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Musculoskeletal Pain and Incident Disability in Community-Dwelling Elders

Aron S. Buchman, MD^{a,b}, Raj C. Shah, MD^{a,c}, Sue E. Leurgans, PhD^{a,b}, Patricia A. Boyle, PhD^{a,d}, Robert S. Wilson, PhD^{a,d}, and David, A. Bennett, MD^{a,b}

^aRush Alzheimer's Disease Center, Rush University Medical Center

^bDepartment of Neurological Sciences, Rush University Medical Center

^cDepartment of Family Medicine, Rush University Medical Center

^dDepartment of Behavioral Science, Rush University Medical Center

Abstract

Objective—To test the hypothesis that the number of areas of musculoskeletal pain reported is related to incident disability.

Methods—Participants included 898 older persons from the Rush Memory and Aging Project without dementia, stroke or Parkinson's disease at baseline. All participants underwent detailed baseline evaluation of self-reported pain in the 1) neck or back, 2) hands, 3) hips, 4) knees, or 5) feet and annual self-reported assessments of instrumental activities of daily living (IADL), basic activity of daily living (ADL), and mobility disability. Mobility disability was also assessed using a performance-based measure.

Results—Average follow-up was 5.6 years. Using a series of proportional hazards models which controlled for age, sex and education, the risk of IADL disability risk increased about 10% for each additional painful area reported (HR=1.10, 95% CI 1.01, 1.20); the risk of ADL disability increased about by 20% for each additional painful area (HR=1.20, 95% CI 1.11, 1.31); The association with self-report mobility disability did not reach significance (HR=1.09, 95% CI 0.99, 1.20). However, risk of mobility disability based on gait speed performance increased about 13% for each additional painful area (HR=1.13, 95% CI 1.04, 1.22). These associations did not vary by age, sex or education and were unchanged after controlling for several potential confounding variables including BMI, physical activity, cognition, depressive symptoms, vascular risk factors and diseases.

Conclusions—Among non-disabled community-dwelling elders, the risk of disability increases with the number of areas reported with musculoskeletal pain.

Musculoskeletal disorders are common and among the major causes of chronic pain in older adults.¹ Persons aged 65 and over represent the fastest growing segment of the US population underscoring the importance of determining the association of musculoskeletal pain with the development of disability in the elderly.² Both cross-sectional and longitudinal studies have reported a link between musculoskeletal pain and disability in the elderly.^{1, 3, 4} However, few longitudinal studies have examined whether the likelihood of developing disability increases as more areas with musculoskeletal pain are reported. In this study, we used data from 898 older participants of the Rush Memory and Aging Project, a longitudinal

study of common chronic conditions of aging,⁵ to test the hypothesis that the risk of developing disability increases as more areas with musculoskeletal pain are reported.

Participants and Methods

Participants

All participants were from the Rush Memory and Aging Project, a longitudinal clinical-pathologic investigation of chronic conditions of old age.⁵ All participants signed an informed consent agreeing to annual clinical evaluation. In addition, study participation required that participants signed an anatomical gift act donating their entire brain and spinal cord, as well as selected nerves and muscles to Rush investigators at the time of death. The study was in accordance with the latest version of the Declaration of Helsinki and was approved by the Rush University Medical Center Institutional Review Board.

At the time of these analyses, 1221 participants had enrolled and completed a baseline evaluation. Eligibility for these analyses required (1) a valid baseline assessment of musculoskeletal pain and disability, (2) the absence of a diagnosis of dementia, stroke, or Parkinson's disease at baseline, and (3) at least one follow-up disability assessment in order to assess incident disability. There were 1185 with a valid musculoskeletal pain and disability assessment at baseline. We excluded 72 persons who met criteria for dementia at baseline, 120 with stroke, and 14 with Parkinson's disease. Also, 28 persons who had completed a baseline evaluation but died before their first follow-up examination and 30 persons who had not been in the study long enough for follow-up evaluation were excluded. Of 921 participants who were eligible for follow-up there were 898 (97.5%) with complete follow-up data who were included in these analyses.

Assessment of Dementia and Other Clinical Diagnoses

Clinical diagnoses were made using a multi-step process.⁵ First, subjects underwent detailed annual cognitive function testing which included 19 cognitive performance tests (see below). Second, the cognitive test data were reviewed by an experienced neuropsychologist who determined if cognitive impairment was present. Next, participants were evaluated in person by an experienced clinician who diagnosed dementia, stroke, or Parkinson's disease using previously published criteria.⁵

Assessment of Musculoskeletal Pain

Musculoskeletal pain was assessed at baseline by asking the participant if they had experienced pain or aching in any of their joints on most days for at least one month during the prior year. Individuals who answered affirmatively about having had musculoskeletal pain, were then questioned whether they had pain or aching on most days for at least one month during the past year, in 5 areas including their a) back or neck, b) hands, c) hips, d) knees, or e) feet. In these analyses, we used the number of areas reported to be painful.

Self-Report Assessment of Disability

Disability was assessed annually via three self-report instruments.⁵ Instrumental activities of daily living (IADLs) were assessed using items adapted from the Duke Older Americans Resources and Services project, which assess eight activities: telephone use, meal preparation, money management, medication management, light and heavy housekeeping, shopping, and local travel. Basic activities of daily living (ADLs) were assessed using a modified version of the Katz scale which assesses six activities: feeding, bathing, dressing, toileting, transferring, and walking across a small room. Mobility disability was assessed using the Rosow-Breslau scale, which assesses three activities: walking up and down a flight of stairs, walking a half mile, and doing heavy housework like washing windows, walls, or

floors. Participants were given the following response choices with regard to their ability to perform each of the above activities: no help, help, unable to do. For these analyses, participants who reported needing help with or an inability to perform one or more tasks on each of the 3 scales were classified as being disabled.

Performance-Based Assessment of Mobility Disability

Based on the participant's annual gait speed when requested to walk 8 feet, mobility disability was considered present if walking speed was $<0.55\text{m/s}$, as previously described in this cohort.⁶

Other Covariates

Demographic information including date of birth, sex, and years of education were collected via participant interview. Body mass index (BMI) was determined by dividing measured weight represented in kilograms with the square of measured height represented in meters. Physical activity was assessed using questions adapted from the 1985 National Health Interview Survey. Minutes spent engaged in each of five activities were summed and expressed as hours of activity per week, as previously described.⁵

A composite measure of cognitive function based on 19 tests was used in these analyses. Immediate and delayed recall of story A from Logical Memory,⁷ immediate and delayed recall of the East Boston Story,^{8, 9} Word List Memory, Word List Recall, Word List Recognition,¹⁰ a 15-item version of the Boston Naming Test,¹¹ Verbal Fluency,¹⁰ a 15-item reading test,⁹ Digit Span Forward, Digit Span Backward,⁷ Digit Ordering,¹² Symbol Digit Modalities Test,¹³ Number Comparison,¹⁴ two indices from a modified version of the Stroop Neuropsychological Screening Test,¹⁵ a 15-item version of Judgment of Line Orientation,¹⁶ and a 16-item version of Standard Progressive Matrices.¹⁷ One additional test, Complex Ideational Material,¹⁸ was used only for diagnostic classification purposes. To compute the composite measure of cognitive function, raw scores on each of the individual tests were converted to z-scores using the baseline mean and standard deviation of the entire cohort, and the z-scores of all 19 tests were averaged. Psychometric information on this composite measure is contained in previous publications.⁵

Depressive symptoms were assessed with a 10-item version of the Center for Epidemiologic Studies Depression scale.⁵ We summarized the number of three vascular risk factors: hypertension, diabetes mellitus, and smoking and the number of four vascular diseases: stroke, myocardial infarction, congestive heart failure, and claudication, as previously described.⁵

Statistical Analysis

Spearman correlations were used to examine the bivariate associations between the number of areas of reported musculoskeletal pain and demographic variables and other covariates at baseline. Two sample t-tests (with Satterthwaite adjustments for unequal variances, when appropriate) and non-parametric tests (as appropriate) were used to compare the baseline characteristics of participants with and without musculoskeletal pain. Next we examined the associations between the five areas which were assessed for pain. Since one or more latent variables might underlie pain in multiple areas, we used tetrachoric correlations to estimate the correlations of latent normally distributed variables from the two-way tables for each pair of joints. The core analysis employed a Cox proportional hazards model to examine if the number of painful areas was related to incident self-report disability. All models controlled for age, sex, and education. In subsequent analyses, we added interaction terms for age, sex and education to examine whether the associations of musculoskeletal pain with risk of disability varied with demographic characteristics. We then added terms for a number

of potential confounders which might affect the association of musculoskeletal pain and disability. We employed both linear and quadratic terms for BMI, since both high and low BMI may be associated with adverse health outcomes. In a final model we examined whether the number of painful areas predicted incident mobility disability based on gait speed performance.⁶ A priori level of statistical significance was 0.05. All models were validated graphically and analytically. Analyses were programmed in SAS®, Version 9.1.3 for LINUX (SAS Institute Inc., Cary, NC).¹⁹

RESULTS

Baseline Musculoskeletal Pain

There were 898 persons in these analyses with mean follow-up of 5.6 years (SD=2.4) and their baseline characteristics are summarized in Table 1. The mean tetrachoric correlation for all pairs of the five areas assessed for pain was 0.65. The mean number of areas with pain was 0.959 (SD = 1.41, range = 0-5), indicating that most participants had no pain or only one painful area. About 25% of the participants reported multiple painful areas (Figure 1). The presence of musculoskeletal pain in one area was associated with an increased risk of pain in other areas (mean OR 9.0, range 6.8 to 13.1). For example, reporting pain in the back increased the odds of also reporting pain in the hip by 13-fold (Table 2).

The number of reported areas of musculoskeletal pain was not associated with age ($r_s = -0.02$, $p=0.487$) but was inversely related to education ($r_s = -0.08$, $p=0.013$) and women reported more areas of musculoskeletal pain ($r_s = -0.20$, $p<0.001$). Musculoskeletal pain was associated with higher BMI ($r_s = 0.16$, $p<0.001$), less physical activity ($r_s = -0.07$, $p=0.037$), and more depressive symptoms ($r_s = 0.25$, $p<0.001$); there were trends for vascular risk factors ($r_s = 0.06$, $p=0.07$) and vascular diseases ($r_s = 0.06$, $p=0.07$) but pain was not related to cognition ($r_s = 0.002$, $p=0.946$).

Musculoskeletal Pain and IADL Disability

In the first analysis testing the hypothesis that musculoskeletal pain is associated with the risk of developing disability in IADLs, we restricted the analysis to the 485 (54% of 898 persons) who reported no disability in IADLs at baseline. Over a mean of 5.8 (SD =2.5) years of follow-up, 295 persons (60.8% of 485) reported impairment in IADLs. In a proportional hazards which controlled for age, sex and education, examining the hazard ratio for this model, each additional area of musculoskeletal pain was associated with about a 10% greater risk of developing IADL disability. The percentage of participants developing disability increased with increasing areas of pain, but the percentage developing disability was similar for 1-2 areas of pain and 3 or more areas (Table 3).

Alternatively, since baseline age in this model also was associated with incident IADL disability (HR=1.10, 95% CI 1.01, 1.20), we can compare the size of the effect of the increased risk of IADL disability associated with each additional area of musculoskeletal pain by comparing this increased risk with a more familiar metric, the risk of IADL disability associated with increasing baseline age. For example, each additional area of musculoskeletal pain at baseline was associated with an equivalent risk of IADL disability associated with a participant being about 1.3 years older at baseline (Areas of musculoskeletal pain, estimate, 0.093 / Age, estimate, 0.069 = 1.3 years). The association of more areas of musculoskeletal pain and incident IADL disability did not vary by age, sex, or education (data not shown). The association of musculoskeletal pain and incident IADL disability were unchanged after adjustment for several covariates (Table 4).

Musculoskeletal Pain and ADL Disability

This analysis was restricted to the 813 persons (91% of 898) who reported no ADL impairment at baseline. Over a mean of 5.6 years (SD=2.4) of follow-up, 275 persons (33.8% of 813) reported ADL impairment. In a proportional hazards model which controlled for age, sex and education, each additional area of musculoskeletal pain was associated with about a 20% greater risk of developing ADL disability which was equivalent to the risk of developing Katz disability associated with a participant being about 2.0 years older at baseline.. The percentage of participants developing disability increased with increasing areas of pain as shown in Table 3 and illustrated in Figure 2. Next, we repeated the core model described above with additional terms for possible interactions with demographic variables. The association of musculoskeletal pain and ADL disability did not vary by age, sex, or education (data not shown). The increased risk of ADL disability with more areas of musculoskeletal pain persisted after adjustment for several covariates (Table 4).

Musculoskeletal Pain and Self-Report Mobility Disability

Next, we examined the association of musculoskeletal pain with the risk of developing mobility disability. This analysis was restricted to the 518 (57.6% of 898 persons) who reported no mobility disability at baseline. Over a mean of 5.8 (SD 2.5) years of follow-up, 291 persons (56.2% of 518) reported mobility disability. There was a trend for an increased risk of self-report mobility disability for each additional painful area reported (Table 4). The association of more areas of musculoskeletal pain with incident mobility disability was essentially unchanged even after adjustment for several covariates (Table 4).

Musculoskeletal Pain and Performance-Based Mobility Disability

We next examined the association of musculoskeletal pain with risk of mobility disability based on physical performance measures which may be more sensitive compared to self-report. There were 599 participants (66.7% of 898 persons) without mobility disability at baseline based on a gait speed >0.55m/s. Over a mean of 5.8 years of follow-up, 336 persons (56.1% of 599) developed mobility disability. Each additional area of musculoskeletal pain was associated with about a 13% greater risk of developing mobility disability which was equivalent to the risk of developing mobility disability associated with a participant being about 2.2 years older at baseline. The percentage of participants developing disability increased with increasing areas of pain but the percentage developing disability was similar for 1-2 areas of pain and 3 or more areas. (Table 3). The estimate for this model was similar to the estimate from the model based on self-reported mobility disability (performance-based: 0.120 versus self-reported: 0.082). The increased risk of mobility disability with more areas of musculoskeletal pain persisted even after adjustment for several covariates (Table 4).

DISCUSSION

In this cohort of about 900 older community-dwelling elders without dementia, stroke, Parkinson's disease, the risk of developing incident IADL, ADL and mobility disability increased as more areas with musculoskeletal pain were reported. These associations did not vary by age, sex or education and remained significant after controlling for several possible confounders including BMI, physical activity, cognition, depressive symptoms, vascular risk factors and vascular diseases. These results extend the prior literature and suggest that musculoskeletal pain may be a modifiable risk factor for decreasing the burden of disability in community-dwelling elders. Further, they suggest that the number of musculoskeletal areas affected by pain may have prognostic significance.

There has been an increased awareness and understanding of the growing burden of musculoskeletal conditions both in the elderly and to society. Studies which have focused on pain in a particular body area such as low back pain or lower extremity pain report that both are associated with subsequent decline in physical performance.²⁰⁻²² There have been few longitudinal studies which have examined the contribution of musculoskeletal pain to the development of disability in community-dwelling elders.²³ A recent longitudinal study of community-dwelling elders reported that the number of locations and severity of chronic musculoskeletal pain is associated with risks of falling.²⁴ Pain in multiple areas has been reported to be associated with an increased risk of progression from mild to severe ADL and mobility disability in women.^{3, 25} The current study extends these prior studies by showing that more widespread musculoskeletal pain is associated with an increased risk of developing both IADL and Katz disability. While the association of musculoskeletal pain and the development of self-reported mobility disability showed a trend for significance, the effect size for this association was similar to the association obtained in a model for incident performance-based mobility disability corroborating this association. A similar percentage of participants with 1-2 areas of pain and 3 or more areas subsequently developed IADL and mobility disability (Table 3, IADL & Mobility Disability). Further work is needed to examine whether there may be a threshold effect for pain and the subsequent development of different disabilities. The current study suggests that the presence of musculoskeletal pain may be an important clinical marker for identifying elders with at increased risk for developing a wide range of disabilities. The results of the current study have important translational implications since they suggest that public health efforts to encourage life-style changes and interventions which ameliorate pain might increase the efficacy of efforts to decrease the burden of disabilities in our rapidly aging population.

Musculoskeletal conditions vary with regard to their pathophysiology but are linked anatomically through the structural changes in bones, joints and muscles leading to long term pain and disability in adults. The basis for the association between musculoskeletal pain and disability is uncertain but is likely multifactorial. Prior studies have shown that radiologic or physical joint changes are not as robustly associated with disability as reports of pain, suggesting that other factors are involved in the association.²⁶ While disability due to musculoskeletal pain is often ascribed to osteoarthritis in a specific joint (i.e., knee) recent work suggests that pain is multi-faceted and complex.²⁷⁻²⁹ For example, the pain matrix in joint or spine disease constitutes an interaction between structural pathology, neural innervation of the joint (sensory, motor, autonomic), dysfunction of pain processing at spinal and cortical levels and various environmental and individual determinants (i.e., affective, cognitive). Thus, pain reflects the integrated result of multiple biologic and psychosocial inputs that are not fully understood.^{28, 29} Our finding that musculoskeletal pain was associated with the development of a wide range of disabilities suggests that pain may effect changes in central nervous system pathways which mediate both motor and non-motor functions. Further work is needed to explicate the biology of the link between pain and disability.

The current study has several limitations. The selected nature of the cohort, which included participants willing to provide organ donation and the low prevalence of musculoskeletal pain, underscores the need for replication of these results in a population-based study. While the current study provides important longitudinal data about pain and incident disability, it is an observational study so causal inferences are limited. Thus we cannot determine whether musculoskeletal pain causes disability or whether both share a common underlying pathophysiology. Pain is a multi-dimensional construct and the current study assessed the number of areas with musculoskeletal pain during a one month period. Further studies are needed to examine the contributions of other dimensions of pain including chronicity, frequency, and severity of pain. Finally, we did not have objective measures physical exam,

radiologic, or pathology findings that would provide more precise characterization and classification of the causes of pain.

Our study is strengthened by having a large cohort in which simultaneous measures of musculoskeletal pain and disability were obtained, the longitudinal design, and our ability to control for important covariates, especially detailed cognitive function. Our use of a community-based sample rather than a clinic based sample reduces one type of selection bias. Further, we excluded persons with common neurological conditions that cause disability and considered several covariates that may affect the relationship of musculoskeletal pain and mobility disability. This study suggests that in ambulatory community-dwelling elders without disability, the number of regions affected with musculoskeletal pain is related to the subsequent risk of developing disability. Public health programs to encourage life-style changes and ameliorate musculoskeletal pain might decrease the burden of disability in our aging population.

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Figure 1. Number of Painful Areas at Baseline

Figure 2. Number of Painful Areas and Participants Developing Katz Disability

Table 1
Baseline Characteristics of Participants With and Without Baseline Musculoskeletal Pain

Variable	No Pain ^a N=528	Yes Pain ^a N=370	p-value ^b
Age (yrs)	79.7 (7.4)	79.7 (6.9)	0.985
<70	10.2%	10.8%	
70 to <80	37.5%	34.6%	
80 to <90	45.3%	50.3%	
90	7.0%	4.3%	
Sex (male)	172 (33 %)	59 (16 %)	<0.001
Education (yrs)	14.7 (3.1)	14.2 (3.1)	0.019
> 12 (yrs)	72.9%	64.3%	
9-12 (yrs)	24.2%	31.9%	
8 (yrs)	2.9%	3.8%	
Mini-Mental State Examination	27.9 (2.1)	28.0 (1.9)	0.441
Body Mass Index (kg/m ²)	26.3 (4.5)	28.3 (6.2)	<0.001
BMI<20	3.7%	2.8%	
BMI 20 to <25	36.5%	26.7%	
BMI 25 to <30	40.6%	38.3%	
BMI 30	19.2%	32.2%	
Physical Activity (hours/week)	3.4 (3.9)	2.8 (2.7)	0.006
Global Cognition (composite z-score)	0.08 (0.53)	0.08 (0.51)	0.896
Depressive Symptoms	0.9(1.5)	1.8 (2.0)	<0.001
Vascular Risk Factors (sum)	1.1 (0.8)	1.2 (0.8)	0.062
Smoking	40 %	40 %	0.835
Diabetes	13 %	12 %	0.880
Hypertension	53 %	65 %	<0.001
Vascular Diseases (sum)	0.20 (0.5)	0.26 (0.5)	0.068
Myocardial Infarction	10 %	12 %	0.478
Congestive Heart Failure	3 %	7 %	0.024
Claudication	6 %	7 %	0.412

^aMean (±SD).

^bStudent t-tests with Satterthwaite-adjusted degrees of freedom as appropriate, Wilcoxon rank sum tests or Chi-Square tests were used to compare the characteristics of both groups at baseline. **MMSE**: Mini-Mental State Examination score is from 0 to 30, a higher score indicates a better cognitive performance **BMI**: Body Mass Index is weight in kilograms divided by the square of height in meters. **Physical Activity**: Self-reported frequency of participation in 5 physical activities (hours/week), a higher score indicates more frequent participation. **Global cognition** composite measure of cognition based on performances on 19 cognitive tests, a higher score indicates a higher level of cognition. **Depressive Symptoms**: Modified 10 item CES-D scale, a higher score indicates more depressive symptoms. **Vascular Risk Factors**: Number of vascular risk factors: smoking, diabetes, and hypertension self-reported. **Vascular Diseases**: Number of vascular diseases: myocardial infarction, congestive heart failure, claudication and stroke.

Table 2
The Presence of Musculoskeletal Pain Is Associated with Increased Odds of Pain in Other Areas

	Hip	Back	Knee	Hand	Feet
Feet	7.91	9.96	9.70	10.71	-
Hand	7.59	9.46	6.83	-	10.71
Knee	7.16	7.72	-	6.83	9.70
Back	13.09	-	7.72	9.46	9.96
Hip	-	13.09	7.16	7.59	7.91

Table 3
Areas of Pain and Percentage of Participants Developing Disability

Painful Areas	IADL	Katz	Rosow-Breslau	Mobility Disability
0	56.2 (181 /322)	30.0 (147/490)	54.4 (190//349)	51.8 (192/371)
1 or 2	69.8 (74/106)	37.17 (75/202)	61.1 (69/113)	62.5 (95/148)
3 or more	70.2 (40/57)	43.8 (53/121)	57.1 (32/56)	61.3 (49/80)

Table 4
Musculoskeletal Pain and Incident Disability*

Covariates	IADL	ADL	Rosow-Breslau	Mobility Disability
Age, Sex, Education	1.10 (1.01, 1.20)	1.20 (1.09, 1.31)	1.09 (0.99, 1.20)	1.13 (1.04, 1.22)
BMI	1.08 (0.99, 1.18)	1.17 (1.07, 1.27)	1.05 (0.95, 1.15)	1.10 (1.02, 1.20)
Physical Activity	1.09 (1.00, 1.19)	1.19 (1.10, 1.30)	1.08 (0.99, 1.19)	1.12 (1.03, 1.21)
Cognition	1.09 (1.00, 1.19)	1.21 (1.11, 1.31)	1.08 (0.99, 1.19)	1.13 (1.05, 1.22)
Depressive Symptoms	1.07 (0.98, 1.18)	1.19 (1.09, 1.29)	1.06 (0.97, 1.17)	1.09 (1.01, 1.19)
Vascular Diseases	1.09 (1.00, 1.19)	1.20 (1.11, 1.31)	1.08 (0.98, 1.18)	1.12 (1.03, 1.21)
Vascular Risk Factors	1.09 (1.00, 1.19)	1.20 (1.11, 1.31)	1.08 (0.98, 1.19)	1.13 (1.05, 1.22)

* Hazards Ratio for a Cox Proportional Hazard Model for the Risk of Incident Disability. All models controlled for age, sex and education and the covariate listed in the first column. **BMI**: Body Mass Index is weight in kilograms divided by the square of height in meters. Included both a linear and non-linear term for BMI. **Physical Activity**: Self-reported frequency of participation in 5 physical activities (hours/week), a higher score indicates more frequent participation. **Global cognition** composite measure of cognition based on performances on 19 cognitive tests, a higher score indicates a higher level of cognition. **Depressive Symptoms**: Modified 10 item CES-D scale, a higher score indicates more depressive symptoms. **Vascular Diseases**: Number of vascular diseases: myocardial infarction, congestive heart failure, claudication and stroke. **Vascular Risk Factors**: Number of vascular risk factors: smoking, diabetes, and hypertension self-reported.