Factors Related to Sleep Disturbance in Older Adults Experiencing Knee Pain or Knee Pain with Radiographic Evidence of Knee Osteoarthritis

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OBJECTIVES: To describe the types and frequencies of sleep complaints and the biopsychosocial factors associated with sleep disturbance in a large community sample of older adults experiencing knee pain or knee pain with radiographic evidence of knee osteoarthritis (OA).

DESIGN: Baseline analyses of an observational prospective study.

SETTING AND PARTICIPANTS: Participants were 429 men and women aged 65 years and older experiencing knee pain or knee pain with radiographic evidence of OA enrolled in the Observational Arthritis Study in Seniors (OASIS).

MEASUREMENTS: Demographic variables (age, gender, ethnicity, education), health (X-rays of knee rated for OA severity, medical conditions, medication use, smoking status, body mass index, self-rated health), physical functioning (self-rated physical functioning, physical performance), knee pain, and psychosocial functioning (social support, depression) were measured.

RESULTS: Problems with sleep onset, sleep maintenance, and early morning awakenings occurred at least weekly among 31%, 81%, and 51% of participants, respectively. Bivariate correlates of greater sleep disturbance in those with OA were less education, cardiovascular disease, more arthritic joints, poorer self-rated health, poorer physical functioning, poorer physical performance, knee pain, depression, and less social support. In regression analyses, each set of variables representing the domains of health, physical functioning, pain, and psychosocial functioning contributed to the prediction of sleep disturbance beyond the demographic set. Finally, in a simultaneous model, white race (trend, $P = .06$), poorer self-rated health, poorer physical functioning, and depressive symptoms were predictive of sleep disturbance.

CONCLUSIONS: Sleep disturbance is common in older adults experiencing knee pain or knee pain with radiographic evidence of OA and is best understood through the consideration of demographic, physical health, physical functioning, pain, and psychosocial variables. Interventions that take into account the multidetermined nature of sleep disturbance in knee pain or knee OA are most likely to be successful. **J Am Geriatr Soc 48:1241–1251, 2000.**

Key words: knee osteoarthritis; knee pain; sleep

Arthritis is the most common chronic health condition affecting older adults.[1] The most prevalent form of arthritis, osteoarthritis (OA), is a leading cause of disability and a major cause of chronic pain.[2–4] The knee and the hip are the most frequently affected weight-bearing joints. OA of the knee greatly impacts important daily activities such as climbing stairs, walking, dressing, and transferring (e.g., in and out of a car or chair). Because there is no cure for OA, current treatments focus on relieving pain with the goal of improving physical functioning and quality of life.[2,5,6]

Health-related quality of life (HRQOL) is now viewed as a critical measure of functioning in individuals with OA.[6] Yet, few studies have examined the prevalence and correlates of sleep disturbance, a component of HRQOL, in this population. The sleep quality of some chronic pain populations, including fibromyalgia[7,8] and rheumatoid arthritis,[9–11] has received extensive empirical study. Yet, detailed sleep studies of individuals with other types of pain and pain related to OA have been less common.

Research suggests that individuals with OA do experience impaired sleep. de Bock and colleagues,[12] in their clinical trial examining the effects of nonsteroidal anti-inflammatory analgesics in participants with OA aged 41 to 75 years and controls aged 41 to 60 years, found that individuals with OA were significantly impaired in the areas of sleep and rest as measured by the Sickness Impact Profile.[13] Doherty and Smith,[14] in their study of patients with OA and fibromyalgia (n = 20), found that both groups of patients reported episodes of wakening, prolonged sleep latency, and EEG-documented periods of mini-arousal. Similarly, Leigh and colleagues[15] found that when compared with age- and sex-matched controls, male OA patients had more Stage 1 sleep (very light stage of sleep similar to drowsiness) and less

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Stage 2 sleep (light sleep). In addition, osteoarthritic pain has been shown to be strongly associated with sleep complaints in both rheumatic and more general samples of individuals.[16,17] In fact, a recent Gallup survey conducted by the National Sleep Foundation found that one in three adult Americans experiences nighttime pain and sleeplessness, and that one-third of respondents with nighttime pain reported arthritic pain.[18] Finally, a recent study[19] found that arthritis (type and area affected not specified) was reported to disrupt sleep in one-third of respondents of the National Survey of Self-Care and Aging study. Of particular importance was the finding that sleep disruption, relative to other daily living disruptions, was associated with the use of the most self-care, complementary, and medical treatments. Although these studies provide evidence that sleep may be negatively impacted by OA, the results are limited by small sample sizes, use of single-item sleep measures, or highly selected samples. Furthermore, none have examined multiple predictors of sleep disturbance in OA.

Chronic pain, a prominent feature of knee OA, is a strong correlate of sleep complaints in community-based samples.[17,20–24] In addition to chronic pain, individuals with knee pain and knee OA commonly experience physical disability and resulting physical inactivity. Both of these factors have also been associated with sleep complaints in older adults.[25–28] Furthermore, coping with a chronic condition can impact quality of life,[6] as individuals must cope with the reality of lost functions and the worries associated with anticipated future declines. Psychological symptoms of depression, anxiety, and other indicators of impaired quality of life have consistently been shown to be associated with impaired sleep in older adults.[27,29–32]

In summary, there are multiple factors associated with both knee OA and sleep complaints, including pain, physical disability, physical inactivity, and impaired quality of life. Yet, few studies have specifically examined sleep complaints in a population with OA. Although there is some evidence that arthritic pain is associated with impaired sleep, studies examining sleep complaints in large samples of individuals with OA are lacking. Finally, although sleep disturbance is multidetermined, studies have not examined factors beyond pain that are associated with sleep complaints in OA patients.

The goals of this paper were (a) to describe the types and frequencies of sleep complaints reported by older adults experiencing knee pain or knee pain with radiographic evidence of OA, using a multi-item measure of sleep disturbance, and (b) to examine the correlates of sleep disturbance in individuals experiencing knee pain or knee pain with documented OA. We considered a biopsychosocial model of sleep that included variables that have been shown to be associated with sleep complaints in epidemiological studies, as well as variables that may be of unique importance to individuals with knee pain or knee OA such as pain and physical disability.

METHODS

Participants and Procedures

Participants were 480 men and women who were part of a prospective epidemiological study of knee osteoarthritis, the Observational Arthritis Study in Seniors (OASIS). For this report, data collected at the baseline assessment are reported. Data were missing or incomplete for the outcome variable (sleep disturbance) for 51 participants. Thus, all analyses were limited to the 429 participants with complete data.

Eligibility criteria for participation in OASIS were as follows (unless otherwise indicated, these were self-reported during the telephone screening): (a) 65 years of age or older, (b) knee pain on most days of the week, and (c) difficulty with at least one everyday activity due to knee pain, including walking a quarter mile, climbing stairs, getting in and out of a car, rising from a chair, lifting and carrying groceries, getting out of bed, getting out of the bathtub, or performing shopping, cleaning, or self-care activities. Participants were excluded from the study if they: (a) were planning to move from the area within 3 years, (b) were under hospice care or were receiving active treatment for cancer (other than skin cancer), (c) had shortness of breath or chest pain at rest, (d) had a Mini-Mental Status Examination[33] score of less than 24 (assessed during the first clinic-based screening visit), (e) had rheumatoid or psoriatic arthritis, amkolosing sponylitis, and polymyalgic rheumatica, or (f) were currently in another study.

Commercial lists were used to recruit participants. Names were randomly allocated to blocks and all persons in randomly selected blocks were contacted. Potential participants were sent brochures in the mail before contact by telephone. A total of 14,955 telephone calls were made, and 8217 of these calls resulted in a human contact. During the telephone call, participants were administered a brief screening questionnaire that assessed basic demographic information and inclusion/exclusion criteria. Based on these criteria, 943 individuals met the initial screening criteria. The remaining 7274 of individuals were ineligible due to one or more of the following reasons: did not meet age criteria (n = 5491), participating in another study (n = 238), reported no difficulties with any of the daily activities (n = 706), unable to walk across the room without assistance (n = 225), reported no difficulties with the daily activities due to knee pain (n = 400), expecting to leave the area within 3 years (n = 51), currently being treated for cancer (n = 61), terminally ill (n = 2), had rheumatoid or psoriatic arthritis (n = 116), or had polymyalgic rheumatica (n = 8). The 943 eligible participants were invited to take part in a series of three clinic-based screening visits. Of those eligible, 643 completed the first screening visit. Of these, 127 were excluded after screening visit 1 (SV1), and 36 were excluded after screening visit 2 (SV3). Of the 163 excluded, 107 were not interested in taking part in the study, 29 could not meet the time requirements of the study, 8 were excluded due to shortness of breath or chest pain while resting, 10 were unable to complete the 6 minute walk, and 9 had a Mini-Mental Status Examination of less than 24. The remaining 480 individuals still eligible after the screening visit took part in the study.

The first screening visit (SV1) took place in the Geriatric Clinical Research Center located within the Wake Forest University School of Medicine, and areas assessed included mental status, radiological assessment of the knees, socidemographic variables, and medical history. The last two screening visits (SV2, SV3) took place in a clinical laboratory at the Wake Forest University–Reynolda Campus. Areas assessed during SV2 included knee pain, physical function, medication use, sleep, and depressive symptoms. Areas assessed during SV3 included general self-rated health, physical activity, social support, and physical performance. The median number of days between the telephone screening and

SV1 was 9 days. The median number of days from SV1 to SV3 was 35 days. Each paper-and-pencil questionnaire included standardized written instructions, and participants were encouraged to ask the examiner questions as they were completing the questionnaires.

Measures

Demographic variables

Participants reported their age (in years), gender, ethnicity, and educational level (according to ordinal categories).

Physical health-related variables

Severity of osteoarthritis was rated from standing knee X-rays with a classification system adapted from Altman and colleagues.[34] Both the medial and lateral compartments were graded for joint space narrowing, osteophyte formation, subchondral sclerosis, subchondral cysts, and chondrocalcinosis on a three-point Likert scale ranging from normal (0) to severe (3). The scores for each feature were added to create a summary severity score that could range from 0 to 48, with higher scores indicating greater OA severity. The summary score for the most severely affected knee was used. The X-ray summary score is a femorotibial score that excluded patellofemoral views. Participants were also classified according to the American College of Rheumatology criteria[35] for knee OA, defined as: (a) knee pain, and (b) radiographic osteophytes, and (c) age $\geq$ 50 years *or* morning stiffness $\leq$ 30 minutes in duration *or* crepitus on motion.

Participants reported whether they had ever been told by a doctor that they had cardiovascular disease (heart attack, angina, stroke, or other heart problems) or chronic obstructive pulmonary disease (emphysema, bronchitis, asthma, breathing or lung problems). Participants were also asked if they had arthritis of the neck, hands, feet, back, shoulders, hips, or knee. A composite index representing the sum of arthritic joints was created and possible scores could range from 0 to 7. A composite index of total medical conditions, including probably depression (see below), was created. Participants completed an open-ended survey of current medications. These medications were later coded according to general categories.

Participants reported whether they were a current smoker (yes/no). Body mass index (BMI) was computed as weight in kilograms divided by height in square meters (kg/m^2). Clinic staff measured height and weight. Participants also completed the Medical Outcomes Study Short-Form General Health Survey.[36] The general health subscale consisted of five items (e.g., "I seem to get sick a little easier than other people," "My health is excellent") in which participants rated their health using five-point Likert scales. As reported by Stewart et al.,[36] scores were summed and converted to a scale ranging from 0 to 100, with higher scores indicating better self-rated health. The alpha coefficient of this scale was 0.78. Participants reported their current alcohol consumption according to the following categories: *never drank, used to drink but don't now* (combined as no current use), *1–2 times per year or very occasionally, less than once a week* (combined as <1/week), *once or twice a week, three or four times a week, nearly every day,* or *every day* (categories of $\geq$3/week were combined into one category).

Physical functioning

The Functional Performance Inventory[37] consists of 23 items that assessed difficulties with activities of daily living (e.g., walking, meal preparation, and dressing). For each activity, participants were asked, "How much difficulty, if any, did you have with each of these activities? Think about the past month." Participants responded to a five-point Likert scale that ranged from *usually did with no difficulty* (1) to *unable to do* (5). For items that were not applicable, participants could respond *usually did not do for other reasons.* This questionnaire has five activity subscales: ambulation and stair climbing, transfer activities, upper extremity tasks, basic activities of daily living, and complex activities of daily living. Averaging the scores on all items created a composite disability score that could range from 1 to 5, with higher scores indicating greater physical disability. The composite index had an alpha coefficient of 0.91. The 6-minute walk measured physical performance. This test measures how many feet an individual can walk in 6 minutes. The 6-minute walk has been used with a number of clinical populations.[38]

Pain

The intensity of knee pain during ambulation (e.g., walking) and transfer (e.g., getting in and out of a car) was assessed by the Knee Pain Scale.[39] Participants rated the intensity of knee pain during the past week during activities of daily living (e.g., getting in and out of bed, walking a block, walking up a flight of stairs), using a six-point Likert scale that ranged from *no pain* (1) to *excruciating pain* (6). Items were summed and averaged so that pain intensity scores for the ambulation and transfer subscales could range from 1 to 6, with higher scores indicating more intense pain. Coefficient alphas for ambulation and transfer pain intensity were 0.84 and 0.82, respectively. Because the two scales were highly correlated ($r = 0.74$), they were summed to form a composite index that represents knee pain during ambulation and transfer.

Psychosocial variables

Depression was measured with the Center for Epidemiological Studies Depression Scale (CES-D).[40,41] Participants reported how often they experienced 20 symptoms of depression in the past week using a four-point Likert scale that ranged from *rarely or none of the time (less than 1 day)* (0) to *most or all of the time (5–7 days)*(3). Items were summed and scores could range from 0 to 60, with higher scores indicating greater depressive symptoms. A cutoff score of 16 is generally used to indicate an increased likelihood of clinical depression. The CES-D had an alpha coefficient of 0.84.

For descriptive analyses, the CES-D total score is reported. For correlational and regression analyses, scores on the sleep item ("My sleep was restless") were subtracted from the total scores so as to not artificially inflate the relationship between sleep disturbance and depression.

Social support was measured with the MOS Social Support Survey.[42] Participants responded to 19 items asking how often different kinds of support were available to them using a five-point Likert scale that ranged from *none of the time* (1) to *all of the time* (5). The survey produces four subscales: emotional/informational support (eight items), affection (three items), tangible support (four items), and positive social interaction (four items). Items were summed to create

an overall functional support index, and scores could range from 19 to 95, with higher scores indicating a greater overall level of social support. This index had an alpha coefficient of 0.97.

Sleep disturbance

The sleep disturbance questionnaire used in OASIS was originally developed for use in the Women's Health Initiative based on both consultation with sleep research experts as well as other sleep surveys. It is similar in content to the Pittsburgh Sleep Quality Index[43] and to other self-report measures of sleep disturbance. Participants reported the frequency of four common types of sleep disturbance (sleep onset latency, sleep maintenance, early morning awakenings, difficulty resuming sleep after early morning awakenings) over the past 4 weeks using a five-point Likert scale that ranged from *no, not in past 4 weeks* (0) to *yes, 5 or more times a week* (4). Participants also rated their typical night's sleep during the past 4 weeks from *very sound or restful* (0) to *very restless* (4). Scores on the five items were summed, and scores could range from 0 to 20, with higher scores indicating greater sleep disturbance. This index had an alpha coefficient of 0.78.

Statistical Methodology

Preliminary analyses were conducted on all variables to assess for skewed, non-normal distributions using box plots and scatterplots. Spearman rank-order correlations were calculated for all variables that had non-normal distributions. Bivariate relationships between each independent variable and sleep disturbance were examined (*t* tests for dichotomous variables, Pearson correlations for normally distributed continuous variables, Spearman correlations for ordinal or non-normal continuous variables). A series of hierarchical multiple regression analyses were used to determine whether the domains (tested in sets) of physical health, physical functioning, pain, and psychosocial functioning were associated with sleep disturbance after controlling for demographic variables. Each analysis examined whether the variance accounted for by the unique set (i.e., physical health, physical functioning, pain, or psychosocial functioning) contributed significantly to the total variance explained by the demographic set alone. The increment in R^2 (IR^2) was tested for statistical significance as recommended by Cohen and Cohen.[44] Finally, a simultaneous multiple regression analysis was conducted with all the variables included in the model.

RESULTS

Preliminary Analyses

The following measures had non-normal distributions: X-ray ratings of OA severity, number of arthritic joints, social support, and depression. Spearman rank-order correlations are reported for correlations involving these variables.

Descriptive Characteristics

Table 1 provides a summary of the demographic and study variables for OASIS participants. Participants averaged 71.8 ± 4.9 years of age. There were approximately equal numbers of men and women. The sample was largely white (82.5%); 13.1% of participants were black, and 4.4% were from other ethnic groups. In 1990, 73.6% of residents in Forsyth County, NC, were non-Hispanic whites, 24.9% were blacks, and 1.5% were from other ethnic groups.[45] Forty-two percent of participants in our sample had a high school education or lower. The remaining 58% attended at least some college. Participants were, on average, overweight (mean BMI = 29.7 ± 5.3 kg/m^2) according to current criteria,[46] and had low rates of smoking and relatively high rates of disease, in addition to knee OA, as is characteristic of this age cohort.[1] Seventy-one percent of the sample met the American College of Rheumatology criteria[35] for knee OA (28.8% did not show radiographic evidence of osteophytes).

Types and Frequencies of Sleep Complaints

Table 2 presents the frequencies of three types of sleep complaints—sleep onset difficulties, sleep maintenance difficulties, and early morning awakenings—and overall sleep quality. As shown, over the past 4 weeks, 30.6% of participants reported difficulties falling asleep (i.e., sleep onset) at least once per week, with 13.8% of participants reporting this problem three or more times per week. Sleep maintenance difficulties were reported at least weekly by 80.9% of participants. In fact, this problem occurred three or more times per week in 58.1% of individuals. Early morning awakenings were also common, occurring at least weekly in 51.3% of the sample. Early morning awakenings occurred three or more times per week for 25.7% of participants. Despite the common occurrence of sleep complaints, 49.4% of the sample reported that their typical night's sleep during the past 4 weeks as average, and another 34.7% reported that their sleep was very sound/restful or sound/restful.

Bivariate Analyses

Table 3 provides a summary of the bivariate relationships between sleep disturbance and the demographic, physical health, physical functioning, pain, and psychosocial functioning variables.

Demographic variables

Participants with a high school education or lower had more sleep disturbance than participants who attended at least some college. Age, gender, and ethnicity were not associated with sleep complaints.

Physical health

Participants with chronic disease had more sleep disturbance than participants free of disease. Namely, participants with self-reported cardiovascular disease (CVD) had significantly more sleep complaints than participants free of CVD, and a greater number of arthritic joints was significantly associated with sleep disturbance. Poorer self-rated health was also associated with greater sleep complaints. A greater number of medical conditions was associated with sleep disturbance. In addition, participants who reported taking benzodiazepines or other sleep medications reported greater sleep disturbance than those not taking benzodiazepines or other sleep medications. X-ray ratings of knee OA severity, BMI, smoking status, and medications other than benzodiazepines were unrelated to sleep complaints.

Physical functioning

Poorer physical functioning and poorer performance on the 6-minute walk (i.e., fewer feet walked) were associated with greater sleep complaints.

Table 1. Demographic, Physical Health, Physical Functioning, Pain, and Psychosocial Characteristics of OASIS Participants (n = 429)

	Total *n*	Proportion	Mean (SD)	Range
Demographic variables				
Age	429		71.76 (4.95)	65–88
Gender—% women	429	52.4		
Ethnicity	429			
% White		82.1		
% Black		13.5		
% Other ethnicity		4.4		
Education	428			
% with 0–8 years		9.6		
% with 9–12 years		32.5		
% with some college		29.4		
% with college degree or higher		28.5		
Physical health				
Knee X-ray ratings	416		5.24 (4.87)	0–21
% meeting knee OA ACR criteria	413	71.2		
Co-morbid health conditions:	416			
% with no reported conditions		39.9		
% with 1 reported condition		32.7		
% with 2 reported conditions		14.9		
% with 3 reported conditions		7.9		
% with 4+ reported conditions		4.6		
Specific health conditions				
% with CVD	428	46.3		
% with COPD	424	12.7		
Arthritic joints (#)	429		2.36 (2.05)	0–7
% who smoke	429	6.5		
Alcohol use	428			
No current use		52.1		
Less than once/week		29.9		
1–2 times/week		7.0		
3+ times/week		10.9		
Medication use	429			
% taking benzodiazepines or other sleep medications		9.8		
% taking antihistamines		8.2		
% taking psychotropics		8.2		
% taking analgesics		45.0		
% of women taking estrogen		23.1		
% taking beta blockers		11.7		
% taking other cardiac or hypertension medications		45.9		
Body mass index (kg/m^2)	429		29.74 (5.30)	18–62
Self-rated health	425		65.95 (17.94)	15–100
Physical functioning				
Functional Performance Inventory	422		1.74 (0.48)	1–3.83
6-minute walk (feet walked)	417		1416.12 (321.44)	385–2370
Pain				
Knee pain intensity (ambulation + transfer)	421		4.89 (1.30)	2–12
Psychosocial variables				
CES-D	424		9.59 (7.39)	0–37
% scoring > 16 on CES-D	424	17.9		
MOS Social Support Survey	422		76.50 (15.18)	26–95
Outcome variable				
Sleep Disturbance Questionnaire	429		7.94 (4.44)	0–20

SD = standard deviation; OA = osteoarthritis; CES-D = Center for Epidemiologic Studies—Depression Scale.
ACR = American College of Rheumatology.
MOS = Medical Outcomes Study.

Table 2. Types and Frequencies (%) of Sleep Complaints and Overall Sleep Quality in the Past Four Weeks Among OASIS Participants (n = 429)

Type of Sleep Complaint	Frequency of Sleep Complaints				
	Not in Past 4 Weeks	<1/Week	1–2/Week	3–4/Week	5+/Week
Sleep onset difficulties	51.3	18.2	16.8	8.9	4.9
Sleep maintenance difficulties	9.1	10.0	22.8	25.9	32.2
Early morning awakenings	30.8	17.9	25.6	14.7	11.0
	Sleep Quality				
	Very sound/restful	Sound/restful	Average	Restless	Very restless
Overall sleep quality	10.7	24.0	49.4	14.0	1.9

Pain

More severe knee pain was associated with greater sleep complaints. Although not shown in the table, greater knee pain was significantly associated with X-ray ratings of the knee ($r = 0.24$, $P < .001$).

Psychosocial correlates

Greater depressive symptoms (CES-D corrected for the sleep item) were associated with greater sleep complaints. Those scoring above 16 on the CES-D had greater sleep complaints than those scoring below 16. Finally, greater social support was associated with fewer sleep complaints.

Regression Analyses

The results of the regression analyses are shown in Table 4. Correlations between independent variables included in the regression models are shown in Table 5. Standard deviations are also presented in this table so that standardized regression coefficients can be calculated. The first regression model tested whether the four demographic variables were associated with sleep disturbance. This model was not statistically significant, F (4,369) = 1.95, $R^2 = 0.02$, $P > .10$. Subsequent hierarchical regression models tested whether each domain (physical health, physical functioning, pain, and psychosocial functioning), represented by a set of variables, significantly contributed to sleep complaints beyond the demographic model.

The addition of the physical health set (Model 2) significantly added to the demographic set, F (8,362) = 4.84, $IR^2 = 0.09$, $P < .01$. Poorer self-rated health was positively related to sleep disturbance. In addition, there was a trend for the presence of CVD ($P = .06$) and the use of benzodiazepines ($P = .08$) to be positively associated with sleep disturbance. The physical functioning set (Model 3) also significantly added to the demographic set, F (2,368) = 12.24, $IR^2 = 0.06$, $P < .01$. Poorer physical functioning was associated with greater sleep disturbance. In addition, knee pain (Model 4) significantly added to the demographic set, F (1,369) = 5.16, $IR^2 = 0.01$, $P < .05$. Greater knee pain was associated with greater sleep disturbance. Finally, the psychosocial functioning set (Model 5) significantly added to the demographic set, F (2,368) = 13.84, $IR^2 = 0.07$, $P < .01$, with greater depressive symptomatology associated with greater sleep disturbance.

The results of the simultaneous multiple regression analysis that included all variables is also shown in Table 4. The overall model was statistically significant, F (17,356) = 3.87, $R^2 = 0.16$, $P < .0001$. Physical functioning, self-rated health, and depressive symptoms remained significant independent predictors of sleep disturbance in this simultaneous multivariate model. There was also a trend ($P = .06$) for whites to report greater sleep disturbance than other ethnic groups.

DISCUSSION

To our knowledge, this is the first study to examine multiple correlates of sleep disturbance in a large sample of older adults experiencing knee pain or knee pain with radiographic evidence of knee OA. We found that sleep onset difficulties, sleep maintenance difficulties, and early morning awakenings were common among these older adults, occurring at least weekly in 30%, 81%, and 51% of participants, respectively. It is difficult to make direct comparisons between our findings and epidemiological studies because questions are asked differently and frequency response options vary. However, rates of sleep complaints in our sample seem to be higher than population prevalences. For example, estimates of disturbed sleep onset range from 10% to 37%, sleep maintenance difficulties range from 14% to 65%, and early morning awakenings range from 17% to 30%.[20,25,27,28,30,32]

We found that a biopsychosocial model was most useful in predicting sleep disturbance. Each of the four domains—physical health, physical functioning, pain, and psychosocial functioning—contributed to the explanation of self-reported sleep disturbance above and beyond demographic variables. In addition, a simultaneous regression model demonstrated that poorer self-rated health, poorer physical functioning, and depressive symptoms were independently associated with poorer sleep. There was also a trend ($P = .06$) for white participants to report poorer sleep than participants from other ethnic groups.

A series of hierarchical regression analyses revealed that less education, white race, CVD (trend, $P = .06$), poorer health, poorer physical functioning, poorer physical performance, and depression were associated with increased sleep disturbance. These findings are consistent with epidemiological studies of sleep,[27–30] and are similar to the results that have been reported in other studies of heterogeneous samples that included OA patients.[16–18] Thus, although the cause of sleep disturbance may not differ greatly between older adults

Table 3. Bivariate Relationships Between Sleep Disturbance and Demographic, Health, Physical Functioning, Pain, and Psychosocial Variables

Independent Variables	Relationship to Sleep Disturbance		
	Mean (SD)	*t* or *F*	*r*
Demographic variables			
Age			.02
Gender		1.02	
Men	7.71 (4.41)		
Women	8.15 (4.47)		
Ethnicity		−0.83	
White	8.02 (4.39)		
Other ethnicity	7.56 (4.67)		
Education*		−2.13	
≤12 years	8.48 (4.64)		
>12 years	7.56 (4.27)		
Health variables			
§Knee X-ray ratings			−.07
ACR criteria for knee OA		−0.64	
Yes	7.82 (4.34)		
No	8.13 (4.65)		
CVD‡		−3.63	
Presence	8.77 (4.58)		
Absence	7.22 (4.21)		
COPD		−1.63	
Presence	8.77 (4.04)		
Absence	7.22 (4.50)		
§Number of arthritic joints†			.15
Smoking status		0.72	
Smoker	7.36 (5.17)		
Nonsmoker	7.98 (4.39)		
Alcoholic drinks (#)		0.69	
No current use	8.17 (4.51)		
<1/year	7.92 (4.60)		
1–2/week	7.03 (4.29)		
≥3/week	7.63 (3.69)		
Benzodiazepine use†		−2.74	
User	9.83 (5.00)		
Nonuser	7.76 (4.35)		
Body mass index (kg/m^2)			−.04
Self-rated health‡			−.23
Number of medical conditions‡			.20
Physical functioning			
FAST Functional Performance Inventory‡			.25
6-minute walk (feet walked)*			−.10
Pain			
Knee pain intensity (ambulation + transfer)†			.13
Psychosocial variables			
§CES-D‡			.24
§MOS Social Support Survey*			−.09

Note: §denotes a Spearman rank-order correlation. All other correlations are Pearson correlations.
*$P < .05$.
†$P < .01$.
‡$P < .001$.

with knee pain or OA and more general older-aged samples, the prevalence of a number of these causes is greater in individuals with knee pain or knee pain related to OA. We cannot ascertain whether knee pain (regardless of knee OA status) or knee OA per se is the most important feature. However, consistent with Hadler's[47] assertion, we found that those who met the American College of Rheumatology criteria for knee OA reported similar levels of sleep disturbance as individuals without radiographic evidence, suggesting that knee pain is the most important factor. Furthermore, and somewhat different from previous reports in more general samples, bivariate associations indicated that more arthritic

4. Unstandardized Regression Coefficients and Standard Errors for the Multivariate Correlates of Sleep Disturbance, According to the Domains of Physical Healt al Functioning (Model 3), Pain (Model 4), and Psychosocial Functioning (Model 5)

el 1	*B*	*SE*	Model 2	*B*	*SE*	Model 3	*B*	*SE*	Model 4	*B*	*SE*	Model 5	*B*	*SE*	Full Model	*B*
	0.024	.049	Age	−0.006	.049	Age	0.001	.051	Age	0.028	.049	Age	−0.014	.048	Age	−0.
der	−0.405	.465	Gender	−0.126	.459	Gender	−0.061	.469	Gender	−0.349	.463	Gender	0.044	.459	Gender	0.
	0.766	.617	Race	0.961	.614	Race	1.033	.610	Race	0.876	.616	Race*	1.232	.604	Race	1.
*	1.097	.475	Educ	0.492	.472	Educ	0.747	.466	Educ*	0.947	.477	Educ	0.477	.475	Educ	0.
			X-ray	−0.021	.048	Phys fnt‡	2.443	.544	Kn pain*	0.393	.174	Dep‡	0.177	.037	X-ray	−0.
			CVD	0.912	.483	6-min wlk	0.000	.001				Soc sup	−0.007	.016	CVD	0.
			COPD	0.402	.685										COPD	0.
			Arth jnts	0.039	.119										Arth jnts	−0.
			Benzo	1.371	.776										Benzo	1.
			Smoking	−0.307	.911										Smoking	−0.
			BMI	−0.043	.045										BMI	−0.
			Health‡	−0.056	.013										Health†	−0.
															Phys fnt*	1.
															6-min wlk	0.
															Kn pain	0.
															Dep*	0.
															Soc sup	0.
Demographics:			R^2 = .11			R^2 = .08			R^2 = .03			R^2 = .09			Total m	
R^2 = .02			Adj. R^2 = .09			Adj. R^2 = .07			Adj. R^2 = .02			Adj. R^2 = .07			R^2 = .1	
Adj. R^2 = .01			Health set:			Physical functioning set:			Knee pain set:			Psychosocial set:			Adj. R^2	
			IR^2 = .09‡			IR^2 = .06‡			IR^2 = .01*			IR^2 = .07‡				

IR^2 refers to the percentage of variance explained by the set (below dashed line) beyond the demographic set. Educ = education; CVD = presence cardiovascular disease; COPD = presence of chronic obstru arth jnts = number of arthritic joints; benzo = benzodiazepine use; BMI = body mass index; Health = self-rated health; phys fnt = physical functioning; kn pain = knee pain; dep = depressive symptoms;

.05.
.01.
.001.

5. Correlations Between the Independent Variables Included in the Regression Analyses

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
Age	**4.64**															
Gender	.038	**0.50**														
Race	−.034	.089	**0.37**													
Education	−.011	−.151	−.113	**0.49**												
Knee X-ray ratings	.130	−.016	−.152	−.051	**4.76**											
CVD	.058	−.042	−.113	.143	−.082	**0.50**										
COPD	.040	−.160	−.019	−.020	.011	.089	**0.33**									
Arthritic joints (#)	−.004	−.113	−.008	.083	−.025	.280	.178	**2.01**								
Benzo, use	.048	−.124	.071	.093	.014	.118	.041	.114	**0.29**							
Smoking	−.030	.011	−.086	.097	.040	.050	−.035	.022	−.009	**0.24**						
BMI	−.131	−.078	−.110	−.007	.136	−.030	−.017	−.025	.005	−.076	**5.07**					
Health rating	−.061	.103	.139	−.215	−.005	−.300	−.177	−.262	−.090	−.011	−.013	**17.99**				
Physical function	.099	−.185	−.128	.183	.158	.237	.156	.304	.151	.059	.129	−.393	**0.48**			
6-min walk	−.295	.263	.211	−.107	−.278	−.210	−.083	−.165	−.125	−.010	−.224	.334	−.494	**323.98**		
Knee pain	−.040	−.083	−.198	.158	.233	.209	.048	.224	−.018	.034	.193	−.210	.509	−.299	**1.33**	
Depression	.128	−.232	−.185	.302	−.014	.284	.138	.205	.189	.067	−.033	−.401	.417	−.320	.256	**6.**
Social support	−.035	.199	.044	−.084	.112	−.095	−.076	−.089	−.127	−.047	−.010	.188	−.299	.239	−.091	−.3

n = 374. For gender, 1 = male and 0 = female; for race, 1 = white race and 0 = other race; for education, 1 = high school education or lower and 0 = greater than a high school education; for CVD and COP
absence; for physical functioning, higher scores indicate greater impairment.
cance levels (two-tailed) at $P < .05$ occur for $r \geq .101$; at $P < .01$ for $r \geq .134$; and at $p < .001$ for $r \geq .168$.
s along the diagonal (in bold) represent standard deviations for that variable. The standard deviation for the sleep composite score was 4.45.

joints, knee pain, and social support were also significantly related to sleep disturbance (these variables, however, did not remain significant in the multiple regression models). These findings suggest that there are additional variables unique to individuals with knee pain that predict sleep problems.

Although statistically significant, knee pain explained little variance in sleep disturbance. This is surprising, as it has been well documented that pain is a strong and consistent predictor of sleep complaints.[11,17,18,20,23] One potential explanation for these seemingly contrary results may be that our sample had a restricted range of pain. To qualify for the study, participants had to report knee pain on most days of the week. Thus, a restricted range in pain would attenuate any relationship with sleep disturbance. Another likely explanation is related to how we measured pain. In this study, intensity of knee pain during ambulation and transfer was assessed. Thus, pain might be experienced during walking and only to a lesser extent during rest. It may be those participants who get up during the night and thus trigger pain who experience sleep disturbance. We cannot address this issue in our data.

Knee OA severity, as measured by X-ray ratings, was not a significant predictor of sleep disturbance in either bivariate or multivariate analyses. It has been suggested that the effects of OA on physical functioning and disability are not consistent; that is, patients with similar clinically assessed OA severity can function at different levels.[48] Davis and colleagues[49] found that both knee pain and radiographic grade of OA influenced the relationship between knee OA and physical functioning. Furthermore, OA is not always progressive. Massardo and colleagues[50] found that over an 8-year period, 20 of 31 patients with OA reported that their knee problems had worsened, but radiographic changes were not associated with symptomatic changes. Thus, radiographic evidence of OA severity may not be as useful in predicting health-related quality of life and physical functioning. Similarly, age was not found to be a significant predictor of sleep disturbance. This is consistent with previous studies, which have frequently shown no relationship between age and sleep when the sample is restricted to older adults or when health factors are considered.[27,28,32] Finally, gender was unrelated to sleep disturbance, despite the common finding that women report greater sleep disturbance than men.[27–32] Perhaps the effects of knee pain on sleep disturbance are greater than gender effects on sleep disturbance, thus resulting in a nonsignificant effect of gender.

There are several limitations of this study. First, the entire model explained only a modest proportion of the variance (16%) in sleep disturbance. This suggests that other factors not assessed in this study are important in understanding sleep disturbance in this population. We cannot overlook the fact that our inclusion and exclusion criteria may have limited the range in variance on some of the independent variables. All participants were experiencing significant knee pain as well as difficulty performing everyday activities. This restricted range would attenuate relationships with sleep. Another limitation is that the majority of the sample was non-Hispanic white and well educated. Moreover, we found a trend for a significant relationship between race and sleep disturbance. This suggests that there may be racial differences in sleep disturbance among patients with knee OA and more studies employing a more diverse sample are warranted. Finally, the cross-sectional design of this study does not allow us to determine the direction of the relationship between the biopsychosocial variables and sleep disturbance.

The results of this study suggest that healthcare providers should routinely incorporate the following into their interactions with OA patients and with older adults experiencing knee pain. These patients should be assessed regarding the adequacy of their sleep. The sleep disturbance questionnaire used with this study is brief, may be self-administered, and is appropriate for screening patients in the clinical setting. When sleep disturbances are discovered, healthcare professionals should assess for the presence of and attempt to alleviate modifiable contributors such as pain, depression, symptoms of comorbid conditions, or drugs that affect sleep quality. A social service or behavioral medicine consult or referral to case management may be used to enhance the patient's social support network and psychosocial functioning. Occupational or physical therapy may be helpful in developing an activity regimen to promote physical functioning. Given the high rate of medication use in this population and common problems of polypharmacy, nonpharmacologic interventions are most appealing, and have been emphasized by the American College of Rheumatology.[5] Physical activity, behavioral, and cognitive-behavioral sleep interventions have been found to be effective with older adults.[51–54]

REFERENCES

1. United States Bureau of the Census. Statistical Abstract of the United States. Washington, DC: US Government Printing Office, 1998.
2. Creamer P, Hochberg MC. Management of osteoarthritis. In: Hazzard WR, Blass JP, Ettinger J et al., eds. Principles of Geriatric Medicine and Gerontology. New York: McGraw-Hill, 1999.
3. Verbrugge LM, Lepkowski JM, Imanaka Y. Comorbidity and its impact on disability. Milbank Q 1989;67:450–484.
4. Verbrugge LM, Lepkowski JM, Konkol LL. Levels of disability among U.S. adults with arthritis. J Gerontol 1991;46:S71–83.
5. Ling SM, Bathon JM. Osteoarthritis in older adults. J Am Geriatr Soc 1998; 46:216–225.
6. Rejeski WJ, Shumaker S. Knee osteoarthritis and health-related quality of life. Med Sci Sports Exerc 1994;26:1441–1445.
7. Harding SM. Sleep in fibromyalgia patients: Subjective and objective findings. Am J Med Sci 1998;315:367–376.
8. Wolfe F, Anderson J, Harkness D et al. Health status and disease severity in fibromyalgia: Results of a six-center longitudinal study. Arthritis Rheum 1997;40:1571–1579.
9. Belza BL. Comparison of self-reported fatigue in rheumatoid arthritis and controls. J Rheumatol 1995;22:639–643.
10. Drewes AM, Svendsen L, Taagholt SJ et al. Sleep in rheumatoid arthritis: A comparison with healthy subjects and studies of sleep/wake interactions. Br J Rheumatol 1998;37:71–81.
11. Nicassio PM, Wallston KA. Longitudinal relationships among pain, sleep problems, and depression in rheumatoid arthritis. J Abnorm Psychol 1992; 101:514–520.
12. de Bock GH, Kaptein AA, Touw-Otten F, Mulder JD. Health-related quality of life in patients with osteoarthritis in a family practice setting. Arthritis Care Res 1995;8:88–93.
13. Bergner M, Bobbitt RA, Carter WB, Gilson BS. The Sickness Impact Profile: Development and final revision of a health status measure. Med Care 1981; 19:787–805.
14. Doherty M, Smith J. Elusive 'alpha-delta' sleep in fibromyalgia and osteoarthritis. Ann Rheum Dis 1993;52:245.
15. Leigh TJ, Hindmarch I, Bird HA, Wright V. Comparison of sleep in osteoarthritic patients and age and sex matched healthy controls. Ann Rheum Dis 1988;47:40–42.
16. Leigh TJ, Bird HA, Hindmarch I, Wright V. A comparison of sleep in rheumatic and non-rheumatic patients. Clin Exp Rheumatol 1987;5:363–365.
17. Moffitt PF, Kalucy EC, Kalucy RS et al. Sleep difficulties, pain and other correlates. J Intern Med 1991;230:245–249.
18. Nighttime pain: A major problem for one out of three adults. Gallup survey says pain interrupts sleep. J Pract Nurs 1996;46:27–29.

19. Jordan JM, Bernard SL, Callahan LF et al. Self-reported arthritis-related disruptions in sleep and daily life and the use of medical, complementary, and self-care strategies for arthritis. Arch Fam Med 2000;9:143–149.
20. Gislason T, Reynisdottir H, Kristbjarnarson H, Benediktsdottir B. Sleep habits and sleep disturbances among the elderly—An epidemiological survey. J Intern Med 1993;234:31–39.
21. Lamberg L. Patients in pain need round-the-clock care. JAMA 1999;281: 689–690.
22. Lamberg L. Chronic pain linked with poor sleep; exploration of causes and treatment. JAMA 1999;281:691–692.
23. Ross MM, Crook J. Elderly recipients of home nursing services: Pain, disability and functional competence. J Adv Nurs 1998;27:1117–1126.
24. Skevington SM. Investigating the relationship between pain and discomfort and quality of life, using the WHOQOL. Pain 1998;76:395–406.
25. Bazargan M. Self-reported sleep disturbance among African-American elderly: The effects of depression, health status, exercise, and social support. Int J Aging Hum Dev 1996;42:143–160.
26. Brassington GS, Hicks RA. Aerobic exercise and self-reported sleep quality in elderly individuals. J Aging Phys Activity 1995;3:120–134.
27. Foley DJ, Monjan AA, Brown SL et al. Sleep complaints among elderly persons: An epidemiologic study of three communities. Sleep 1995;18:425–432.
28. Newman AB, Enright PL, Manolio TA et al. Sleep disturbance, psychosocial correlates, and cardiovascular disease in 5201 older adults: The Cardiovascular Health Study. J Am Geriatr Soc 1997;45:1–7.
29. Blazer DG, Hays JC, Foley DJ. Sleep complaints in older adults: A racial comparison. J Gerontol 1995;50:M280–284.
30. Middelkoop HA, Smilde-van den Doel DA, Neven AK et al. Subjective sleep characteristics of 1,485 males and females aged 50–93: Effects of sex and age, and factors related to self-evaluated quality of sleep. J Gerontol 1996; 51:M108–115.
31. Schechtman KB, Kutner NG, Wallace RB et al. Gender, self-reported depressive symptoms, and sleep disturbance among older community-dwelling persons. FICSIT group. Frailty and Injuries: Cooperative Studies of Intervention Techniques. J Psychosom Res 1997;43:513–527.
32. Ganguli M, Reynolds CF, Gilby JE. Prevalence and persistence of sleep complaints in a rural older community sample: The MoVIES project. J Am Geriatr Soc 1996;44:778–784.
33. Folstein MF, Folstein SE, McHugh PR. "Mini-Mental State." A practical method for grading the cognitive states of patients for the clinician. J Psychiatr Res 1975;12:189–198.
34. Altman RD, Fries JF, Bloch DA et al. Radiographic assessment of progression in osteoarthritis. Arthritis Rheum 1987;30:1214–1225.
35. Hochberg MC, Altman RD, Brandt KD et al. Guidelines for the medical management of osteoarthritis. Part II. Osteoarthritis of the knee. Arthritis Rheum 1995;38:1541–1546.
36. Stewart AL, Hays RD, Ware JE Jr. The MOS short-form general health survey. Reliability and validity in a patient population. Med Care 1988;26:724–735.
37. Rejeski WJ, Ettinger WH Jr, Schumaker S et al. Assessing performance-related disability in patients with knee osteoarthritis. Osteoarthritis Cartilage 1995;3:157–167.
38. Peeters P, Mets T. The 6-minute walk as an appropriate exercise test in elderly patients with chronic heart failure. J Gerontol 1996;51:M147–151.
39. Rejeski WJ, Ettinger WH Jr, Shumaker S et al. The evaluation of pain in patients with knee osteoarthritis: The knee pain scale. J Rheumatol 1995;22: 1124–1129.
40. Radloff LS. The CES-D scale. A self-report depression scale for research in the general population. Appl Psych Measure 1977;1:385–401.
41. Radloff LS, Teri L. Use of the Center for Epidemiological Studies-Depression Scale with older adults. Clinical Gerontologist 1986;5:119–135.
42. Sherbourne CD, Stewart AL. The MOS Social Support Survey. Soc Sci Med 1991;32:705–714.
43. Buysse DJ, Reynolds CF, Monk TH et al. The Pittsburgh Sleep Quality Index: A new instrument for psychiatric practice and research. Psychiatry Res 1989;28:193–213.
44. Cohen J, Cohen P. Applied multiple regression/correlation analysis for the behavioral sciences. Hillsdale, NJ: Lawrence Erlbaum, 1983.
45. United States Bureau of the Census. 1990 Census of Population. General Population Characteristics. North Carolina. Washington, DC: US Government Printing Office, 1992.
46. Executive summary of the clinical guidelines on the identification, evaluation, and treatment of overweight and obesity in adults. Arch Intern Med 1998;158:1855–1867.
47. Hadler NM. Knee pain is the malady—not osteoarthritis. Ann Intern Med 1992;116:598–599.
48. Lawrence RC, Helmick CG, Arnett FC et al. Estimates of the prevalence of arthritis and selected musculoskeletal disorders in the United States. Arthritis Rheum 1998;41:778–799.
49. Davis MA, Ettinger WH, Neuhaus JM, Mallon KP. Knee osteoarthritis and physical functioning: Evidence from the NHANES I Epidemiologic Followup Study. J Rheumatol 1991;18:591–598.
50. Massardo L, Watt I, Cushnaghan J, Dieppe P. Osteoarthritis of the knee joint: An eight year prospective study. Ann Rheum Dis 1989;48:893–897.
51. Integration of behavioral and relaxation approaches into the treatment of chronic pain and insomnia. NIH Technology Assessment Panel on Integration of Behavioral and Relaxation Approaches into the Treatment of Chronic Pain and Insomnia. JAMA 1996;276:313–318.
52. King AC, Oman RF, Brassington GS et al. Moderate-intensity exercise and self-rated quality of sleep in older adults. A randomized controlled trial. JAMA 1997;277:32–37.
53. Morin CM, Colecchi C, Stone J et al. Behavioral and pharmacological therapies for late-life insomnia: A randomized controlled trial. JAMA 1999;281: 991–999.
54. Singh NA, Clements KM, Fiatarone MA. A randomized controlled trial of the effect of exercise on sleep. Sleep 1997;20:95–101.