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Racial/Ethnic Differences in Sleep Quality Among Older Adults with Osteoarthritis

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Abstract

Objective—To examine racial/ethnic differences in sleep quality and the pain-sleep association among older adults with osteoarthritis (OA) of the knee.

Design—Baseline interview followed by a 7-day microlongitudinal study using accelerometry and self-reports.

Setting—Participants were community residents in western Alabama and Long Island, NY.

Participants—Ninety-six African Americans (AAs) and 128 non-Hispanic Whites (NHWs) with physician-diagnosed knee OA, recruited from a variety of clinical and community settings.

Measurements: Self-reports yielded demographics, body mass index, physical health problems, and depressive symptoms. Sleep quality was measured over 3 to 7 nights using wrist-worn accelerometers; pain was self-reported daily over the same period.

Results—With demographics and health controlled, AAs displayed poorer sleep efficiency, greater time awake after sleep onset and sleep fragmentation, and marginally more awakenings during the night, but no differences in total sleep time (TST). AAs also showed greater night-to-night variability in number of awakenings and sleep fragmentation, and marginally greater variability in TST and sleep efficiency. Sleep quality was not associated with pain either the day

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Notes

1. We acknowledge the rudimentary nature of this approach to treatment of missing data; however, the small number of cases and the peripheral focus on this variable argue against more sophisticated treatment. We compared analyses using this approach vs. exclusion of missing cases, and found no difference in patterns or levels of significance (i.e., $p < .05$ vs. $.05 < p < .10$ vs. $p > .10$).
2. Details of these analyses are available on request from the first author.

before sleep nor the day after. Average daily pain interacted with race: whereas AAs displayed no effect of pain on sleep efficiency, NHWs exhibited better sleep efficiency at higher levels of average pain.

Conclusions—These data corroborate previous studies documenting poorer sleep among AAs vs. NHWs. The findings of greater night-to-night variability in sleep among AAs, as well as a negative association of pain with sleep quality among NHWs, are unique. Further study is needed to elucidate these findings.

Keywords

Sleep; Race/ethnicity; Osteoarthritis; Pain

Sleep problems are observed across the life span. However, because of normal age changes in sleep architecture, older adults as a group are at high risk of disordered sleep.¹ These normal age-related changes are often compounded by comorbid health problems that may further impair sleep.² One such comorbidity is osteoarthritis (OA), a degenerative joint disorder characterized by persistent pain and stiffness. Among the most common disability-producing health problems nationwide, OA affects more than half of persons over 65^{3,4}. Individuals with OA experience high rates of sleep disturbance^{5,6}, due at least in part to the linkage of pain with sleep problems both short- and long-term^{6,7}.

However, OA is not an “equal opportunity” disorder: there are notable racial/ethnic differences in its prevalence and effects both overall and with respect to specific joints affected. For example, knee OA is more prevalent among African Americans (AAs) than non-Hispanic Whites (NHWs), particularly among women.³ Evidence on racial/ethnic differences in OA symptoms is scant and somewhat contradictory. However, there is reason to believe that AAs may experience greater pain and disability consequent to OA than do NHWs^{4,8,9}

An emerging literature similarly suggests that there may be distinct racial/ethnic differences in sleep disturbance. However, as with OA and its effects, findings regarding the effects of race on sleep quality are inconsistent. Using methods ranging from self-report^{10–12} to actigraphy¹¹ to polysomnography¹⁰, a number of studies report shorter sleep time among Blacks as compared with Whites across the adult life span. Others, however, report both shorter and longer sleep times for AAs, suggesting greater variability among AAs vis-à-vis NHWs¹³. Additional studies report poorer sleep quality among African Americans on a number of measures, including overall efficiency, sleep latency, wakefulness after sleep onset (WASO), and sleep fragmentation^{10,11,14,15}. Notably, the majority of extant studies in this area have included only younger adults^{11,15,16} or population samples.^{12,13} Only a handful (e.g.,^{14,17}) have examined racial/ethnic differences in sleep quality specifically in older adults.

To summarize, there are known racial/ethnic differences both in prevalence of sleep disturbances and in prevalence and (less clearly) symptoms of osteoarthritis. Further, OA pain appears to be associated with sleep disturbance among older individuals.^{5,6} However, most previous studies of OA sufferers have assessed sleep disturbances subjectively and

globally, using summary self-reports rather than objective measures of sleep quality. This is an important concern, as the sleep-pain association may present differently in self-report as compared with objective assessments.¹⁸

A growing body of research with chronic pain patients documents the linkage of sleep and pain over both short^{19,20} and longer terms^{21,22} (but see Anderson et al.²³). Although causal flow between sleep and pain appears bidirectional when assessed on a day-to-day basis^{24,25}, the bulk of the literature has implied a stronger causal path from sleep disturbance to pain than from pain to sleep problems^{25–27}. Again, however, the vast majority of these samples were younger adults. There is some work documenting the day-to-day association of sleep disturbances with pain in older adults with insomnia²⁸. However, we found only one study that examined within-subject covariation of sleep and pain among persons with OA.²⁹ In contrast, research on racial/ethnic differences in sleep quality is methodologically diverse, variously using self-reports, actigraphy, and polysomnography. However, only a few of these studies have targeted older adults specifically and even fewer, individuals with osteoarthritis.

In sum, there is a paucity of data examining racial differences in sleep quality among older adults, particularly in the context of chronic pain. The prevalence of the disorder and the debilitating impact of OA pain make osteoarthritis an excellent model for examining these effects. However, most previous work in this area has used subjective, largely global measures. The research reported here aimed to fill these gaps by examining objective sleep quality in older African American and non-Hispanic White individuals with osteoarthritis of the knee. Specifically, we tested the relation of race with five measures of sleep quality derived over 3 to 7 nights' actigraphic monitoring. In a notable departure from previous work, primary analyses used multilevel models to examine both overall racial differences in sleep quality as well as the role of pain in those observed differences. Because of the potential confounding effects of, e.g., socioeconomic status on the association of race/ethnicity with sleep disturbance¹², demographic characteristics as well as health-related factors were controlled.

Participants and Methods

Sample and procedure

The sample comprised 224 individuals with physician-diagnosed osteoarthritis of the knee, all participating as part of a larger study (AG046155). The multi-site sample included 132 (58.9%) western and central Alabama residents and 92 (41.4%) persons on Long Island, NY. Recruitment sources were diverse to capture a broad segment of the public, and included medical clinics, senior centers, churches, independent living facilities, and public service advertisements in a variety of media. Inclusion criteria were diagnosed knee OA, self-identified AA or NHW race/ethnicity, absence of other rheumatologic conditions or potentially debilitating health problems, and cognitive status sufficient to permit completion of the protocol (Short Portable Mental Status Questionnaire³⁰ score ≥ 3 errors). The current sample includes all participants who yielded three or more night's sleep data.

Following telephonic screening for eligibility, interested participants were mailed a packet including authorization to contact the participant's physician, informed consent materials,

and a packet of self-administered questionnaires. Those whose physicians confirmed the knee OA diagnosis then completed an in-person interview followed by a 7-day experience sampling method (ESM) protocol that included continuous activity monitoring and four self-reports each day.

Table 1 presents sample characteristics as a function of race. The 96 African American and 128 non-Hispanic White participants did not differ in age or depressive symptoms. However, AAs were more likely than NHWs to be female and unmarried/cohabiting. They also reported lower levels of education and income, higher body mass index (BMI), higher levels of daily pain, and a larger number of health conditions other than OA. Note also that AAs were disproportionately represented in the Alabama sample. There were no location differences, nor any interaction of location with race, for any of the sleep measures (Note 2). We therefore did not consider location in further analysis.

Measures

Demographics—*Age, sex, race* (self-identified AA vs. NHW), *marital status* (married/cohabiting vs. single/divorced/separated/widowed), *education* (5-point scale, “less than high school” through “graduate/professional degree”), and annual *income* (8-point scale, “less than \$10,000” through “\$70,000 or more”) were self-reported. Eighteen persons declined to report income; these missing values were replaced by the sample mean (Note 1).

General health and well-being—Interviews yielded BMI based on self-reported height and weight; a count of physical *health problems* other than OA endorsed from a list of 30, and *depressive symptoms*, captured by the Center for Epidemiologic Studies Depression Scale³¹.

Sleep measures—Sleep quality was assessed during the 7-day ESM procedure using Actigraph® GTX-3W accelerometers worn on the dominant wrist. Participants were asked to wear the units continuously unless contraindicated (e.g., while swimming or bathing), yielding up to 6 nights’ sleep data over the 7-day period. Overall, the 224 participants yielded sleep data for 1211 nights. Although 6 nights’ data was the norm (N=127, 56.7%), variable compliance along with a very few instances of equipment malfunction reduced available data for some respondents. Thus, useable data per participant ranged from 3 to 7 nights (M = 5.41, SD = 0.82). (Because of missing self-report data, one participant completed an extra day’s assessment, yielding a 7th night’s data.) As just noted, more than half the sample completed 6 nights’ monitoring; another 67 (29.9%) provided 5 nights’ data, 20 (8.9%) reported for 4 nights, and 9 individuals (4.0%) had 3 nights’ sleep data. Ten people with two or fewer nights’ sleep data were excluded from the final sample of 224. There were no racial/ethnic differences in compliance (Table 1).

Accelerometer data were processed via Actilife® software, using Cole-Kripke adult scoring algorithms³² applied to 10sec sampling epochs. Because of questionable accuracy in self-reported bed and wake times, each night’s sleep period was defined by sleep onset and wake times derived algorithmically from accelerometer data. The sleep period bracketed five sleep quality measures: (1) *total sleep time (TST)*, computed as number of minutes scored as “asleep” during the sleep period; (2) *wake after sleep onset (WASO)*, defined as total

number of minutes the subject was awake during the sleep period; (3) number of *awakenings* over the sleep period; (4) *sleep fragmentation*, an index of restlessness computed as the percentage of one-minute epochs scored as awake, and (5) *sleep efficiency*, the proportion of minutes asleep vs. awake over the entire sleep period.

Daily pain—The ESM protocol included 4 phone calls daily for 7 days, beginning the morning before the first night's sleep monitoring. At each call, pain at that moment was assessed on a 1-to-5 scale ("none" to "extreme pain"). For current analyses, we averaged momentary ratings within each day to yield a summary measure of daily pain for each day. This variable was then linked with each night's sleep data to create two pain indices for current analyses. *Previous day pain* links pain prospectively to sleep variables for that night (i.e., how does today's pain affect tonight's sleep?); *next day pain* represents pain on the day following observed sleep, providing a test of how last night's sleep affects today's pain. In addition, daily pain ratings were averaged within participants across days to yield a person-level measure of *average daily pain* (ADP).

Analytic plan

Preliminary analyses identified demographic and health status variables to be used as covariates. Because of the nested nature of the data (nights within individuals), primary analyses used maximum likelihood multilevel modeling (MLM) to examine within- and between-person variability in sleep quality. A null model was first run for each of the 5 sleep variables to examine the proportion of total variance attributable to intra-individual (level 1; within-person changes from one night to the next) versus inter-individual variability (level 2; consistent between-person differences in sleep patterns). We next added race to estimate overall effect. A third step added covariates (see below) to examine independent effects of race controlled for potentially confounding demographic and health characteristics. Finally, in separate MLM analyses, previous day pain and next day pain were entered, along with average daily pain in each equation, to examine associations of those variables with sleep quality. Moderating effects of race on the pain-sleep association were also tested. Additional, supplementary person-level analyses examined overall differences in sleep quality between AAs and NHWs.

Results

Covariates

Selection of demographic and health variables for control in primary analyses was guided, first, by sample descriptives (Table 1). Because age and depressive symptoms were not significantly associated with race/ethnicity, they were excluded from further analyses; mean daily pain was also excluded due to its conceptual centrality to primary analyses. The remaining potential covariates—sex, marital status, education, income, BMI, and health conditions—were used as predictors in separate MLM analyses of each sleep quality measure.

Sex was significantly associated with total sleep time ($b = -4.71$, $SE = 12.52$, $t = -3.77$, $p < .001$), time awake after sleep onset ($b = 18.09$, $SE = 7.30$, $t = 2.48$, $p < .015$), sleep

fragmentation ($b = 7.07$, $SE = 2.38$, $t = 2.97$, $p < .003$), and sleep efficiency ($b = -5.17$, $SE = 1.55$, $t = -3.33$, $p < .001$). All effects were in the direction of poorer sleep among men. Educational attainment was negatively associated with number of awakenings ($b = -.593$, $SE = .299$, $t = -1.98$, $p < .05$). Income was a significant predictor of WASO ($b = -4.51$, $SE = 1.57$, $t = -2.87$, $p < .005$), sleep fragmentation ($b = -1.49$, $SE = .512$, $t = -2.91$, $p < .004$), and sleep efficiency ($b = .887$, $SE = .335$, $t = 2.65$, $p < .009$), reflecting better sleep quality among persons with higher incomes. Number of health conditions was negatively associated with number of awakenings ($b = -.414$, $SE = .184$, $t = -2.25$, $p < .03$), reflecting a counterintuitive linkage of chronic conditions with sleep quality. Finally, BMI was only marginally associated with TST ($p < .075$) and sleep fragmentation ($p < .06$), and marital status did not uniquely predict any of the sleep measures (Note 2).

Based on these findings, all subsequent analyses included sex, education, income, and health conditions as covariates. Marital status and BMI were excluded from further examination.

Racial differences in sleep quality

Differences in overall sleep quality—Intraclass correlations, reflecting the proportion of total variance attributable to inter-individual versus intra-individual variability, were 0.301 (69.9% of variability is within persons) for TST, 0.420 (58.0% within-person variance) for WASO, 0.427 (57.3%) for number of awakenings, 0.422 (57.8%) for sleep fragmentation, and 0.469 (53.1%) for sleep efficiency. Thus, there was clearly sufficient night-to-night variability within individuals to warrant using MLM for primary analyses.

In separate MLM equations, each sleep quality variable was regressed onto race; the four covariates (sex [female as index group], education, income, and health conditions) were then added. Because adding covariates did not change the pattern of significance for race, only the latter step is presented here (Table 2). In addition to effects of covariates described earlier, race was significantly associated with WASO, fragmentation, and efficiency. Race was marginally predictive of number of awakenings, but was not related to total sleep time. All effects reflect poorer sleep quality among AAs vis-à-vis NHWs.

To illustrate these patterns more clearly, within-person means for each sleep variable were computed and submitted to multivariate analysis of variance (MANOVA) for effects of race. The left portion of Table 3 presents raw means along with marginal means adjusting for effects of sex, education, income and health conditions. The uncontrolled MANOVA yielded a significant multivariate effect of race. Examination of univariate F s (all $df = 1, 222$) indicated significant effects for WASO, $F = 19.19$, number of awakenings, $F = 7.82$, sleep fragmentation, $F = 30.63$, and sleep efficiency, $F = 22.13$, but not TST, $F < 1$. The effect of race was robust after adjustment for covariates. As marginal means (3rd and 4th columns of Table 3) indicate, the effect of number of awakenings was reduced to marginal status, $F(1,222) = 3.18$; however, significant racial differences persisted for WASO ($F = 6.71$), sleep fragmentation ($F = 15.67$) and sleep efficiency ($F = 12.17$), all $df = 1, 222$.

Differential variability of sleep quality—Examination of standard deviations for these raw means suggested slightly greater between-person variability among AAs versus NHWs.

However, Levene tests were significant only for sleep fragmentation, $F(1, 222) = 4.51, p < .04$.

To explore possible racial differences in *within-person* variability from night to night, we computed within-person standard deviations for the 5 sleep measures, representing variability of each individual's sleep around his/her own mean for the 3–7 day monitoring period^{33,34}. These within-person SDs were then treated as dependent variables in MANOVAs paralleling those just described.

Uncontrolled analysis (right side of Table 3) yielded a significant overall effect of race whereby African Americans displayed greater night-to-night variability than did NHWs on all five sleep measures, TST $F = 7.86$, WASO $F = 5.94$, number of awakenings $F = 11.08$, fragmentation $F = 15.44$, and efficiency $F = 8.34$, all $df = 1, 222$. However, introduction of covariates reduced the overall effect of race to marginal status. Of the covariates, only health conditions was a significant predictor of variability in sleep quality, multivariate $F(5, 214) = 3.21, p < .008$. Effects of race on night-to-night variability remained significant for number of awakenings, $F = 4.56$, and sleep fragmentation, $F = 7.27$, but were reduced to marginal status for TST, $F = 2.31$, and sleep efficiency, $F = 3.55$, and entirely eliminated for WASO, $F = 1.47$, all univariate $df = 1, 218$.

Pain, race and sleep quality

Each of the 5 MLM equations was extended to examine effects of previous day pain and next day pain both overall and in interaction with race. Separate analyses were conducted for previous day pain and next day pain, each centered to reflect within-person deviation from one's own mean. Average daily pain (ADP), the within-person mean across all days, was included as a Level 2 variable to detect the overall impact of pain on sleep quality across multiple days' monitoring.

Analyses for pain the day preceding sleep revealed no significant main effects of either average daily pain or previous day pain for any of the five sleep variables. However, for sleep efficiency, race interacted significantly with ADP, $b = 4.091, SE = 1.564, t = 2.615, p < .01$, and marginally with previous day pain, $b = -2.109, SE = 1.164, t = -1.813, p < .07$. A marginal $ADP \times$ race interaction was also observed for WASO, $b = -12.963, SE = 7.371, t = -1.759, p < .08$.

Next-day pain similarly was not associated with any of the five sleep variables. The $ADP \times$ race interaction again obtained for sleep efficiency, $b = 4.164, SE = 1.512, t = 2.754, p < .006$, but was not replicated for WASO, $p = .10$.

To explicate the observed interaction of average daily pain and race on sleep efficiency, depicted graphically in Figure 1, we reran the model separately for AAs and NHWs, using only ADP in addition to covariates. For African Americans, there was no significant effect, $b = -1.876, SE = 1.179, t = -1.59, p = .115$. In contrast, non-Hispanic Whites displayed a significant association in the opposite direction, $b = 2.204, SE = 1.026, t = 2.15, p < .04$, reflecting better sleep among those with greater average daily pain.

Discussion

This research is unique in examining sleep quality among older individuals with knee osteoarthritis in terms of racial/ethnic differences and how those differences may (or may not) interact with pain to affect sleep. Findings document substantially poorer sleep quality among African Americans as compared with non-Hispanic Whites. After controlling demographic characteristics and health status, AAs displayed more time awake after sleep onset, greater sleep fragmentation, poorer sleep efficiency, and marginally fewer awakenings over the course of the night. In addition, AAs' sleep was, to some extent, more variable from night to night within individuals. Notably, we found no main effect of pain on sleep either globally (average daily pain) or on a day-to-day basis (previous day's pain on sleep, sleep on next-day pain). However, race did moderate the relationship of pain with sleep efficiency, reflecting a paradoxical positive effect of average daily pain on sleep efficiency among NHWs.

These findings corroborate earlier work reporting racial/ethnic differences in overall sleep efficiency^{10,11,14,16}, fragmentation¹¹, and time awake after sleep onset^{11,14,15}. Reflecting findings for WASO, AAs also experienced a marginally greater number of awakenings during the night. However, we did not observe racial differences in total sleep time reported by previous investigators, using methods similar to our own, for both younger^{10,11} and older persons^{14,17}. Further, the tendency of men in our sample to display poorer sleep quality than did women contradicts the bulk of clinical research evidence^{1,5,17}. Interestingly, however, our results corroborate an animal model study examining sleep architecture in the presence of induced OA.³⁵

The greater observed variability in sleep among AAs in this study is of some interest. It has been suggested¹³ that Blacks may be more prone to exhibit both very long and very short sleep times. Our findings did not support this at the between-person level, but we did find greater *within-person* variability among AAs for all five sleep measures. Statistical control of demographic characteristics and health status attenuated the effect somewhat, recommending cautious interpretation. Nonetheless, significant effects remained for number of awakenings and sleep fragmentation, and marginal effects for TST and sleep efficiency. These findings compound the current, conflicting state of the literature on racial/ethnic differences in night-to-night variability in sleep^{33,34,36}, no doubt due in part to the diversity of samples and methods used in extant studies. The clinical significance of this difference remains to be established. Nonetheless, previous work documents the role of night-to-night variability as a factor in obstructive sleep apnea³⁷, individual differences in sleep quality³⁸, and responsiveness to treatment³⁹. Future work with older adults, including those with OA, clearly should examine other predictors of individual variability over multiple nights, as well as the association of variability with physical (e.g., fatigue, weight gain) and mental health outcomes (e.g., anxiety, depression).

The absence of consistent main effects linking pain to sleep quality is in marked contrast to the majority of existing studies. However, only a handful of those assessed the sleep-pain relationship microlongitudinally and with objective sleep measures^{19,23,24,28}, and we found none that dealt specifically with older adults with a persistently painful condition such as

OA. It is likely that the source and nature of pain may affect its relationship to sleep, particularly in disorders such as OA, in which localized pain may interfere with preferred sleeping positions, or be closely linked with daily activities. The latter point is a prime area for further investigation. Similarly, future work should examine indices of pre- and post-sleep arousal and mood states as possible influences on the sleep – pain linkage.¹⁹ Nonetheless, corroborating work with fibromyalgia patients⁴⁰, we did find an association of average daily pain with sleep efficiency. Here, the emergence of a moderating effect of race is intriguing, particularly as pain was paradoxically related to better sleep among Whites. One possible explanatory factor may be fatigue. Previous research with older OA sufferers⁹ documents a stronger within-day trajectory of fatigue among NHWs than AAs, who showed little variability in fatigue over the course of the day. Thus, NHWs' greater fatigue later in the day may facilitate efficient sleep. There may also be racial/ethnic differences in momentary coping with pain, e.g., willingness to continue activities despite pain may be differentially tiring. This is, of course, speculation based on an isolated effect; further work is needed to confirm and explicate this finding.

A few limitations of this study should be noted. First, use of a nonclinical sample has drawbacks as well as benefits. Although the data are more readily generalizable to OA sufferers as a whole (many of whom may not seek specialty care), we were not able to obtain clinical measures of joint degeneration or other disease markers that may differ among AAs and NHWs and that may complicate the relationship of pain to sleep disturbance. Second, use of actigraphy to measure sleep, without supporting self-report data nor the objective gold standard of polysomnography, curtails interpretability of findings. For example, we were unable to screen out persons with sleep apnea, restless limb syndrome, or other sleep disorders that may reduce sleep quality independent of pain. Similarly, lacking the subjective sleep quality information available from, e.g., self-reported wake/sleep time, other sleep diary data, or global self-reports, we cannot definitively compare our findings to previous work that included those measures. Finally, we did not assess daily use of sleep or pain medications; this is an important focus for future research.

Clinical Implications

Despite its limitations, this study corroborates previous findings regarding racial/ethnic differences in sleep quality, and extends those findings to older adults with OA. Clearly, AAs' generally poorer sleep quality should be taken into account in evaluating overall health status in persons with OA and exploring treatment options in a variety of healthcare settings. Of particular interest is our finding that sleep is more variable from night to night among AAs. Absent linkage of this variability to physical and mental health outcomes such as fatigue, functional disability, depression, and anxiety, no strong recommendations can be made. Nonetheless, our findings certainly suggest that assessment of sleep disturbances span multiple nights in order to capture this potentially important aspect of sleep quality.

As noted, the absence of consistent results for the sleep-pain association is surprising. However, the emergence of a moderating effect of race on the association of pain with sleep efficiency highlights the multifaceted nature of sleep problems and the need for carefully

assessment of a broad range of personal and clinical characteristics before proceeding with treatment.

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Figure 1. Moderating effect of race on the association of average daily pain with sleep efficiency

Table 1
Baseline Characteristics of Participants as a Function of Race/Ethnicity

Variable (range in this sample)	African American N=96	Non-Hispanic White N= 128	F or χ^2	p
	Mean (SD) or N (%)	Mean (SD) or N (%)		
Alabama	71 (74.0%)	61 (47.7%)	15.68	.001
New York	25 (26.0%)	67 (52.3%)		
Age in years (48–97)	63.2 (8.6)	64.2 (9.1)	< 1	.405
Female	81 (84.4%)	92 (71.9%)	4.86	.027
Male	15 (15.6%)	36 (28.1%)		
Married/cohabiting	34 (35.4%)	74 (57.8%)	11.02	.001
Not married/cohabiting	62 (64.6%)	54 (42.2%)		
Less than high school	19 (19.8%)	6 (4.7%)	24.59 ^a	.001
High school/GED	27 (28.1%)	21 (16.4%)		
Some post-high school	24 (25.0%)	32 (25.0%)		
College degree	13 (13.5%)	28 (21.9%)		
Graduate degree	13 (13.5%)	41 (32.0%)		
Income (1, 8) ^b	4.3 (2.9)	6.0 (4.0)	48.17	.001
Health problems (0, 12)	3.9 (2.5)	2.9 (2.7)	9.15	.003
BMI (15.1–76.1)	36.0 (8.3)	32.3 (7.7)	11.59	.001
Depressive symptoms (0, 54)	13.3 (11.8)	10.9 (10.4)	2.48	.117
Nights' sleep monitored (3,7)	5.3 (0.5)	5.5 (0.8)	1.33	.250
Average daily pain (1, 4.95)	2.17 (0.85)	1.94 (0.80)	4.09	.044

Note: For χ^2 values, df = 1, and for F values, df = 1, 222 unless otherwise noted.

^a χ^2 df = 4.

^b Figures are median and interquartile range.

^c Samples sizes are 95 for African Americans, 125 for non-Hispanic Whites; df = 1, 218

Table 2

Sleep quality as a function of race/ethnicity and covariates (N = 224)

	Total Sleep Time		Wake After Sleep Onset		Number of Awakenings		Sleep Fragmentation		Sleep Efficiency	
	b (SE)	t (df)	b (SE)	t (df)	b (SE)	t (df)	b (SE)	t (df)	b (SE)	t (df)
<i>Fixed effects</i>										
Sex ¹	-43.39 (12.32)	-3.42 ^d (221.7)	17.78 (7.06)	2.52 ^a (221.1)	.749 (1.01)	> 1 (222.5)	7.17 (2.27)	3.16 ^c (222.1)	-5.10 (1.49)	-3.43 ^d (221.1)
Education level	-4.78 (3.53)	-1.36 (225.7)	-1.86 (2.02)	< 1 (225.7)	-510 (.290)	-176 [*] (225.8)	-206 (.650)	< 1 (226.5)	-.066 (.426)	< 1 (225.1)
Income	-.030 (2.57)	< 1 (224.2)	-4.16 (1.48)	-2.82 ^c (224.1)	-.246 (.212)	-1.17 (224.5)	-1.19 (.474)	-2.52 ^a (224.9)	.770 (.310)	2.48 ^a (223.6)
Health conditions	-4.41 (2.12)	-2.08 ^a (223.3)	1.08 (1.21)	< 1 (222.9)	-.324 (.174)	-1.85 [*] (223.8)	.608 (.390)	1.56 (223.8)	-.300 (.256)	-2.27 (222.7)
Race ²	8.94 (11.40)	< 1 (224.9)	-16.94 (6.54)	-2.59 ^b (224.8)	-1.75 (0.94)	-1.86 [*] (223.8)	-8.38 (2.10)	-3.99 ^d (225.7)	4.82 (1.38)	3.50 ^d (224.3)

¹ Female = 0, Male = 1

² African American = 0, Non-Hispanic White = 1

* .05 < p < .10

^a p < .05

^b p < .01

^c p < .005

^d p < .001

Table 3
Racial/ethnic differences in sleep quality: magnitude (means) and variability (standard deviations)

	Within-Person Means						Within-Person Standard Deviations					
	Raw			Adjusted			Raw			Adjusted		
	AA	NHW	Mean (SD)	AA	NHW	Mean (SE)	AA	NHW	Mean (SD)	AA	NHW	Mean (SE)
Total sleep time	399.7 (81.1)	402.5 (77.9)	81.7 (4.8)	395.9 (8.4)	405.3 (7.2)	64.5 ^b (4.1)	80.3 (44.4)	64.7 ^c (38.2)	77.3 (4.4)	67.0 [*] (3.8)		
Wake after sleep onset	87.4 (51.3)	60.3 ^d (41.4)	81.7 (4.8)	81.7 (4.8)	64.5 ^b (4.1)	45.3 (29.8)	45.3 (29.8)	34.2 ^a (36.4)	42.4 (3.6)	36.3 (3.1)		
Number of awakenings	13.6 (6.6)	11.4 ^b (6.2)	13.4 (0.7)	13.4 (0.7)	11.7 [*] (0.6)	6.1 (2.7)	6.1 (2.7)	4.8 ^d (2.8)	5.8 (0.3)	5.0 ^a (0.3)		
Sleep fragmentation	36.9 (16.7)	25.8 ^d (13.1)	35.4 (1.5)	35.4 (1.5)	26.9 ^c (1.3)	16.5 (9.0)	16.5 (9.0)	12.3 ^d (7.0)	15.9 (0.8)	12.8 ^b (0.7)		
Sleep efficiency	79.9 (10.3)	86.0 ^d (9.1)	80.6 (1.0)	80.6 (1.0)	85.4 ^d (0.9)	9.2 (6.0)	9.2 (6.0)	6.8 ^c (6.2)	8.8 (0.7)	7.2 [*] (0.6)		
Multivariate F	8.595, $p < .001$			4.726, $p < .001$			4.489, $p < .001$			2.015, $p < .08$		

AA = African American; NHW = non-Hispanic White. Degrees of freedom for all multivariate Fs = 5, 218. Adjusted means are controlled for sex, education, income, and health conditions.

Superscripts indicate significantly different means between AAs and NHWs. See text for details of analyses.

* .05 < $p < .10$

^a $p < .05$

^b $p < .01$

^c $p < .005$

^d $p < .001$