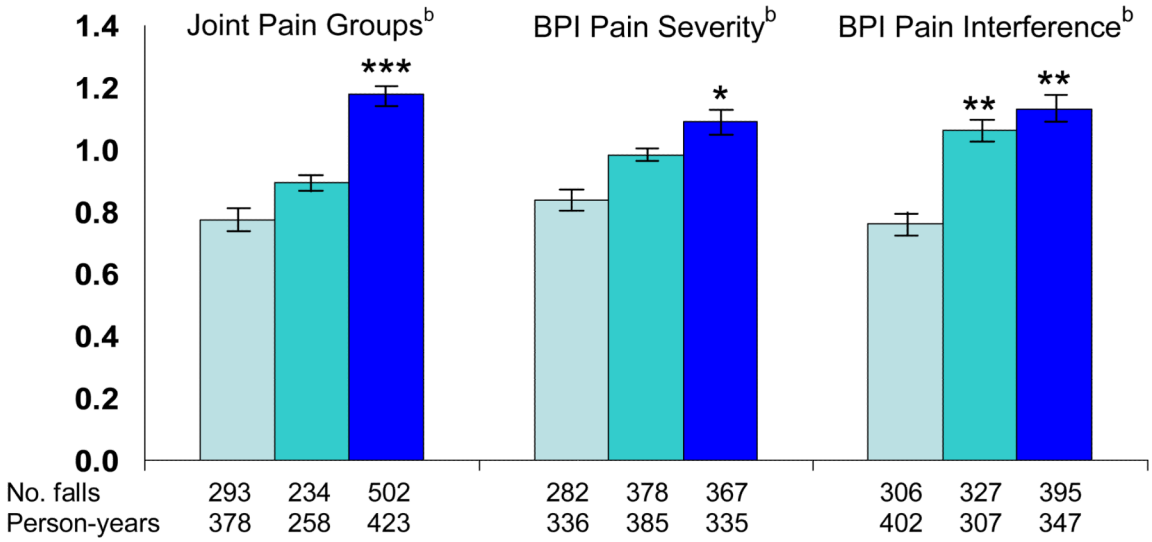

Figure 1. Age-adjusted fall rates according to pain measures[a]

[a] Age-adjusted rates and 95% confidence intervals derived using the direct method, adjusted to the age distribution of the study cohort.

[b]Joint pain groups: no pain, single site, multisite pain

BPI=Brief Pain Inventory, Pain Severity tertiles=0–0.99, 1.0–3.25, 3.26–10

Pain Interference tertiles= 0, 0.1–1.9, 2–10.

* compared to lowest category, p-value <0.05, ** <0.01, *** <0.001

Table 1

Baseline characteristics[a] according to chronic musculoskeletal pain categories.

Characteristics and fall risk factors	No Pain (n=267)	Single site (n=181)	Polyarticular pain (n=300)	p-value (trend)[b]
	No. (%)	No. (%)	No. (%)	
Age in years				
70–75	76 (28.5)	49 (27.1)	93 (31.0)	
75–79	87 (32.6)	64 (35.4)	93 (31.0)	
80–84	67 (25.1)	45 (24.9)	69 (23.0)	
≥ 85	37 (13.9)	23 (12.7)	45 (15.0)	0.78
Women	155 (58.1)	106 (58.6)	212 (70.7)	0.002
Education				
< high school	17 (6.4)	20 (11.0)	48 (16.0)	
high school graduate	64 (24.1)	26 (14.4)	84 (28.0)	
college graduate	185 (69.5)	135 (74.6)	168 (56.0)	<0.001
Race:				
White	212 (79.4)	142 (78.5)	225 (75.3)	
Black	37 (13.9)	29 (16.0)	57 (19.1)	
Other	18 (6.7)	10 (5.5)	17 (5.7)	0.51
Body Mass Index[c]				
<25	97 (37.0)	50 (28.2)	70 (24.0)	
25–29.9	108 (41.2)	82 (46.3)	125 (43.0)	
>= 30	57 (21.8)	45 (25.4)	96 (33.0)	<0.001
Visual deficit[d]	73 (27.5)	38 (21.0)	75 (25.1)	0.53
Physical activity score[e]				
0 – 66	83 (31.1)	54 (30.3)	110 (37.3)	
66.01 – 124	87 (32.6)	68 (38.2)	91 (30.8)	
124.01 – 559	97 (36.3)	56 (31.5)	94 (31.9)	0.12
MMSE < 24[f]	29 (10.9)	19 (10.5)	44 (14.7)	0.16
Fell in past year	75 (28.3)	69 (38.3)	132 (44.2)	<0.001
Psychotherapeutic medication use[g]				
None	222 (83.5)	139 (76.8)	233 (77.7)	
Less than daily	10 (3.8)	17 (9.4)	15 (5.0)	
Single drug daily	26 (9.8)	19 (10.5)	36 (12.0)	
≥Two drugs daily	8 (3.0)	6 (3.3)	16 (5.3)	0.07
Daily analgesic use[g]	31 (11.7)	40 (22.1)	114 (38.0)	<0.001
Impaired balance[h] (score <4 out of 7)	67 (25.1)	41 (22.7)	115 (38.5)	<0.001
Slow gait speed [i] (< 0.78m/sec)	53 (19.9)	39 (21.6)	94 (31.4)	0.001
Slow chair stands[j] (> 16.37 sec)	46 (17.2)	31 (17.1)	109 (36.5)	<0.001

[a] One person of the original 749 was missing musculoskeletal pain information.

[b] Mantel -Haenzel chi-square test for trend (1 d.f.), except for race comparisons, which used chi-square test for overall differences (6 d.f.).

[c] Body Mass Index calculated as weight in kilograms divided by height in meters squared

[d] Vision deficit assessed as lowest quartile in score of distant vision using Good Lite Box.

[e] Physical activity tertiles measured using the Physical Activity Scale for the Elderly

[f] Mini Mental State Examination cutpoint for cognitive impairment

[g] Used one or more analgesic medications at least daily in the previous 2 weeks

[h] Balance score was based on 4 progressively difficult stands: feet side-by-side, semi-tandem, tandem, and 1-leg stand.

[i] Slow gait speed (meters/second) is slowest 25% based on time of fastest of 2 usual-paced 4 meter walks

[j] Slowest 25% of timed performance of 5 repeated stands from a chair without using arms

Table 2

Baseline medical conditions according to pain categories.

Medical conditions	No Pain (n=267)	Single site (n=181)	Polyarticular pain (n=300)	p-value (trend)[a]
	No. (%)	No. (%)	No. (%)	
Spinal Stenosis/Disc Disease[b]	31 (11.6)	29 (16.0)	78 (26.0)	<0.001
Arthritis [c]				
Neither site	236 (88.4)	116 (64.1)	118 (39.5)	
Knee Only	16 (6.0)	36 (19.9)	81 (27.1)	
Hand Only	14 (5.2)	26 (14.4)	46 (15.4)	
Both	1 (0.4)	3 (1.7)	54 (18.1)	<0.001
Rheumatoid Arthritis[b]	7 (2.6)	7 (3.9)	24 (8.0)	0.003
Depression[d]	11 (4.1)	7 (3.9)	37 (12.3)	<0.001
Peripheral Neuropathy[e]	27 (10.2)	21 (11.7)	44 (15.1)	0.08
Peripheral Arterial Disease[f]	10 (3.8)	13 (7.2)	49 (16.3)	<0.001
Heart Disease[g]	94 (35.2)	81 (44.8)	139 (46.3)	0.008
Diabetes[f]	44(16.5)	40(22.1)	67(22.3)	0.09
Parkinson's Disease[b]	0 (0)	3 (1.7)	3 (1.0)	0.20
Stroke[b]	24 (9.0)	15 (8.3)	34 (11.3)	0.34

[a] Mantel -Haenzel chi-square test for trend (1 d.f.)

[b] Assessed by self-report during home interview

[c] Assessed in clinic exam using American College of Rheumatology clinical criteria

[d] Mild to severe depression based on CESD-revised and DSM-IV criteria

[e] Assessed using Semmes-Weinstein monofilament testing of great toes.

[f] Based on disease algorithms (Peripheral arterial disease: using Rose claudication questionnaire and ankle-brachial index; Diabetes: using random glucose, HbA1c, antidiabetic medications or insulin, and self-report)

[g] Assessed by self-report during home interview (heart disease included items about any heart disease, heart attack, irregular heart rhythm, pacemaker, angina, or heart failure).

Table 3

Rate ratios for the occurrence of falls[a] according to baseline pain measures.

			Model 1[b] Adjusted for sociodemographic characteristics		Model 2[c] (+ chronic conditions, physical and cognitive status)		Model 3[d] (+physical performance and psychotherapeutic medications)		Model 4[e] (+ analgesic use and hand and knee arthritis clinical criteria)	
Pain categories	**N[f]**	**No. falls[f]**	**RR**	**95% CI**	**RR**	**95% CI**	**RR**	**95% CI**	**RR**	**95% CI**
Chronic Musculoskeletal Pain										
None	267	293	1.00		1.00		1.00		1.00	
Single site	181	234	1.19	0.90, 1.56	1.15	0.86, 1.53	1.11	0.84, 1.47	1.11	0.84, 1.48
Polyarticular pain	300	502	1.70	1.34, 2.16	1.71	1.33, 2.20	1.60	1.23, 2.06	1.53	1.17, 1.99
No. in model[f]				N=746		N=709		N=709		N=709
BPI Pain Severity Score[g]										
Low severity tertile (0–0.99)	237	282	1.00		1.00		1.00		1.00	
Middle tertile (1.0–3.25)	267	378	1.19	0.92, 1.53	1.12	0.86, 1.46	1.12	0.86, 1.46	1.11	0.85, 1.44
High severity tertile (3.26–10)	242	367	1.54	1.18, 2.01	1.54	1.16, 2.05	1.50	1.12, 2.01	1.53	1.12, 2.08
No. in model[f]				N=744		N=708		N=708		N=708
BPI Pain Interference Score[g]										
Low interference tertile (0)	284	306	1.00		1.00		1.00		1.00	
Middle tertile (0.1–1.9)	211	327	1.44	1.11, 1.85	1.38	1.07, 1.80	1.33	1.02, 1.73	1.31	1.01, 1.71
High interference tertile (2–10)	251	395	1.67	1.31, 2.14	1.62	1.24, 2.10	1.52	1.16, 2.01	1.53	1.15, 2.05
No. in model[f]				N=744		N=707		N=707		N=707

[a] Adjusted rate ratios and 95 % confidence intervals (C. I.) from negative binomial models predicting fall rate during up to 18 months of follow-up.

[b] Model 1 covariates included age, sex, race, education

[c] Model 2 included all variables from model 1 and heart disease, diabetes, Parkinson's disease, history of stroke, vision score, BMI, cognitive function (MMSE), physical activity (PASE).

[d] Model 3 included all variables from model 2 and balance score, repeated chair stand time, gait speed, and psychotherapeutic medications

[e] Model 4 included all variables from model 3 and daily use of analgesic and non-pain clinical criteria for hand and knee osteoarthritis.

[f] Totals vary between pain measures and between models due to missing information about pain and other covariates.

[g] Pain severity and pain interferences subscales of the Brief Pain Inventory, each scored 0–10.

Table 4

Rate ratios for the occurrence of falls[a] according to pain sites.

Pain categories	N[b]	No. falls	RR[c]	95% CI
Back and other joint pain				
None	266	292	1.00	
Pain other than back	283	474	1.40	1.08, 1.79
Back only	23	35	1.37	0.75, 2.50
Back and other pain	175	227	1.22	0.90, 1.66
No. in model[c]			N = 708	
Hip and other joint pain				
None	267	293	1.00	
Pain other than hip	352	540	1.31	1.03, 1.68
Hip only	14	24	1.23	0.56, 2.69
Hip and other pain	113	170	1.46	1.03, 2.07
No. in model[c]			N = 707	
Knee and other joint pain				
None	267	293	1.00	
Pain other than knee	251	354	1.32	1.02, 1.72
Knee only	52	66	0.95	0.60, 1.49
Knee and other pain	176	315	1.51	1.12, 2.04
No. in model[c]			N = 708	
Feet and other joint pain				
None	267	293	1.00	
Pain other than feet	297	433	1.24	0.97, 1.60
Feet only	30	36	1.07	0.62, 1.84
Feet and other pain	152	265	1.70	1.24, 2.32
No. in model[c]			N = 708	
Hands/wrist and other joint pain				
None	266	293	1.00	
Pain other than hands/wrist	293	402	1.18	0.92, 1.53
Hands/wrist only	32	50	1.37	0.81, 2.32
Hands/wrist and other pain	156	284	1.65	1.22, 2.22
No. in model[c]			N = 708	
Shoulder and other joint pain				
None	267	293	1.00	
Pain other than shoulder	325	471	1.23	0.96, 1.57
Shoulder only	20	14	0.82	0.36, 1.83
Shoulder and other pain	136	251	1.79	1.30, 2.46
No. in model[c]			N = 709	

[a] Rate ratios (RR) and 95 % confidence intervals (C. I.) from negative binomial models predicting fall rate during up to 18 months of follow-up; model covariates include age, sex, race, education, heart disease, diabetes, Parkinson's disease, history of stroke, vision score, BMI, neuropathy,

cognitive function (MMSE), physical activity (PASE), balance test score, repeated chair stand time, gait speed, daily use of psychotherapeutic medications, daily use of analgesic medications, hand and knee osteoarthritis clinical criteria excluding pain.

[b] Totals vary slightly due to missing pain information for selected pain questions.

[c] Sample sizes of models vary due to missing pain and covariate information.

Table 5

Adjusted odds ratios[a] for falls in the subsequent month according to monthly pain ratings.

Pain categories	No. falls	Months	Adj. OR	95% CI
Bodily Pain Severity Rating[b]				
None	169	2983	1.00	
Very mild	254	3252	1.36	1.08, 1.71
Mild	228	2698	1.49	1.18, 1.89
Moderate	275	2906	1.59	1.26, 2.01
Severe/Very severe	122	1218	1.77	1.32, 2.38

[a] Pooled logistic regression predicting one or more falls in the month subsequent to the monthly average pain severity rating, SF-36 bodily pain item on monthly calendar postcards; model adjusted for baseline covariates: age, sex, race, education heart disease, diabetes, Parkinson's disease, history of stroke, vision score, neuropathy, BMI, cognitive function (MMSE), physical activity (PASE), balance score, gait speed, chair stands, analgesic use, psychoactive medication use, hand and knee osteoarthritis clinical criteria.

[b] The severe and very severe categories were combined due to small numbers. Pain ratings were missing for 2% of the completed fall calendars.