

Osteoarthritis and Sleep: The Johnston County Osteoarthritis Project

KELLI D. ALLEN, JORDAN B. RENNER, BRENDA DEVELLIS, CHARLES G. HELMICK, and JOANNE M. JORDAN

ABSTRACT. *Objective.* Little is known about the association of symptomatic osteoarthritis (OA) with sleep disturbance. We compared the prevalence and severity of current sleep problems among individuals with and without symptomatic hip or knee OA in a large, community-based sample.

Methods. Participants (N = 2682, 28% with symptomatic hip or knee OA) were from the Johnston County Osteoarthritis Project. Six sleep variables were grouped into 2 categories: insomnia (trouble falling asleep, trouble staying asleep, or waking early) and insufficient sleep (daytime sleepiness, not enough sleep, or not feeling rested). The presence of any sleep problem (insomnia or insufficient sleep) was also assessed, as were annual frequency and cumulative days of sleep problems. Adjusted models examined associations of symptomatic OA with sleep problems controlling for demographic characteristics, obesity, self-reported health, and depressive symptoms.

Results. Symptomatic hip or knee OA was associated with increased odds of any sleep problem (odds ratio 1.25, 95% confidence interval 1.02–1.54), insomnia (OR 1.29, 95% CI 1.07–1.56), and insufficient sleep (OR 1.35, 95% CI 1.12–1.62) in adjusted models. Among participants with sleep problems, those with symptomatic OA reported higher median numbers of annual and cumulative days of insomnia and insufficient sleep, although these associations were not statistically significant in adjusted models.

Conclusion. Symptomatic hip and knee OA are significantly associated with sleep problems, independent of other factors related to sleep difficulties, including self-rated health and depression. Patients with OA should be regularly screened for sleep disturbance as part of routine care. (First Release May 15 2008; J Rheumatol 2008;35:1102–7)

Key Indexing Terms:

SLEEP DISTURBANCES

INSOMNIA

OSTEOARTHRITIS

Sleep disturbances are common among adults, with 54% of US adults reporting at least one symptom of insomnia (including difficulty falling asleep, waking a lot during the

night, waking up too early and not being able to get back to sleep, or waking up feeling unrefreshed) a few nights a week or more and 33% reporting at least one of these symptoms almost every night during the past year¹. Difficulties with sleep can have a major influence on pain, quality of life, vocational performance, personal relationships, morbidity, and healthcare use^{1–4}. Studies show health problems are important contributors to sleep difficulties^{5,6}, and more specifically, associations have been shown between arthritis and sleep problems^{6–11}. For example, among a large nationally representative sample of Canadians, the prevalence of insomnia and unrefreshing sleep were both about twice as high among individuals with self-reported arthritis or rheumatism compared to those without arthritis (insomnia, 25% vs 11%; unrefreshing sleep, 12% vs 6%, respectively)¹⁰. The same study showed that the presence of pain mediated a substantial amount of the association between arthritis and sleep problems, and other studies have shown that chronic pain in general has a significant influence on sleep¹².

Although there is evidence for an association between arthritis and sleep difficulties, most studies have either focused specifically on rheumatoid arthritis (RA)^{7–9} or more broadly on self-reported arthritis or rheumatic disorders, without respect to a specific or verified diagnosis^{6,10}. Very few studies have specifically examined the association of

From the Health Services Research and Development Service, Durham Veterans Affairs Medical Center; Department of Medicine, Duke University Medical Center; Durham, North Carolina; Thurston Arthritis Research Center, Department of Radiology, Department of Health Behavior and Health Education, Department of Psychology, Department of Medicine, and Department of Orthopaedics, University of North Carolina at Chapel Hill, Chapel Hill, North Carolina; and Centers for Disease Control and Prevention, Atlanta, Georgia, USA.

Supported by the Centers for Disease Control and Prevention/Association of Schools of Public Health cooperative agreements S1734 and S3486 (JMJ, JBR), the NIAMS Multipurpose Arthritis and Musculoskeletal Disease Center grant 5-P60-AR30701 (JMJ, JBR), and the NIAMS Multidisciplinary Clinical Research Center grant 5 P60 AR49465-03 (JMJ, JBR).

K.D. Allen, PhD, Health Services Research and Development Service, Durham Veterans Affairs Medical Center; Department of Medicine, Duke University Medical Center; J.B. Renner, MD, Thurston Arthritis Research Center; Department of Radiology, University of North Carolina at Chapel Hill; B. DeVellis, PhD, Thurston Arthritis Research Center; Department of Health Behavior and Health Education, Department of Psychology, University of North Carolina at Chapel Hill; C.G. Helmick, MD, Centers for Disease Control and Prevention; J.M. Jordan, MD, MPH, Thurston Arthritis Research Center; Department of Medicine, Department of Orthopaedics, University of North Carolina at Chapel Hill.

Address reprint requests to Dr. J.M. Jordan, 3300 Thurston-Bowles, Box 7280, University of North Carolina, Chapel Hill, NC 27599. E-mail: joanne_jordan@med.unc.edu

Accepted for publication January 24, 2008.

osteoarthritis (OA) with sleep difficulties^{5,11,13-15}. One study reported a high prevalence of problems with sleep onset (31%), sleep maintenance (81%), and early morning awakenings (51%), occurring at least weekly, among older adults with knee pain or knee pain with radiographic OA¹⁵. Another study of older adults showed that individuals with OA (identified by an ICD-9 code) reported more days per month of not getting enough sleep compared with those who did not have OA or RA¹¹. These prior studies are limited by small sample sizes, lack of concurrent control group without OA, or OA not being verified radiographically.

Because OA is one of the most common chronic conditions among adults, as well as a leading cause of pain, it is important to understand the effect of this disease on sleep. We examined the association of hip or knee OA with the prevalence of sleep problems in a large, community-based sample. We first examined the association of radiographic hip or knee OA (irrespective of symptoms) with the presence of sleep problems. However, our primary interest was in the association of symptomatic radiographic OA (sOA) with sleep problems, since symptomatic disease is of greater clinical and public health importance.

In addition to examining sleep problems overall, this study focused more specifically on 2 types of sleep problems: insomnia and unrefreshing sleep. Insomnia has been more widely studied and is defined as an impression of inadequate sleep, associated with deficits in initiating or maintaining sleep¹⁶. Unrefreshing (or nonrestorative) sleep refers to lack of satisfaction with the sleep experience and is associated with feeling unrefreshed after sleep¹⁰. We chose to examine these 2 types of sleep problems separately because some data indicate these different problems may not be highly related¹⁰. We also examined the association of sOA with annual and cumulative days of sleep disturbance.

MATERIALS AND METHODS

Subjects. The cross-sectional sample was composed of individuals enrolled in the Johnston County Osteoarthritis Project, an ongoing, population-based study of the occurrence of knee and hip OA in a rural, biracial population of North Carolina. Details of this study have been reported¹⁷. Briefly, this study involved civilian, noninstitutionalized adults aged ≥ 45 years who resided in 6 townships in Johnston County. Participants were recruited by probability sampling, with oversampling of African Americans. The sample for this analysis included 2748 individuals who had participated in either the first followup of the study, conducted between 1999 and 2004 ($N = 1733$), or had been newly enrolled in 2003 or 2004 ($N = 1015$). New individuals were enrolled in 2003–2004 to enrich the sample for African Americans and younger individuals who were deliberately targeted for inclusion. As such, the newly enrolled participants were younger (mean age 65.8 yrs and 59.3 yrs, in first followup and newly enrolled subsample, respectively) and more likely to be African American (28% vs 40%). For these analyses, participants were also required to have completed sleep questions and to have the information needed to identify symptomatic hip or knee OA (including radiographs and responses to survey items regarding hip and knee pain). Among the total sample of 2748, 66 individuals did not complete sleep questions and/or did not have data needed to

identify symptomatic hip or knee OA, leaving an analytic sample of 2682. In this sample, there were 1687 participants from the first followup (1999–2004) and 995 from the newly enrolled group (2003–2004).

Sleep questions. Sleep questions were adapted from the Medical Outcomes Study sleep questionnaire¹⁸. The validity and reliability of the Medical Outcomes Study sleep items have been established in a nationally representative sample of US adults¹⁹. In addition, other studies have shown that individuals are able to accurately recall sleep patterns, with recall-based measures showing high correlations with sleep log data²⁰. Participants were asked whether they were “currently troubled by” any of the following 6 specific sleep problems: trouble falling asleep, waking up during the night (trouble staying asleep), waking up early and not being able to fall asleep again (waking early), falling asleep during the day (daytime sleepiness), not getting enough sleep (not enough sleep), not feeling rested upon awakening in the morning (not rested). We examined associations of participant characteristics with each of these individual sleep disturbances. We also combined these variables into 3 general categories of any current sleep problem (comprising all 6 variables), current insomnia (comprising the first 3 items: trouble falling asleep, trouble staying asleep, and waking early) and current insufficient sleep (comprising the last 3 items: daytime sleepiness, not enough sleep, and not feeling rested). The insomnia and insufficient sleep categories and their component questions were based on previous definitions of sleep disturbances¹⁰.

Participants were asked the frequency of each sleep problem they reported currently experiencing. Specifically, participants were first asked the number of times per week they were currently troubled by the sleep problem. If they had this sleep problem less than once per week, they were asked how many times per month they were currently troubled by the sleep problem. If they had this sleep problem less than once per month, they were asked how many times per year they were currently troubled by the sleep problem. From these data, we computed the total number of days per year (annual frequency) that participants reported being troubled by each sleep problem. We then computed the mean number of days per year participants reported being troubled by any sleep problem, insomnia, and insufficient sleep, using the categories described above. For these computations, we calculated the mean annual frequency of all specific sleep items included in each of the 3 general categories. Participants also reported the total number of years they had ever experienced each sleep problem. We multiplied the annual frequency data by the number of years participants reported having each general sleep problem to compute the cumulative number of days participants were troubled by any sleep problem, insomnia, and insufficient sleep.

Demographic and clinical characteristics. All participants underwent posteroanterior radiography of both knees with weight-bearing, using the SynaFlex® positioning frame (Synarc Inc., San Francisco, CA, USA). Supine anteroposterior pelvis radiographs were obtained for all men and all women ≥ 50 years of age. All radiographs were read for Kellgren-Lawrence (K-L) score by a single bone and joint radiologist (Dr. Renner) without regard to clinical status. Previous assessment showed interrater and intrarater reliability of the radiologist to be high (weighted kappas = 0.9)²¹. Radiographic knee or hip OA was defined as K-L grade ≥ 2 in at least one knee or hip. Participants were asked, “On most days, do you have pain, aching, or stiffness in your...right hip, left hip, right knee, and left knee.” We defined symptomatic hip or knee OA as the presence of both radiographic OA and joint symptoms in the same joint.

We also examined the following participant characteristics, which have been associated with sleep problems in some previous studies: age, sex, race (African American vs Caucasian), education (≥ 12 yrs vs < 12 yrs), obesity [defined as a body mass index (BMI) ≥ 30], depression [defined as Center for Epidemiologic Studies Depression Scale (CES-D) score ≥ 16 ²²], and self-rated health compared to other people the same age (excellent or good vs fair or poor)^{5,6,10,15,23,24}. Height without shoes was measured in centimeters, and weight was measured in kilograms using a balance-beam scale. BMI was calculated as kg/m^2 .

Analyses. Chi-square tests were used to compare demographic and clinical characteristics of participants with and without hip or knee sOA. While our primary interest was in sOA, we first examined whether radiographic hip or knee OA, irrespective of symptoms, was associated with sleep problems. Specifically, we used chi-square tests to compare the prevalence of sleep problems among those with and without radiographic hip or knee OA. We then compared the proportions of individuals with each sleep problem among those with and without hip or knee sOA and computed unadjusted odds ratios (OR) and 95% confidence intervals (95% CI) for each sleep problem, according to sOA status. Next, we conducted 3 separate multiple logistic regression models examining associations of hip or knee sOA with the following outcomes: (1) any current sleep problem, (2) insomnia, and (3) insufficient sleep. In addition to hip and knee sOA, other predictors in each logistic regression model included age, sex, race, education, obesity, self-rated health, and depression.

Among those who reported sleep problems, we compared the number of days per year and cumulative days of any sleep problem, insomnia, and insufficient sleep between those with and without hip or knee sOA. Because these variables were highly skewed, we compared median values rather than means²⁵. Since these variables did not meet assumptions for linear regression (i.e., normally distributed residuals) and transformation of variables did not improve this situation, we divided each sleep problem frequency variable into tertiles and used generalized logit models to examine associations of hip or knee sOA with these variables, adjusting for all other participant characteristics listed above.

RESULTS

The total sample numbered 2682 individuals, including 28% with hip or knee sOA. Demographic and clinical characteristics of the study sample, as well as according to sOA status, are presented in Table 1. Participants with hip or knee sOA were significantly older, less educated, and more often obese, and more often reported fair or poor self-rated health ($p < 0.001$).

About 71% of the sample reported having some current sleep problem, 56% reported current insomnia, and 56% reported current insufficient sleep (Table 2). Among the individual sleep disturbance items, the most commonly reported was trouble staying asleep (41%), with the other 5 items being reported by 29%–34% of the sample. In unadjusted analyses there were no significant differences between participants with and without radiographic hip or

knee OA (irrespective of symptoms) with respect to any sleep problem (70% vs 71%; $p = 0.665$), insomnia (both 56%; $p = 0.869$), or insufficient sleep (both 56%; $p = 0.941$); adjusted analyses for radiographic OA were not pursued. However, the unadjusted odds of having each specific sleep problem, as well as the 3 general categories of sleep problems (any sleep problem, insomnia, and insufficient sleep), were significantly higher for those with hip or knee sOA compared with those without (all OR 1.13–1.53; Table 2).

In adjusted analyses, individuals with hip or knee sOA remained 25%–35% more likely than people without hip or knee sOA to report having any sleep problem, insomnia, or insufficient sleep (Table 3). Fair/poor self-rated health and depression were also significantly associated with all 3 sleep variables, and less education was associated with greater odds of insomnia and insufficient sleep.

Among study participants who indicated having a sleep problem, the median annual number of days of experiencing any sleep problem was 208, with medians of 156 days for both insomnia and insufficient sleep (Table 4). The median annual number of days of insomnia and insufficient sleep were 22 and 26 days higher, respectively, among those with sOA compared to those without sOA. In multivariable generalized logit models that included all other participant characteristics, there were no significant differences in annual days of any sleep problem, insomnia, or insufficient sleep according to sOA status.

The median cumulative days of any sleep problem was 728, with medians of 347 days of insomnia and 693 days of insufficient sleep (Table 4). The median cumulative number of days of insomnia and insufficient sleep were 52 and 32 days higher, respectively, among those with sOA compared to those without sOA. In multivariable generalized logit models that included all other participant characteristics, there were no significant differences in cumulative days of any sleep problem, insomnia, or insufficient sleep according to sOA status.

Table 1. Participant characteristics overall and by sOA status.

Characteristics	Total Sample, n = 2682	Symptomatic Hip or Knee OA	
		Yes, n = 759	No, n = 1923
Age, yrs, %*			
45–54	24.4	16.2	27.5
55–64	32.6	32.0	32.9
65 and older	43.0	51.8	39.6
Women, %	65.7	67.3	65.0
African American, %	33.1	35.3	32.2
< 12 years of education, %*	28.2	37.3	24.6
Obese, % *†	46.7	60.6	41.2
Fair or poor self-rated health, % *	26.8	38.9	22.0
Depressed (CES-D), %	12.9	13.3	12.7

* Significant difference between participants with and without symptomatic OA ($p < 0.001$). † Obese = Body Mass Index ≥ 30 .

Table 2. Prevalence and unadjusted OR of Sleep Problems Overall and by sOA Status.

Sleep Problem	Total Sample, %	Symptomatic Hip or Knee OA		Unadjusted OR for OA (95% CI)
		Yes, %	No, %	
Any sleep problem	70.8	76.4	68.5	1.49 (1.23–1.80)
Insomnia	56.0	62.9	53.3	1.48 (1.25–1.76)
Trouble falling asleep	33.3	38.4	31.2	1.37 (1.15–1.64)
Trouble staying asleep	41.0	47.2	38.6	1.42 (1.20–1.69)
Waking early	30.7	35.4	28.9	1.35 (1.13–1.61)
Insufficient sleep	55.7	63.1	52.8	1.53 (1.29–1.82)
Daytime sleepiness	33.7	40.3	31.0	1.50 (1.26–1.79)
Not enough sleep	29.3	33.6	27.6	1.13 (1.11–1.60)
Not rested	32.1	38.5	29.6	1.49 (1.25–1.78)

Table 3. Adjusted associations of participant characteristics with sleep problems.

Characteristics	Any Sleep Problem, OR* (95% CI) [†]	Insomnia, OR (95% CI)	Insufficient Sleep, OR (95% CI)
Symptomatic knee or hip OA	1.25 (1.02–1.54)	1.29 (1.07–1.56)	1.35 (1.12–1.62)
Age, yrs			
45–54	1.00	1.00	1.00
55–64	1.16 (0.92–1.47)	0.97 (0.78–1.20)	0.92 (0.74–1.14)
65+	1.13 (0.88–1.40)	0.90 (0.72–1.11)	0.88 (0.71–1.09)
African American race	0.97 (0.80–1.18)	0.85 (0.71–1.01)	1.09 (0.91–1.30)
Women	1.64 (1.37–1.96)	1.47 (1.25–1.75)	1.52 (1.28–1.79)
< 12 years of education	1.18 (0.95–1.45)	1.25 (1.03–1.52)	1.22 (1.01–1.47)
Obese	1.03 (0.86–1.24)	1.08 (0.91–1.27)	1.07 (0.91–1.26)
Fair/poor self-rated health	2.45 (1.92–3.12)	2.10 (1.72–2.57)	2.13 (1.74–2.61)
Depression	3.15 (2.15–4.60)	2.62 (1.96–3.51)	2.79 (2.07–3.74)

Table 4. Unadjusted annual frequency and cumulative days of sleep problems overall and by sOA status.

Sleep Problem	Total Sample (Median)	Symptomatic Hip or Knee OA	
		Yes (Median)	No (Median)
Any sleep problem			
Annual frequency, days	208	208	208
Cumulative days*	728	728	728
Insomnia			
Annual frequency, days	156	156	134
Cumulative days	347	364	312
Insufficient sleep			
Annual frequency, days	156	182	156
Cumulative days	693	708	676

* Mean days per year \times mean years duration of sleep problem.

DISCUSSION

This study involved a detailed examination of sleep disturbances in a large community-based sample characterized for hip and knee sOA. Overall, there was a high burden of sleep disturbance in this sample, with 71% of participants reporting some current sleep problem, and 56% reporting insomnia and insufficient sleep. Previous studies have used varying definitions of sleep difficulties, making direct comparisons difficult. However, these results are similar to a recent national survey in the US, in which 75% of adults reported

some sleep problem and 54% reported symptoms of insomnia a few nights a week or more¹. In this study, the most common among 6 specific sleep problems was trouble staying asleep. Other studies have also reported that trouble staying asleep (sleep maintenance) is one of the most common sleep disturbances^{1,15}, suggesting this is a problem that should be screened for during regular clinic visits.

While studies have reported a high prevalence of sleep problems among patients with OA^{4,15}, this is one of the first to directly compare sleep difficulties among individuals

with and without sOA. It is particularly notable that symptomatic hip or knee OA was independently associated with increased odds of reporting any sleep problem, insomnia, and insufficient sleep, even when adjusting for fair/poor health and depression, both of which are known to be strongly associated with poor sleep^{5,15}. Radiographic hip or knee OA, irrespective of symptoms, was not significantly associated with sleep problems in this study. Prior studies have also indicated that arthritis alone may not be strongly associated with sleep problems, but that the presence of arthritis-related pain is an important predictor of sleep difficulty¹⁰. Other data show that among individuals with radiographic knee OA, increasing pain severity is associated with greater sleep disturbance¹⁵.

This is also one of the first studies to examine annual frequency and cumulative days of sleep problems, particularly with regard to sOA status. Among those who had some sleep problem, the median number of annual days reported was 208, indicating a very high burden of sleep difficulty. Participants with sOA reported almost a month more per year of both insomnia and insufficient sleep. However, sOA was not significantly associated with either annual or cumulative days of sleep problems in multivariable models. Thus, while sOA is independently associated with having a sleep problem in general, it does not appear to be independently associated with severity of sleep difficulties among individuals who report sleep problems. One limitation to the assessment of cumulative days of sleep problems in our study is that the total duration of sleep problems was considered, irrespective of sOA onset.

The participant characteristics most strongly associated with sleep problems in this study were depression and fair/poor self-rated health. Previous studies also reported associations of these variables with sleep disturbance^{5,10,23}, and clinicians should be particularly vigilant about screening for sleep problems among individuals with depressive symptoms or overall poor health. It is surprising that obesity was not associated with sleep problems in this study, since there is a strong relationship between obesity and sleep apnea²⁶. However, previous studies have reported mixed results regarding the association of obesity or BMI with more general self-reported sleep problems^{10,15}. Further research is needed regarding possible associations of BMI and other anthropometric characteristics, including percentage body fat, with self-reported sleep problems.

Because of the high prevalence of OA among adults, its association with sleep problems has important clinical and public health implications. Many individuals do not report sleep problems to their healthcare providers^{1,27}, so it is important for clinicians to regularly screen patients for possible sleep difficulties, particularly when patients have health problems such as arthritis that may increase the risk. In a recent national US survey, only 29% of participants indicated that their doctor had ever asked them about their

sleep¹. Failure to screen for sleep problems may result in missed opportunities to improve both sleep and arthritis symptoms. Recent data show that sleep deprivation activates cellular and genomic markers of inflammation²⁸. Therefore improving sleep quality may have a positive influence on arthritis pain and other symptoms²⁹. In addition to pharmacological options for managing sleep disturbance, patients should be educated regarding sleep hygiene³⁰. From a public health perspective, there is a clear need for additional education regarding the importance of discussing and treating sleep problems, among both patients and clinicians.

REFERENCES

1. National Sleep Foundation. 2005 Sleep in America Poll. Washington, DC: National Sleep Foundation; 2005.
2. Stoller MK. Economic effects of insomnia. *Clin Ther* 1994;16:873-97.
3. Jordan JM, Bernard SL, Callahan LF, Kincade JE, Konrad TR, DeFries GH. 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;9:143-9.
4. Dominick KL, Ahern FM, Gold CH, Heller DA. Health-related quality of life and health service utilization among older adults with osteoarthritis. *Arthritis Care Res* 2004;51:326-31.
5. Katz DA, McHorney CA. Clinical correlates of insomnia in patients with chronic illness. *Arch Intern Med* 1998;158:1099-107.
6. Sutton DA, Moldofsky H, Badley EM. Insomnia and other health problems in Canadians. *Sleep* 2001;24:665-70.
7. Hirsch M, Carlander B, Verge M, et al. Objective and subjective sleep disturbances in patients with rheumatoid arthritis. A reappraisal. *Arthritis Rheum* 1994;37:41-9.
8. Wolfe F, Michaud K, Li T. Sleep disturbance in patients with rheumatoid arthritis: evaluation by medical outcomes study and visual analog sleep scales. *J Rheumatol* 2006;33:1942-51.
9. Drewes AM, Svendsen L, Taagholt SJ, Bjerregard K, Nielsen KD, Hansen B. Sleep in rheumatoid arthritis: a comparison with healthy subjects and studies of sleep/wake interactions. *Br J Rheumatol* 1998;37:71-81.
10. Power JD, Perruccio AV, Badley EM. Pain as a mediator of sleep problems in arthritis and other chronic conditions. *Arthritis Care Res* 2005;53:911-9.
11. Dominick KL, Ahern FM, Gold CH, Heller DA. Health-related quality of life among older adults with arthritis. *Health Qual Life Outcomes* 2004;2:5.
12. Menefee LA, Cohen MJM, Anderson WR, Doghramji K, Frank ED, Lee H. Sleep disturbance and nonmalignant chronic pain: A comprehensive review of the literature. *Pain Med* 2000;1:156-72.
13. 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;47:40-2.
14. 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.
15. Wilcox S, Brenes GA, Levine D, Sevcik MA, Shumaker SA, Craven T. Factors related to sleep disturbance in older adults experiencing knee pain or knee pain with radiographic evidence of knee osteoarthritis. *J Am Geriatr Soc* 2000;48:1241-51.
16. Baker TL. Sleep apnea disorders: introduction to sleep and sleep disorders. *Med Clin North Am* 1985;69:1123-52.
17. Jordan JM, Helmick CG, Renner JB, et al. Prevalence of knee symptoms and radiographic and symptomatic knee osteoarthritis in African Americans and Caucasians: the Johnston County Osteoarthritis Project. *J Rheumatol* 2007;31:172-80.

18. Hays RD, Stewart AL. Sleep measures. In: Stewart AL, Ware JE, editors. *Measuring functioning and well-being: The Medical Outcomes Study Approach*. Durham, NC: Duke University Press; 1992:235-59.
19. Hays RD, Martin SA, Sesti AM, Spritzer KL. Psychometric properties of the Medical Outcomes Study sleep measure. 2005;6:41-4.
20. Backhaus J, Junghanns K, Broocks A, Riemann D, Hohagen F. Test-retest reliability and validity of the Pittsburgh Sleep Quality Index in primary insomnia. *J Psychosom Res* 2002;53:737-40.
21. Jordan JM, Linder GF, Renner JB, Fryer JG. The impact of arthritis in rural populations. *Arthritis Care Res* 1995;8:242-50.
22. Radloff LS. The CES-D Scale: a self-report depression scale for research in the general population. *Appl Psychol Meas* 1977;1:385-401.
23. Strine TW, Chapman DP. Associations of frequent sleep insufficiency with health-related quality of life and health behaviors. *Sleep Med* 2005;6:23-7.
24. Jean-Louis G, Magai C, Consedine NS, et al. Insomnia symptoms and repressive coping in a sample of older Black and White women. *BMC Womens Health* 2007;29:1.
25. Lang TA, Secic M. *How to report statistics in medicine*. Philadelphia: American College of Physicians; 1997.
26. Young T, Peppard PE, Gottlieb DJ. Epidemiology of obstructive sleep apnea: a population health perspective. *Am J Resp Crit Care Med* 2002;165:1217-39.
27. National Commission on Sleep Disorders Research. *Wake up America: a national sleep alert: Executive summary and report*. Washington, DC: National Commission on Sleep Disorders Research; 1993.
28. Irwin MR, Wang M, Compomayor CO, Collado-Hidalgo A, Cole S. Sleep deprivation and activation of morning levels of cellular and genomic markers of inflammation. *Arch Intern Med* 2006;166:1756-62.
29. Davis GC. Improved sleep may reduce arthritis pain. *Holist Nurs Pract* 2003;17:128-35.
30. Erman MK. Therapeutic options in the treatment of insomnia. *J Clin Psychiatry* 2005;66 Suppl:18-23.