Association Between Discrimination and Objective and Subjective Sleep Measures in the Midlife in the United States Study Adult Sample

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ABSTRACT

Objective: Evidence suggests that sleep quality is worse in nonwhite minorities compared with whites. Poor sleep is associated with higher levels of perceived interpersonal discrimination, which is consistently reported among minorities. However, the literature is limited in exploring discrimination with both objective and subjective sleep outcomes in the same sample. We examined the relationship between discrimination and markers of subjective and objective sleep in a racially diverse sample.

Methods: The analytic sample included 441 participants of the Midlife in the United States II (MIDUS) study (M [SD] age, 46.6 [1.03]; female, 57.9%; male, 42.1%; nonwhite, 31.7%). Complete data were available for 361 participants. Sleep measures included the Pittsburgh Sleep Quality Index, sleep latency, wake after sleep onset, and sleep efficiency derived from 7-day actigraphy. Discrimination was measured with the Williams Everyday Discrimination Scale. Ordinary least squares and logistic regression models were used to assess the relationship between discrimination and the subjective and objective measures of sleep.

Results: After adjusting for covariates, respondents with higher discrimination scores were significantly more likely to experience poor sleep efficiency (odds ratio, 1.12; $p = .005$) and report poorer sleep quality (odds ratio, 1.09; $p = .029$) on the basis of the Pittsburgh Sleep Quality Index. Higher discrimination scores were also associated with longer wake after sleep onset (b = 0.032, $p < .01$) and more sleep difficulties (b = 0.049, $p = .01$). Discrimination attenuated all differences in the sleep measures between whites and nonwhites except for sleep efficiency.

Conclusions: The findings support the model that discrimination acts as a stressor that can disrupt subjective and objective sleep. These results suggest that interpersonal discrimination explains some variance in worse sleep among nonwhites compared with whites.

Key words: discrimination, disparities, MIDUS, psychosocial, race, sleep.

INTRODUCTION

Inadequate sleep, as well as poor sleep quality, is associated with increased risk for cardiometabolic complications, increased body mass index (BMI), and all-cause mortality (1–5). Adequate sleep is critical for regulating the effects of stress on chronic disease outcomes, with both biological and population-level associations to poor health (3–5), and racial/ethnic minorities are more likely to report poorer sleep quality as well as a higher prevalence of comorbid conditions (6–8). Although the literature on correlates of poor sleep in racial/ethnic minorities is limited, researchers have suggested psychosocial stressors such as perceived discrimination may account for some variation in health outcomes by race/ethnicity (9,10). Specifically, African Americans have greater exposure to and more frequent experiences with discrimination. Moreover, stronger

BMI = body mass index, **CI** = confidence interval, **MIDUS** = Midlife in the United States Study, **OR** = odds ratio, **PSG** = polysomnography, **PSQI** = Pittsburgh Sleep Quality Index, **SE** = standard error, **SOL** = sleep onset latency, **SWAN** = Study of Women's Health Across the Nation, **WASO** = wake after sleep onset

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associations between psychosocial stress and impaired sleep have been documented in African Americans (6–16).

Although research has linked everyday discrimination to a variety of health outcomes, the pathway remains unclear (17–20). One proposed mechanism linking discrimination and negative health consequences is through impaired sleep. Some evidence suggests that discrimination affects diurnal cortisol patterns and blood pressure, physiological functions that are also impaired as a result of sleep disturbances (19,20). Moreover, disruption of the hypothalamic-pituitary-adrenal axis is found to occur with both discrimination and impaired sleep (19,20). Growing research has shown associations between discrimination and poor sleep (3,9–11,14–18). Overall, at least 17 studies of discrimination and sleep have been reported, all of which have found a significant association between discrimination and sleep measures (9). Although there is a body of evidence suggesting that sleep plays a critical role in well-being and physiological recovery, evidence of the impact of chronic daily stressors, such as discrimination, in relation to both subjective and objective sleep quality measures is limited (9). In addition, further exploration of the association between discrimination and sleep may inform potential causal models for assessing racial/ethnic health disparities (11–13).

Differentiating the relationships that discrimination has to various measures of sleep is critical because subjective sleep quality measures may not directly align with objective measures of and may, in fact, characterize unique aspects of the sleep experience not currently understood (21–23). Psychosocial factors are commonly cited explanations for differences in subjectively and objectively measured sleep quality (24–29); therefore, discrimination as a psychological factor may have varying correlates to subjective and objective sleep that may be useful in characterizing the general mechanisms by which psychosocial stressors may affect sleep. However, most discrimination and sleep studies used subjective measures of sleep exclusively. Only four studies have investigated discrimination and objective sleep, and only one study to date has investigated the association between discrimination and both subjective and objective sleep quality (9). However, this study was conducted exclusively in a sample of older women, a demographic that is known to report subjective sleep outcomes that differ from their objective sleep measures. (9–11,14–18). Given the limited research regarding discrimination and both objective and subjective sleep as well as the known lack of correlation between subjective and objective sleep measures (22,23,30), examining the association of discrimination with both subjective and objective sleep measures in a racially diverse sample of adults is warranted. As such, a clearer understanding of the distinctions between subjective and objective sleep quality measures and their relationships to discrimination is a necessary step in moving the field forward.

Using data from the Midlife Development in the United States Study (MIDUS) study, we aimed to (1) explore the associations between discrimination and sleep through an unprecedented variety of objective and subjective sleep measures and (2) elucidate any inconsistencies in the relationships with discrimination between subjective and objective sleep quality.

METHODS

Participants and Data Collection

We used data from two study "waves": the baseline (1995) and follow-up (2004) studies of MIDUS. MIDUS is a stratified, multistage probability sample of community-based English-speaking adults, ages 25 to 74 years, recruited from a random digit dial nationally representative sampling frame of the coterminous United States. The study was developed to study the role of biopsychosocial factors in understanding age-related differences in physical and mental health (31,32). In 2004–2006, 4975 of the baseline participants (n = 7108) were reinterviewed. The overall response rate between the two data collection periods was approximately 76% after accounting for the 421 confirmed decedents. In this study, we limited the analytic sample to the respondents who participated in the Actiwatch sleep study (n = 441) component of the Biomarker project (project 4) administered only to the participants at the Midwest (University of Wisconsin-Madison [UW-Madison]) location in 2004. MIDUS participants were eligible for project 4 if they (1) completed the MIDUS II project 1 phone interview and self-administered questionnaire, (2) were in the main random digit dial (not including city oversamples), twin or African American samples, and (3) lived in the continental United States (33). The institutional review board for Human Subject Protection at the UW-Madison approved the data collection study protocol.

Measures

Sleep Measures

Participants in the sleep study wore the Actiwatch-64, a wrist-worn accelerometer that measures rest/activity cycles in participants to provide validated measures of objective sleep in this study. The Actiwatch-64 data were collected for seven consecutive days beginning in the morning on the Tuesday after the day the respondent returned home after their general clinical research clinic visit at UW-Madison. The data collection period ended at the time the respondent woke up on the following Tuesday. For each respondent, the available data set included data for seven rest periods, with seven sleep periods, and six activity periods occurring between first and last rest/sleep periods. Our analyses focused on three objectives (wake after sleep onset [WASO], sleep efficiency, and sleep onset latency [SOL]) and two subjective measures (the Pittsburgh Sleep Quality Index [PSQI] and a single measure of self-reported sleep quality). The objective sleep measures (SOL, WASO, and sleep efficiency) were derived from the Actiwatch software. WASO is the total minutes of wakefulness between the initiation and termination of the sleep period (does not include SOL, 33). Sleep efficiency is expressed as a percentage, calculated as the ratio of time spent asleep to total time spent in bed, multiplied by 100. SOL is defined as the amount of time elapsed from "lights out" (the beginning of the rest interval) to when sleep was actually initiated (33). To manage skewedness, we log transformed the WASO and SOL measures, and the sleep efficiency measure was dichotomized to reflect reduced (<85th percentile) and normal (≥85th percentile) sleep efficiency.

Participants also provided subjective measures of sleep. The well-validated PSQI is a nineteen-item self-report instrument used to subjectively assess sleep quality for the past month (34). Respondents completed four open response items about the timing and duration of their sleep periods and one item about sleep quality (assessed on a 4-point scale). For the remaining items, respondents indicated how often they experienced sleep problems and disruptions in daily functioning related to sleep on a 4-point frequency scale (0 = "not during the past month"; 1 = "less than once a week"; 2 = "once or twice a week"; 3 = "three or more times a week"). Seven component scores were generated the nineteen items: sleep quality, sleep latency, sleep duration, habitual sleep efficiency, sleep disturbances, use of sleep medication, and daytime dysfunction. The component scores (range, 0–3; with higher scores indicating more sleep difficulty) were summed to give a global sleep score (range, 0–21). Scores higher than 5 indicated poor sleep quality (34,35). The internal consistency of the global PSQI in the MIDUS study was 0.7442.

The sleep difficulty variable assessed the frequency (1 = never to 5 = almost always) with which the respondents had (1) trouble falling asleep, (2) woke up during the night, and (3) woke up too early. We averaged the responses to create a summary measure with a range of 1 to 5, with higher values indicating higher sleep difficulties.

Discrimination

Perceived interpersonal experiences of discrimination were measured using the nine-item version of the interpersonal discrimination scale constructed by Williams et al. (36) in both waves. The interpersonal discrimination scale, a measure of perceived day-to-day interpersonal discrimination, assesses the frequency with which individuals encounter unfair treatment (35). Specifically, respondents reported their perception of how often (3) they were treated with less courtesy than other people; (4) they were treated with less respect than other people, (5) they received poorer service than others; they believed others acted as if they were (1) not smart, (2) afraid of them, (6) dishonest, and (7) not as good as they were; they were (8) called names or insulted; or (9) they felt threatened or harassed. The response option indicating frequency for each item in the questionnaire ranged from 1 to 4, with 1 indicating "often" to 4 indicating "never." Within each wave, the responses were reverse coded and summed across the nine items, which resulted in a range of 0 to 27, with higher scores reflecting greater frequency of discrimination (36). The nine items in this study have an internal consistency of 0.93 in the first wave and 0.91 in the second wave, using the full sample. For this study, we created a mean of the scales from both waves.

Covariates

To adjust for potential confounding, an a priori decision was made to include variables that captured several sociodemographic, psychosocial, and health-related characteristics that may be associated with discrimination and the measures of sleep used in the analyses. The psychosocial variables assessed sleeping problems, depression diagnosis, and stressful life events, three important measures associated with sleep (1,37). In particular, the sleeping problem variable is an indicator variable that assessed, at the time of the study, the history of being treated for chronic sleeping problems within the last 12 months. The depression variable is a continuous variable (0 = lowest to 7 = highest) that assesses the severity of depressive disorder and anhedonia, defined as the motivation/desire to engage in an activity characteristic of many mood disorders (38). The stressful life events variable is a count of the "yes" responses to 24 potential major stressful life events, such as experiencing the death of a parent and/or a sibling or being fired from a job (39). Sociodemographic covariates assessed age (continuous), sex, self-reported race/ethnicity (white versus all other nonwhite groups), and educational attainment (>12 years versus ≤12 years). The variables measuring health-related characteristics included past 12-month diagnosis of diabetes (yes versus no), continuous BMI (weight in kilograms divided by height in meters squared), and current cigarette smoking status (yes versus no). Each of these covariates has been significantly associated with discrimination and sleep in both subjective and objective studies (9,14–18). All of the covariates in the analyses were from the second wave only, whereas the discrimination outcome measures were from both waves.

Analysis

After accounting for missing data across the variables used in the study, of the 441 respondents, there were 80 subjects (18.14%) missing on one or more responses leaving 361 respondents available for analyses. We further evaluated the item nonresponse for each of the variables with respect to the other variables. Compared with those with complete nonmissing data (n = 361), independent t test and χ^2 analyses confirmed respondents with missing data (n = 80) did significantly differ with regard to the three actigraphy-based sleep outcome variables but not on the PSQI and sleep difficulty variables. In addition, there were some differences across some covariates. Specifically, those respondents who were not missing on any of the variables were more likely ($p < .05$) to be nonwhite and have high blood pressure when compared with the respondents who had a missing response on one or more of the variables. No statistically significant differences ($p > .05$) were noted between the two groups with respect to sex, education, diabetes status, smoking status, having a sleep problem, mean levels of discrimination across the two periods, age, BMI, life events, or depressive disorders/anhedonia. Although we suspected that the data may have been missing at random (40), we chose to impute data for missing cases using an iterative imputation method that imputed multiple variables by using chained equations, a sequence of univariate imputation methods with fully conditional specification of prediction equations (41,42). Missing data are of concern in social science research, especially with the use of a self-administered survey. The exclusive use of nonmissing data, when not missing at random, leads to biased results, including larger standard errors and wider confidence interval (39–43). Multiple imputation is one method to deal with the bias that may result when estimating relationships when only the nonmissing data are included in the analysis.

All missing and nonmissing variables presented in this study were used in the multiple imputation process. Because the distribution of each variable is required to be specified in the imputation process, the imputed variables are constrained to the observed variability in the nonmissing data and incorporate some variability on the basis of variables correlated with the missing data and causes of missingness with the use of multiple imputed data sets (41–43). For example, being a continuous variable, age was imputed as a continuous variable and was abounded by the original range of the nonmissing data when it was being imputed.

For the final postimputation analyses, we used 10 imputed data sets of 441 respondents in each data set. All of the analyses in this study used multiple (mi) estimation commands within STATA, which adjusted the coefficients and standard errors for the variability between the 10 imputed data sets according to the combination rules proposed by Rubin (43). Ordinary least squares (WASO, SOL, and sleep difficulties) and logistic regression (poor sleep efficiency and PSQI) models were used to assess the relationship between discrimination and the subjective and objective measures of sleep, controlling for all of the covariates. Respondent characteristics were summarized and are presented in Table 1. Results from the bivariate and multivariate analyses are presented in Tables 2 and 3, respectively. (Results of regression analyses are presented as unstandardized b coefficients and standard errors [SE].) In all of the analyses, two-sided p values of less than 0.05 were considered statistically significant. All analyses were performed using STATA v13.1 (44).

RESULTS

Descriptive Characteristics

The sample was predominantly female (57.9%), white (68.2%), and had 12 or fewer years of education (72.1%). Discrimination scores averaged 5.06 (standard error [SE] = 0.27, range = 0–27). The average depression score

TABLE 1. Sample Characteristics of Sleep Architecture, Select Variables, and Covariates of Interest Using Imputed Data for All Actiwatch Subsample in MIDUS I and II

Objectively sleep measures	
SOL, M [SE], min	21.1 [1.05]
Poor sleep efficiency[a] (< 85%)	67.8
WASO, M [SE], min	43.8 [1.02]
Subjective sleep measures	
Sleep difficulties,[b] M [SE]	2.63 [0.07]
Poor Pittsburgh Sleep Quality Index[c] (>5)	50.2
Discrimination,[d] M [SE]	5.06 [0.27]
Depression,[e] M [SE]	1.38 [0.13]
Chronic sleeping problems within last 12 mo,[f] %	16.9
Major life events, M [SE]	1.91 [0.10]
Age, M [SE], y	46.6 [1.03]
Female, %	57.9
Nonwhites, %	31.7
≤12-y education, %,	72.1
BMI, M [SE], kg/m^2	28.1 [0.72]
Diabetes diagnosis, %	13.4
Current smokers, %	17.9

SOL = sleep onset latency; SE = standard error; WASO = wake after sleep onset; BMI = body mass index.

N = 441. As noted in the methods section, data for missing responses were imputed.

[a] Poor sleep efficiency <85%.

[b] Sleep difficulties define as a count of the "yes" responses to questions assessing the frequency they (1) had trouble falling asleep, (2) woke up during the night, and (3) woke up too early.

[c] Poor sleep quality defined as a score of <5 on the basis of the Pittsburgh Sleep Quality Index.

[d] Mean of wave 1 and wave 2 reports of everyday interpersonal discrimination.

[e] Depression: assesses the severity of depressive disorder and anhedonia.

[f] Chronic sleep problems: assesses symptoms/treatment of chronic health problems in past 12 months.

was 1.38 (SE = 0.13, range = 0–7), and the average number of major life events reported was 1.91 (SE = 0.10, range = 0–24). The average BMI was 28.1 (SE = 0.72, range = 14–49); 27.9% of the sample reported a diabetes diagnosis, and 17.9% were current smokers in 2004 (Table 1).

The average WASO time was 43.8 minutes (SE = 1.02), and average SOL was 21.1 minutes (SE = 1.05). Poor sleep efficiency was identified in 32.2% of the sample. The average sleep difficulty score was 2.63 (SE = 0.07); poor sleep quality based on the PSQI was reported by 50.2% of the sample, and 16.9% of the respondents reported being treated for chronic sleeping problems within the last 12 months.

Bivariate Regression Model Results

Results of bivariate regressions between each predictor and outcome variable are shown in Table 2.

Multivariate Regression Model Results

Results of the multivariate models showed that higher discrimination scores remained statistically associated with longer WASO (b = 0.03, SE = 0.01, $p < .01$), 12% higher odds of poor sleep efficiency (95% confidence interval [CI] = 1.04–1.22), reporting more sleep difficulties (b = 0.05, SE = 0.02, $p = .01$), and a 9% increase odds in poorer sleep quality based on the PSQI (95% CI = 1.01–1.18). Nonwhites had 3.69 (95% CI = 1.39–9.81) times the odds of reporting poor sleep efficiency compared with whites; no other racial/ethnic differences in the objectively or subjectively measured sleep outcomes was found (Table 3).

Older age was associated with a modest increase in WASO (b = 0.01, SE = 0.002, $p = .03$), SOL (b = 0.01, SE = 0.004, $p = .01$), and increased odds of poor sleep efficiency (odds ratio [OR] = 1.02, 95% CI = 1.00–1.04). Males had longer WASO (b = 0.14, SE = 0.06), longer SOL (b = 0.43, SE = 0.095, $p < .01$), and greater odds of poor sleep efficiency (OR = 2.67, 95% CI = 1.61–4.44) than females. Chronic sleep problems for the last 12 months remained associated with more reports of sleep difficulties (b = 0.91, SE = 0.20, $p < .01$) and greater odds of poor sleep based on the PSQI (OR = 6.38, 95% CI = 1.69–24.12). Education was no longer significantly associated with any of the sleep measures. Higher depression scores were associated with longer WASO (b = 0.04, SE = 0.02, $p = .04$), longer latency (b = 0.07, SE = 0.03, $p = .04$), more sleep difficulties (b = 0.07, SE = 0.03, $p = .01$), and greater odds of poor sleep based on the PSQI (OR = 1.21, 95% CI = 1.03–1.42). Respondents who reported more major life events had shorter WASO (b = −0.03, SE = 0.01, $p = .05$). Among the health covariates, BMI and smoking status were no longer significantly associated with any of the sleep measures; diagnosed diabetics had greater odds of reporting poor sleep based on the PSQI than nondiabetics (OR = 3.07, 95% CI = 1.25–7.56).

DISCUSSION

The purposes of this study were to investigate the associations between discrimination and sleep measures using a variety of objectively and subjectively measured sleep variables and to clarify inconsistencies in the relationships between discrimination and these measures. We found that higher discrimination scores were significantly associated with poorer objective (WASO, sleep efficiency >85%) and subjective sleep measures (sleep difficulties, PSQI) in both bivariate and multivariate models. Furthermore, we determined that the roles of the demographic, mental health, and physical health factors on the relationships between discrimination and the sleep measures were varied but only accounted for minor proportions of the associations between discrimination and most of the sleep measures. The results of our study provide a thorough analysis of

TABLE 2. Bivariate Associations Between Sleep Architecture and Select Variables in the MIDUS Actiwatch Subsample

	Logged WASO		Logged SOL		Poor Sleep Efficiency[a]		Sleep Difficulties[b]		PSQI Poor Sleep[c]	
	b	*P* [SE]	b	*P* [SE]	OR	*P* (95% CI)	b	*P* [SE]	OR	*P* (95% CI)
Mean discrimination[d]	0.035	<.001 [6.42]	0.061	<.001 [4.78]	1.22	<.001 (1.15–1.29)	0.067	<.001 [5.07]	1.15	<.001 (1.09–1.22)
Nonwhites (ref = whites)	0.254	<.001 [5.30]	0.571	<.001 [6.00]	8.94	<.001 (4.63–17.25)	0.411	.009 [2.93]	2.67	<.001 (1.70–4.19)
Age (y), continuous	0.006	.014 [2.50]	0.013	.010 [2.70]	1.02	.037 (1.00–1.04)	0.009	.20 [1.34]	1.02	.090 (1.00–1.04)
Male (ref = female)	0.103	.20 [1.34]	0.414	.007 [2.98]	1.91	.054 (0.99–3.70)	−0.002	.99 [−0.01]	0.78	.37 (0.44–1.37)
12+-y education	−0.035	.65 [−0.45]	−0.050	.79 [−0.27]	0.84	.68 (0.36–1.95)	−0.053	.71 [−0.38]	1.18	.59 (0.64–2.16)
Chronic sleep problems[f] (ref = no)	−0.189	.15 [1.51]	−.071	.81 [0.24]	2.46	.16 (0.67–9.01)	1.072	<.001 [5.77]	9.65	.001 (2.72–34.24)
BMI, kg/m^2	0.007	.28 [1.09]	−0.025	.053 [2.02]	1.03	.45 (0.95–1.11)	0.020	.17 [1.43]	1.02	.47 (0.97–1.07)
Current smoker (ref = nonsmoker)	−0.054	.59 [0.55]	0.102	.68 [0.43]	1.62	.45 (0.44–5.98)	−0.057	.81 [−0.25]	1.14	.81 (0.36–3.66)
Diabetic (ref = no)	0.179	.10 [1.70]	0.606	.001 [3.56]	4.09	.010 (1.42–11.80)	0.519	.044 [2.22]	4.34	<.001 (1.97–9.59)
Depression score[e]	0.061	<.001 [4.70]	0.109	.001 [4.61]	1.49	<.001 (1.29–1.73)	0.134	<.001 [4.86]	1.37	<.001 (1.21–1.55)
Major life events	−0.029	.006 [2.79]	−0.027	.20 [1.29]	0.91	.041 (0.86–1.00)	−0.018	.52 [0.66]	0.99	.85 (0.90–1.09)

WASO = wake after sleep onset; SOL = sleep onset latency; PSQI = Pittsburgh Sleep Quality Index; SE = standard error; OR = odds ratio; CI = confidence interval.

N = 441. As noted in the methods section, data for missing responses were imputed.

ORs are reported from logistic regression procedures. b coefficients are reported from ordinary least squares.

[a] Poor sleep efficiency <85%.

[b] Sleep difficulties define as a count of the "yes" responses to questions assessing the frequency they (1) had trouble falling asleep, (2) woke up during the night, and (3) woke up too early.

[c] Poor sleep quality defined as a score of <5 on the basis of the Pittsburgh Sleep Quality Index.

[d] Mean of wave 1 and wave 2 reports of everyday interpersonal discrimination.

[e] Depression: assesses the severity of depressive disorder and anhedonia.

[f] Chronic sleep problems: assesses symptoms/treatment of chronic health problems in past 12 months.

TABLE 3. Multivariate Associations Between Sleep Architecture and Select Variables in the MIDUS Actiwatch Subsample

	Logged WASO		Logged SOL		Poor Sleep Efficiency[a]		Sleep Difficulties[b]		PSQI Poor Sleep[c]	
	b	*P* [SE]	b	*P* [SE]	OR	*P* (95% CI)	b	*P* [SE]	OR	*P* (95% CI)
Mean discrimination[d]	0.032	<.001 [0.007]	0.035	.051 [0.017]	1.12	.005 (1.04–1.22)	0.049	.006 [0.016]	1.09	.029 (1.01–1.18)
Nonwhites (ref = whites)	−0.106	.23 [0.087]	0.275	.097 [0.165]	3.69	.009 (1.39–9.81)	−0.348	.17 [0.241]	0.73	.57 (0.24–2.23)
Age (y), continuous	0.006	.026 [0.002]	0.010	.014 [0.004]	1.02	.033 (1.00–1.04)	0.009	.20 [0.006]	1.02	.057 (1.00–1.04)
Male (ref = female)	0.144	.011 [0.055]	0.434	<.001 [0.095]	2.67	<.001 (1.61–4.44)	0.112	.27 [0.099]	0.92	.75 (0.54–1.56)
12+-y education (ref = ≤12 y)	−0.053	.35 [0.057]	−0.071	.60 [0.135]	0.78	.38 (0.44–1.38)	−0.079	.46 [0.105]	1.21	.50 (0.70–2.10)
Depression[e]	0.037	.041 [0.018]	0.068	.039 [0.032]	1.17	.066 (0.99–1.39)	0.068	.010 [0.026]	1.21	.023 (1.03–1.42)
Diabetic (ref = no)	0.028	.77 [0.093]	0.323	.11 [0.196]	2.25	.11 (0.83–6.10)	0.183	.42 [0.220]	3.07	.015 (1.25–7.56)
BMI, kg/m^2	0.001	.78 [0.005]	0.01	.28 [0.009]	0.99	.82 (0.95–1.04)	0.009	.41 [0.011]	0.99	.72 (0.95–1.04)
Current smoker (ref = nonsmoker)	−0.003	.98 [0.085]	−0.023	.88 [0.155]	1.22	.63 (0.54–2.74)	−0.213	.13 [0.137]	0.90	.81 (0.40–2.07)
Sleep problems[f] (ref = no)	0.061	.60 [0.114]	−0.271	.28 [0.242]	1.03	.95 (0.41–2.56)	0.910	<.001 [0.201]	6.38	.008 (1.69–24.12)
Major life events	−0.025	.050, [0.013]	0.021	.43 [0.026]	1.03	.67 (0.91–1.17)	−0.014	.61 [0.027]	1.08	.31 (0.93–1.24)
Equal FMI model *F* test	*F*(11,256.6) = 4.41		*F*(11,229.8) = 5.26		*F*(11,5497.9) = 5.26		*F*(11,129.3) = 5.94		*F*(11,689.4) = 3.36	
Model probability	*p* < .001		*p* < .001		*p* < .001		*p* < .001		*p* < .001	
Adjusted R^2	0.16		0.20		NA		0.35		NA	

WASO = wake after sleep onset; SOL = sleep onset latency; PSQI = Pittsburgh Sleep Quality Index; OR = odds ratio; CI = confidence interval; BMI = body mass index; NA = not available.

N = 441. As noted in the methods section, data for missing responses were imputed.

ORs are reported from logistic regression procedures. b coefficients are reported from ordinary least squares.

[a] Poor sleep efficiency <85%.

[b] Sleep difficulties define as a count of the "yes" responses to questions assessing the frequency they (1) had trouble falling asleep, (2) woke up during the night, and (3) woke up too early.

[c] Poor SLEEP quality defined as a score of <5 on the basis of the Pittsburgh Sleep Quality Index.

[d] Mean of wave 1 and wave 2 reports of everyday interpersonal discrimination.

[e] Depression: assesses the severity of depressive disorder and anhedonia.

[f] Chronic sleep problems: assesses symptoms/treatment of chronic health problems in past 12 months.

discrimination and various sleep measures in a large, diverse sample of US adults. The findings contextualize the discrimination and sleep literature, which is largely conducted using either subjective or objective measures (45,46).

In addition to subjective measures, our study used three measures of objective sleep (WASO, SOL, and sleep efficiency), the most ever used in a discrimination study (9). The objectively measured sleep findings are consistent with a previously reported association between polysomnography (PSG)-assessed WASO and everyday discrimination among midlife women from the Study of Women's Health Across the Nation (SWAN, 14). Similarly, among a sample of African American and white adolescents, more unfair treatment was negatively associated with both PSG- and actigraphy-assessed sleep efficiency but not WASO (20). However, another study by Thomas et al (2006) reported no association between discrimination and polysomnographically assessed WASO or sleep efficiency, although this study used a different scale of discrimination that asked about ethnic identity rather than experiences of unfair treatment, which likely measures a different concept (15,18).

We speculate that this slight variation across studies may have arisen because of participant and methodological differences between the studies. For instance, our study as well as others that found relations between discrimination and WASO or sleep efficiency included participants who were older or women, whereas studies with null associations had younger study populations (23,27). As expected, older adults had lower average sleep efficiency and larger standard deviations in our study. This greater variability may lend to a higher probability of detecting an association. In addition, other studies that did not find associations between discrimination and WASO or sleep efficiency studied participants in the laboratory and scheduled set bed and wake times (46). Participants may have differed in their ability to maintain sleep during the given sleep period because of differences in chronotype or preferred sleep timing (47). Conversely, our MIDUS cohort study, the SWAN study (22), and the Beatty et al. (2009) community study (20), all of which reported associations between the Everyday Discrimination Scale and WASO or sleep efficiency, studied the participants in a nonlaboratory setting allowing participants to choose sleep periods and timing (20). These findings across demographics warrant further investigation, including associations between discrimination based on the Everyday Discrimination Scale with both actigraphy and PSG.

In contrast to the study's objective sleep findings, subjective sleep associations with discrimination were significant and consistent with other studies (10,11,45). The review by Slopen et al. (2015) showed significant associations between sleep and discrimination in all 16 studies included (11). The subjective associations persisted across study populations, including the SWAN study, the Michigan & Wisconsin Behavioral Risk Factor Surveillance System, and various community studies (9,48). These various populations ranged from adolescents to older adults and across countries, showing a consistent association between discrimination and sleep (11). The MIDUS study provides a snapshot of middle-aged American adults with an oversampling of African Americans, and the findings remain remarkably consistent.

PSQI scores and self-reported sleep difficulties had significant relationships to discrimination but not major life events in this study. This result is reflected in other psychosocial research, which finds that daily discrimination is a stronger correlate to poor health outcomes than major life events (49). The Everyday Discrimination Scale used in this study is a schedule that measures the frequency of discriminatory events occurring in the participants' lives (1). The frequency of discrimination is an important predictor of poor subjective sleep in addition to other mental and physical health outcomes (50,51). Therefore, a causal pathway that connects chronic discrimination to sleep, yielding poor health outcomes, should be considered. Evidence from previous research has shown African Americans as more likely to report short sleep duration (46,52,53). Furthermore, among individuals who do not subjectively report sleep complaints, African Americans are more likely to have longer SOL and greater nap duration (46). The existing literature also suggests that differences in sleep by race/ethnicity vary by age and sex (52–55). A community sample showed that young to middle-aged African American men reported insomnia more frequently than whites, although older African American men sleep longer than older white men (54). One study found that African American women are significantly less likely to self-report poor sleep quality than white women, although African American women are more likely to have several poor objective sleep measures (46,53). The inconsistencies among these findings have unclear origins, and may be attributed to psychosocial factors, including discrimination. This suggests that the racial/ethnic differences in sleep that has been previously reported (13,52) deserves further investigation to determine whether perceived discrimination, the covariates entered into our models, or a combination of these contribute to racial and ethnic sleep disparities via psychosocial stress. In other words, long-term hypothalamic-pituitary-adrenal axis dysregulation may occur when enduring chronic discrimination. This stress can impair proper diurnal cortisol cycling, thus disrupting both objectively and subjectively measured sleep (15,19).

In exploratory analyses of covariates, we found differences in sleep latency and efficiency by sex. Differential results in objective and subjective sleep measures are not uncommon among various populations, and sex differences in the two often arise. Sex differences in sleep quality have

been documented in other settings with a generalized finding that women report poorer subjective sleep while men have worse objective sleep (23,26). Our findings show that men had significantly worse objective measures (WASO, latency, and sleep efficiency) than women in the multivariate model. However, no differences in sex arose for the subjective sleep measures. Future research may address this sex difference and its relationship to discrimination.

Overall, our study confirmed the finding that both WASO and subjective sleep quality are significantly associated with discrimination. In addition, we found that sleep efficiency and SOL were associated with discrimination. This study may serve as a useful comparison to community samples of discrimination and sleep, as well as studies focusing on racial/ethnic health disparities.

Limitations

A limitation of the current study is that by design, only correlational conclusions can be drawn. Discrimination is a self-reported measure that is vulnerable to reporting error, although it has consistently shown associations with poor health outcomes across various study populations (1,4). In addition, the MIDUS study investigates midlife individuals and an oversampling of African Americans, which is not entirely representative of young, elderly, and other minority populations. However, the MIDUS study is a national, racially diverse sample with greater statistical power than smaller samples.

Future Directions

Determining whether discrimination affects sleep architecture is an important avenue for future research. Previous work suggests that increased discrimination is associated with increased time spent in lighter, stage 2 sleep, and decreased time in slow wave sleep and rapid eye movement sleep (11,15,18). Polysomnography was not a part of the MIDUS data collection, so we were unable to measure sleep architecture in relation to discrimination in the current study. The pathway linking discrimination to poor health is unclear; however, exploring impaired sleep as a mechanism may be promising as a causal model. The results of this study indicate that discrimination is an important factor associated with sleep measures in middle-aged adults. Discrimination in the MIDUS sample predicted slightly variable differences in individual sleep measures, and these findings add finer resolution to the understanding of the relationship between discrimination and sleep.

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REFERENCES

1. Cappuccio FP, D'Elia L, Strazzullo P, Miller MA. Sleep duration and all-cause mortality: a systematic review and meta-analysis of prospective studies. Sleep 2010;33:585–92.
2. Cappuccio FP, Cooper D, D'Elia L, Strazzullo P, Miller MA. Sleep duration predicts cardiovascular outcomes: a systematic review and meta-analysis of prospective studies. Eur Heart J 2011;32:1484–92.
3. Harrell JP, Hall S, Taliaferro J. Physiological responses to racism and discrimination: an assessment of the evidence. Am J Public Health 2003;93:243–8.
4. Ayas NT, White DP, Al-Delaimy WK, Manson JE, Stampfer MJ, Speizer FE, Patel S, Hu FB. A prospective study of self-reported sleep duration and incident diabetes in women. Diabetes Care 2003;26:380–4.
5. Gottlieb DJ, Redline S, Nieto FJ, Baldwin CM, Newman AB, Resnick HE, Punjabi NM. Association of usual sleep duration with hypertension: the sleep heart health study. Sleep 2006;29:1009–14.
6. Pigeon WR, Heffner K, Duberstein P, Fiscella K, Moynihan J, Chapman BP. Elevated sleep disturbance among blacks in an urban family medicine practice. J Am Board Fam Med 2011;24:161–8.
7. Mezick EJ, Matthews KA, Hall M, Strollo PJ Jr., Buysse DJ, Kamarck TW, Owens JF, Reis SE. Influence of race and socioeconomic status on sleep: Pittsburgh SleepSCORE project. Psychosom Med 2008;70:410–6.
8. Lauderdale DS, Knutson KL, Yan LL, Rathouz PJ, Hulley SB, Sidney S, Liu K. Objectively measured sleep characteristics among early-middle-aged adults: The CARDIA study. Am J Epidemiol 2006;164:5–16.
9. Slopen N, Lewis TT, Williams DR. Discrimination and sleep: a systematic review. Sleep Med 2015;18:88–95.
10. Hicken MT, Lee H, Ailshire J, Burgard SA, Williams DR. "Every shut eye, ain't sleep": the role of racism-related vigilance in racial/ethnic disparities in sleep difficulty. Race Soc Probl 2013;5:100–12.
11. Beatty DL, Hall MH, Kamarck TA, Buysse DJ, Owens JF, Reis SE, Mezick EJ, Strollo PJ, Matthews KA. Unfair treatment is associated with poor sleep in African American and Caucasian adults: Pittsburgh SleepSCORE project. Health Psychol 2011;30:351–9.
12. Centers for Disease Control and Prevention (CDC). Perceived insufficient rest or sleep among adults - United States, 2008. MMWR Morb Mortal Wkly Rep 2009;58:1175–9.
13. Chapman DP, Wheaton AG, Perry GS, Sturgis SL, Strine TW, Croft JB. Household demographics and perceived insufficient sleep among US adults. J Community Health 2012;37:344–9.
14. Lewis TT, Troxel WM, Kravitz HM, Bromberger JT, Matthews KA, Hall MH. Chronic exposure to everyday discrimination and sleep in a multiethnic sample of middle-aged women. Health Psychol 2013;32:810–9.

15. Tomfohr L, Pung MA, Edwards KM, Dimsdale JE. Racial differences in sleep architecture: the role of ethnic discrimination. Biol Psychol 2012;89:34–8.
16. Johnson DA, Lisabeth L, Lewis TT, Sims M, Hickson DA, Samdarshi T, Taylor H, Diez Roux AV. The contribution of psychosocial stressors to sleep among African Americans in the Jackson Heart Study. Sleep 2016;39:1411–9.
17. Steffen PR, Bowden M. Sleep disturbance mediates the relationship between perceived racism and depressive symptoms. Ethn Dis 2006;16:16–21.
18. Thomas KS, Bardwell WA, Ancoli-Israel S, Dimsdale JE. The toll of ethnic discrimination on sleep architecture and fatigue. Health Psychol 2006;25:635–42.
19. DeSantis AS, Adam EK, Hawkley LC, Kudielka BM, Cacioppo JT. Racial and ethnic differences in diurnal cortisol rhythms: are they consistent over time? Psychosom Med 2015;77:6–15.
20. Beatty DL, Matthews KA. Unfair treatment and trait anger in relation to nighttime ambulatory blood pressure in African American and white adolescents. Psychosom Med 2009;71: 813–20.
21. Krystal AD, Edinger JD. Measuring sleep quality. Sleep Med 2008;9(Suppl 1):S10–7.
22. Van Den Berg JF, Van Rooij FJ, Vos H, Tulen JH, Hofman A, Neven AK, Tiemeier H. Disagreement between subjective and actigraphic measures of sleep duration in a population-based study of elderly persons. J Sleep Res 2008;17: 295–302.
23. Vitiello MV, Larsen LH, Moe KE. Age-related sleep change: gender and estrogen effects on the subjective–objective sleep quality relationships of healthy, noncomplaining older men and women. J Psychosom Res 2004;56:503–10.
24. Jackowska M, Dockray S, Hendrickx H, Steptoe A. Psychosocial factors and sleep efficiency: discrepancies between subjective and objective evaluations of sleep. Psychosom Med 2011;73:810–6.
25. Armitage R, Trivedi M, Hoffmann R, Rush AJ. Relationship between objective and subjective sleep measures in depressed patients and healthy controls. Depress Anxiety 1997;5:97–102.
26. Bei B, Milgrom J, Ericksen J, Trinder J. Subjective perception of sleep, but not its objective quality, is associated with immediate postpartum mood disturbances in healthy women. Sleep 2010;33:531–8.
27. Enderlin CA, Coleman EA, Cole C, Richards KC, Kennedy RL, Goodwin JA, Hutchins LF, Mack K. Subjective sleep quality, objective sleep characteristics, insomnia symptom severity, and daytime sleepiness in women aged 50 and older with nonmetastatic breast cancer 2011;38:E314–E325.
28. Friedman EM, Love GD, Rosenkranz MA, Urry HL, Davidson RJ, Singer BH, Ryff CD. Socioeconomic status predicts objective and subjective sleep quality in aging women. Psychosom Med 2007;69:682–91.
29. Maglione JE, Ancoli-Israel S, Peters KW, Paudel ML, Yaffe K, Ensrud KE, Stone KL. Depressive symptoms and subjective and objective sleep in community-dwelling older women. J Am Geriatr Soc 2012;60:635–43.
30. Tworoger SS, Davis S, Vitiello MV, Lentz MJ, McTiernan A. Factors associated with objective (actigraphic) and subjective sleep quality in young adult women. J Psychosom Res 2005; 59:11–9.
31. Brim OG, Baltes PB, Bumpass LL, Cleary PD, Featherman DL, Hazzard WR, Kessler RC, Lachman ME, Markus HZ, Marmot MG, Rossi AS, Ryff CD, Shweder RA. National Survey of Midlife Development in the United States (MIDUS), 1995–1996 2011.
32. Ryff C, Lachman ME. Midlife Development in the United States (MIDUS II), 2004–2006 [computer file]. ICPSR04652-v1. Ann Arbor, MI: Inter-university Consortium for Political and Social Research [distributor] 2007:03–22.
33. Dienberg Love G, Seeman TE, Weinstein M, Ryff CD. Bioindicators in the MIDUS national study: protocol, measures, sample, and comparative context. J Aging Health 2010;22:1059–80.
34. Buysse DJ, Reynolds CF, Monk TH, Berman SR, Kupfer DJ. The Pittsburgh sleep quality index: a new instrument for psychiatric practice and research. Psychiatry Res 1989; 28:193–213.
35. Fung MM, Peters K, Ancoli-Israel S, Redline S, Stone KL, Barrett-Connor E. Total sleep time and other sleep characteristics measured by actigraphy do not predict incident hypertension in a cohort of community-dwelling older men. J Clin Sleep Med 2013;9:585.
36. Williams DR, Yan Y, Jackson JS, Anderson NB. Racial differences in physical and mental health: socio-economic status, stress and discrimination. J Health Psychol 1997;2: 335–51.
37. Prather AA, Bogdan R, Hariri AR. Impact of sleep quality on amygdala reactivity, negative affect, and perceived stress. Psychosom Med 2013;75:350–8.
38. Wang PS, Gilman SE, Guardino M, Jeanine CM, Morselli PL, Mickelson K, Kessler RC. Initiation of and adherence to treatment for mental disorders: examination of patient advocate group members in 11 countries. Med Care 2000; 38:926–36.
39. Dohrenwend BS. Events as stressors: a methodological inquiry. J Health Soc Behav 1973;14:167–175.
40. Buhi ER, Goodson P, Neilands TB. Out of sight, not out of mind: strategies for handling missing data. Am J Health Behav 2008;32:83–92.
41. StataCorp LP STATA: Multiple-Imputation Reference Manual: Release 13. College Station, TX: StataCorp, LP; 2013.
42. White IR, Royston P, Wood AM. Multiple imputation using chained equations: issues and guidance for practice. Stat Med 2011;30:377–99.
43. Rubin DB. Multiple Imputation for Nonresponse in Surveys, vol. Vol. 81. New York: John Wiley & Sons; 2004.
44. StatCorp LPSTATA Statistical Software: Release 13. College Station, TX: StataCorp, LP; 2013.
45. Slopen N, Lewis T, Williams D. Discrimination and sleep: a systematic review. Sleep Med 2015;18:89–95.
46. Petrov ME, Lichstein KL. Differences in sleep between black and white adults: an update and future directions. Sleep Med 2016;18:74–81.
47. Roenneberg T, Kuehnle T, Juda M, Kantermann T, Allebrandt K, Gordijn M, Merrow M. Epidemiology of the human circadian clock. Sleep Med Rev 2007;11:429–38.
48. Grandner MA, Hale L, Jackson N, Patel NP, Gooneratne NS, Troxel WM. Perceived racial discrimination as an independent predictor of sleep disturbance and daytime fatigue. Behav Sleep Med 2012;10:235–49.
49. Kessler RC, Mickelson KD, Williams DR. The prevalence, distribution, and mental health correlates of perceived discrimination in the United States. J Health Soc Behav 1999; 40:208–230.

50. Williams DR, Mohammed SA. Racism and health I: pathways and scientific evidence. Am Behav Sci 2013;57, 0002764213487340.
51. Paradies Y, Priest N, Ben J, Truong M, Gupta A, Pieterse A, Kelaher M, Gee G. Racism as a determinant of health: a protocol for conducting a systematic review and meta-analysis. Syst Rev 2013;2:85.
52. Whinnery J, Jackson N, Rattanaumpawan P, Grandner MA. Short and long sleep duration associated with race/ethnicity, sociodemographics, and socioeconomic position. Sleep 2014;37:601–11.
53. Grandner MA, Petrov ME, Rattanaumpawan P, Jackson N, Platt A, Patel NP. Sleep symptoms, race/ethnicity, and socioeconomic position. J Clin Sleep Med 2013;9:897–905. 905A–905D.
54. Song Y, Ancoli-Israel S, Lewis CE, Redline S, Harrison S, Stone KL. The association of race/ethnicity with objectively measured sleep characteristics in older men. Behav Sleep Med 2011;10:54–69.
55. Pascoe EA, Smart Richman L. Perceived discrimination and health: a meta-analytic review. Psychol Bull 2009; 135:531.