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Original Article

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Associations between everyday discrimination and sleep quality and duration among African-Americans over time in the Jackson Heart Study

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Abstract

Study Objectives: African-Americans have a high burden of poor sleep, yet, psychosocial determinants (e.g. discrimination) are understudied. We investigated longitudinal associations between everyday discrimination and sleep quality and duration among African-Americans (N = 3404) in the Jackson Heart Study.

Methods: At Exam 1 (2000–2004) and Exam 3 (2008–2013), participants completed the Everyday Discrimination Scale, rated their sleep quality (1 = poor to 5 = excellent), and self-reported hours of sleep. A subset of participants (N = 762) underwent 7-day actigraphy to objectively measure sleep duration and sleep quality (Sleep Exam 2012–2016). Changes in discrimination were defined as low stable (reference), increasing, decreasing, and high stable. Within-person changes in sleep from Exam 1 to Exam 3 were regressed on change in discrimination from Exam 1 to Exam 3 while adjusting for age, sex, education, income, employment, physical activity, smoking, body mass index, social support, and stress.

Results: At Exam 1, the mean age was 54.1 (12.0) years; 64% were female, mean sleep quality was 3.0 (1.1) and 54% were short sleepers. The distribution of the discrimination change trajectories were 54.1% low stable, 13.5% increasing, 14.6% decreasing, and 17.7% were high stable. Participants who were in the increasing (vs. low stable) discrimination group had greater decrease in sleep quality. There was no association between change in discrimination and change in sleep duration. Among Sleep Exam participants, higher discrimination was cross-sectionally associated with shorter self-reported sleep duration, independent of stress.

Conclusion: Discrimination is a unique stressor for African-Americans; thus, future research should identify interventions to reduce the burden of discrimination on sleep quality.

Statement of Significance

African-Americans are disproportionately affected by poor sleep quality and short sleep duration; however, the determinants are unclear. Although a small literature has shown perceived discrimination is associated with poor sleep, few studies have investigated the effect of change in discrimination on sleep. This study examined the effect of the 8-year change in discrimination on sleep quality and duration, and included subjective and objective measures of sleep. Perceived discrimination was associated with poor sleep quality over time and cross-sectionally associated with sleep duration among older adults. Increasing experiences of discrimination were associated with worse sleep quality independent of stress. The results suggest that experiences of discrimination change over time and is a unique stressor and barrier to healthy sleep among African-Americans. Targeting these factors (e.g. psychosocial) may help to improve the burden of poor sleep among African-Americans.

Key words: discrimination; stress; sleep duration; sleep quality; longitudinal; Jackson Heart Study

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Introduction

Sleep disturbances and short sleep duration are highly prevalent in the United States.[1] Twenty-five percent of American adults report insufficient sleep or rest at least 15 out of every 30 days; and 29% report sleeping < 7 hours per night.[2] Insufficient sleep (e.g. short sleep duration or poor sleep quality) is associated with loss of work-related productivity and injuries, motor vehicle accidents, as well as adverse health outcomes including obesity, hypertension, diabetes, stroke, heart disease, and all-cause mortality.[3–8] These adverse health conditions are known to disproportionately affect minority populations, especially African-Americans.[9–11] Also, African-Americans are more likely to experience shorter sleep duration, poorer sleep quality, and more sleepiness than non-Hispanic whites.[10–13] In order to address health disparities caused by sleep, it is important to identify modifiable factors related to poor sleep in African-Americans.

Discrimination (or unfair treatment based on race/ethnicity, sex/gender, socioeconomic status, or sexual orientation) is associated with adverse physical and mental health outcomes.[14, 15] There are several potential mechanisms linking discrimination to poor health.[16] Insufficient sleep may be part of the pathway linking discrimination to poor health outcomes. Although limited, it is hypothesized that discrimination may affect sleep through several pathways including mood (depression, anxiety, worry, rumination) or negative emotional states that can lead to biological dysregulation, which affects sleep and/or it can increase risky health behaviors including declines in healthcare utilization and engagement [14] that may prevent treatment of a sleep disorder. It is also plausible that discrimination, a psychosocial stressor, affects sleep through autonomic arousal (heart rate variability), [16] which is associated with adverse sleep outcomes. Growing research suggests that poor sleep is associated with psychosocial stressors including discrimination.[16–30] In a 2019 review, Lewis and McKinnon identified 39 studies that investigated the association between discrimination and sleep, and found that higher discrimination was associated with poor sleep.[16] The vast majority of these studies were cross-sectional,[16, 31] and the observational prospective studies were limited to non-US samples [25, 32–34], which limits our understanding of discrimination over time among African-Americans. Investigating changes in discrimination over time is particularly important for understanding how changes in the pattern of discrimination can affect health, including the impact on sleep over the lifecourse.[35] Also, exploring longitudinal associations provides insight on the temporal association between discrimination and sleep. Thus, there is a critical need to evaluate longitudinal associations between discrimination and sleep, particularly in large cohorts of African-American men and women.

Evidence indicates that African-Americans report higher levels of discrimination than non-Hispanic whites,[36, 37] and may be more vulnerable to the effects of discrimination.[38] However, discrimination typically occurs in the context of other psychosocial stressors, particularly for African-Americans.[39] Therefore, studies are needed to understand the independent association of discrimination and stress on sleep in this population. But few studies have simultaneously examined stress and discrimination, including interactive effects in relation to sleep among African-Americans, which may provide insight regarding the accumulation of multiple stressors and poor sleep. The association between discrimination and sleep may be different based on stress level. There is substantial evidence that supports that high stress is associated with poor sleep.[21, 23, 40] Perceived discrimination is associated with higher stress, thus associations of discrimination on sleep may be masked in the presence of high stress.

Using data from the Jackson Heart Study (JHS), we investigated the longitudinal associations between everyday discrimination and self-reported sleep quality and duration. We hypothesized that categories of change in discrimination would be associated with differences in changes in sleep. There is limited data suggesting that discrimination may have a stronger impact on health for women compared to men, which may operate through an overall vulnerability to stress. Similar data with sleep as an outcome is lacking. Because African-American women and men generally appear to cope with discrimination differently; [41, 42] the influence of discrimination on sleep may vary by gender. However, this is underexplored. Thus, we explored whether the discrimination-sleep associations varied by gender. We also tested the hypothesis that the association between discrimination and objectively measured sleep duration is independent of psychological stress, and the association between discrimination and sleep may be more pronounced among those reporting less stress.

Methods

The JHS, a large longitudinal study of African-Americans in Jackson Mississippi, is designed to study cardiovascular disease risk factors over time. At baseline (Exam 1), 5,306 adults between 21 and 94 years of age were recruited from three counties in Jackson, Hinds, Madison, and Rankin between September 2000 and March 2004. Details of JHS recruitment were previously published.[43] There were two follow-up studies, Exam 2 (2005–2008) and Exam 3 (2008–2013). The current analysis uses data from Exam 1, Exam 3, and the Sleep Exam (2012–2016). Study procedures were approved by institutional review boards and informed consent was obtained from all participants.

Perceived everyday discrimination

Trained African-American interviewers administered the JHS discrimination instrument (JHSDIS) during Exams 1 and 3.[41] The JHSDIS included questions targeted at identifying experiences with and reactions to perceived everyday discrimination, assessed by a modified version of a scale developed by Williams and colleagues.[44] This scale measured perceptions of discrimination without attribution to the source (e.g. race, gender, socioeconomic status, sexual orientation). During both Exams, participants were asked questions such as, "How often on a day-to-day basis do you have the following experiences? You are treated with less courtesy. You are treated with less respect. You receive poorer service than others at restaurants." A total of nine items were asked, and responses ranged from 1 ("never") to 7 ("several times a day"). The mean of the nine responses were used as the score for the frequency of perceived everyday discrimination. The scale had good internal consistency ($\alpha = 0.88$).[45] The 9-item scale for each Exam was first divided into tertiles: high exposure of perceived discrimination for the upper tertile and low exposure corresponded to the lower and middle tertile (separate tertiles for each exam). Then we assessed the

relationships between tertile ranking across examinations to assess change in perceived discrimination over the 8-year period as follows: low stable exposure at both Exams, increasing from Exam 1 to Exam 3, decreasing from Exam 1 to Exam 3, and high stable. We created categories of discrimination to allow us to model within subject changes in relative discrimination at each time point, thus allowing us to characterize trajectories of low stable, increasing (low to high), decreasing (high to low) and high stable. The low stable group is the referent and comprises participants who reported fewer experiences of discrimination at both exams. The high stable group includes the participants who experienced a persistently high level of discrimination. The increasing and decreasing groups reflect the change (low to high and high to low, respectively) in discrimination over the 8-year period. This scheme was based on previously observed patterns of reports of discrimination across time, which suggests that perceived discrimination is not static, and exploring change categories/trajectories enhances the ability to characterize associations of perceived discrimination over time as it changes.[46] We also analyzed perceived everyday discrimination as the change in continuous scores (standardized to the full distribution per visit) between Exam 1 and Exam 3.

Sleep quality and duration

Self-reported sleep quality and duration were collected at Exam 1 and Exam 3. Participants indicated their level of sleep quality by responding to the following question, "During the past month, how would you rate your sleep quality overall?" Responses were reported on a Likert scale (1 = poor, 2 = fair, 3 = good, 4 = very good, and 5 = excellent) and analyzed as a continuous variable with higher scores indicating better sleep quality. At Exam 1 sleep duration was reported by the participants from following question: "During the past month, excluding naps, how many hours of actual sleep did you get at night (or day, if you work at night) on average?" At Exam 3, participants responded to the following question: "How much sleep do you usually get a night (or main sleep period) on weekdays or workdays?" Responses were given in hours and transformed into minutes for analysis. Sleep duration was analyzed continuously and categorically as short sleep (<7 hours) compared to recommended (≥7 hours).[47] Long sleep (> 9 hours) was not analyzed as a separate category due to the small sample size (Exam 1: 4.7% and Exam 3: 4.1%). Given the lack of u-shape pattern, long sleepers were included in the recommended sleep.

While the aforementioned measures are self-reported, objective measures of sleep duration and sleep quality were collected at the Sleep Exam following Exam 3 between 2012 and 2016, [48] and were included in a secondary analysis. Participants (N = 840) wore GT3X® + Activity Monitor on the non-dominant wrist for 7 consecutive days and simultaneously completed a sleep diary.[49] Actigraphic data during 60-s epochs were scored as sleep or wake by ActiLife version 6.13 analysis software (ActiGraph Corp Pensicola, FL) using the validated algorithm (Cole-Kripke).[50] Activity counts recorded during the measured epoch were modified by the level of activity in the surrounding time period (4 min before and 2 min after) to yield the final activity count for each epoch. Actigraphic studies were manually edited using the sleep diary and activity counts. Similar to self-reported sleep duration, short sleep was defined as sleep duration <7 hours and was compared to recommended sleep duration of ≥7 hours. In addition to actigraphy-measured sleep duration, a single item self-reported sleep duration was collected at the Sleep Exam and was included in the analyses. We also included two measures that provide information about sleep continuity (which tracks well with sleep depth): sleep efficiency and wakefulness after sleep onset (WASO). Sleep efficiency is the percent time in bed spent asleep during the sleep period, and <85% is considered low sleep efficiency. WASO is the total minutes spent awake during the sleep period.

Covariates

Age, gender, educational attainment, family household income, physical activity, [51] alcohol drinking, smoking status, and social support were collected at Exam 1 only, all other questionnaire-based data were collected at both visits. Body Mass Index (BMI) was calculated in kg/m^2 using measured weight and height. At Exam 1, perceived stress was measured using the Global Perceived Stress Scale, an 8-item questionnaire that measures the perception of the severity of chronic stress experienced over a prior period of 12 months.[52] At the Sleep Exam, perceived stress was measured by the 10-item Perceived Stress Scale (PSS-10).[53] Low stress was defined as a total score of PSS-10<14, and high stress was defined as a total score>14. The Cronbach alpha for the PSS-10 was 0.86. Depressive symptoms were collected using the Center for Epidemiological Studies Depression scale, [54] among a subset of Exam 1 participants and all Sleep Exam participants. The Cronbach alpha for the CES-D was 0.87 (Exam 1) and 0.87 (Sleep Exam).

Statistical analysis

Participants with complete data on perceived everyday discrimination, sleep quality and duration as well as the covariates (except income) at Exam 1 and 3 were included in the main analytic dataset, N = 3404. Participants with missing data for perceived everyday discrimination (1.8% Exam 1, 6.3% Exam 3), sleep quality (0.9% Exam 1, 1.2% Exam 3), sleep duration (0.9% Exam 1, 1.1% Exam 3), and covariates (age 0.1%, gender 0%, education 0.3%, body mass index 0.2%, smoking 0.2%, alcohol 0.4%, physical activity 0.2%, social support 0.2%, and stress 0.6%) were excluded (n = 354). An additional 40 participants were excluded due to possible implausible self-reported sleep duration values of <3 hours. To address the missingness for income in the dataset, we imputed 10 complete datasets using the imputation procedures in SAS. Multiple imputation was conducted based on 10 imputations for income missing values (508 were missing income). The variables included in the imputation model for income were: age, gender, education, employment, physical activity, alcohol, smoking, BMI, social support, and stress.

Secondary analyses were conducted among participants (N = 755) of the Sleep Exam with objective sleep data measured by actigraphy. Selected sociodemographic characteristics are shown by discrimination groups using chi-square and t-tests in Table 1.

To assess the longitudinal associations between perceived everyday discrimination and sleep measures, we regressed the within-person change of self-reported sleep quality and duration from Exam 1 to Exam 3 on change in perceived everyday

discrimination from Exam 1 to Exam 3 while adjusting for baseline covariates. We analyzed changes in perceived everyday discrimination both categorically and continuously in separate models. Categories of change in perceived discrimination included: low stable (referent), increasing, decreasing, and high stable. Continuous change was the standardized differences of the residualized change in perceived everyday discrimination between Exam 3 and 1. To examine how baseline level of perceived discrimination was associated with change in sleep, we regressed change in sleep between Exam 3 and 1 on Exam 1 standardized perceived discrimination while adjusting for covariates. Some of the selected covariates such as the health behaviors may be possible mediators, which may be a response to discrimination, or actual confounders thus we utilized a sequential modeling approach to assess the associations in the presence and absence of these variables.

Additionally, we fit log-binomial models with robust variance to estimate the risk ratio of incident short sleep at Exam 3 associated with change in perceived discrimination between Exams 3 and 1 after excluding participants with short sleep at Exam 1 (N = 1891) while adjusting for baseline covariates. Follow-up years, age, and gender were adjusted for in Model 1. In Model 2, we further adjusted for baseline educational attainment, income, employment status, physical activity, alcohol drinking, smoking status, BMI, and social support. Lastly, we adjusted perceived stress at Exam 1 (Model 3). Depression is likely a confounder of the association between discrimination and sleep, however, depressive symptoms were collected only among a subset of participants in Exam 1. In sensitivity analyses, we restricted the dataset to participants with data on depressive symptoms (n = 805), and further adjusted for depressive symptoms.

In secondary analyses, we conducted cross-sectional analyses to examine how self-reported and objectively measured sleep duration, odds of short sleep (<7 hours), and sleep continuity were associated with stress and perceived discrimination independently and tested the interaction between stress and perceived discrimination while adjusting for covariates among the Sleep Exam participants. Continuous PSS-10 total score collected at the Sleep Exam and standardized perceived everyday discrimination collected in Exam 3 was regressed on continuous sleep duration, sleep continuity, or odds of short sleep. Age and sex were adjusted for in Model 1, and we added education, income, employment status, physical activity level, alcohol drinking, smoking, BMI, and social support in Model 2. We further adjusted for the PSS-10 in Model 3. All the covariates that were adjusted for were collected from Exam 1 except for BMI which was from Exam 3.

In all sets of analyses interaction was tested between exposure groups (i.e. change in perceived discrimination or discrimination levels) and gender without covariate adjustment. SAS 9.4 (SAS Institute, Cary, NC) was used to perform the above analyses.

Results

At Exam 1, the mean age of participants was 54.1(standard deviation: 12) years (Table 1). Forty-four percent of the sample had a college degree. The prevalence of obesity was 53.9%. The mean sleep quality score and sleep duration was 3.0(1.1) and 6.4(1.4), respectively and prevalence of self-reported short sleep duration was 54.5%. Sample characteristics differed by discrimination groups. The distribution of the discrimination change trajectories, were 54.1% low stable, 13.5% increasing, 14.6% decreasing, and 17.7% were high stable. Participants in the high stable were more likely to be younger, male, college educated, employed, obese, report more stress, depressive symptoms, and have short sleep duration.

The average perceived everyday discrimination score was 2.1(1.0) at baseline. Perceived discrimination scores were slightly lower at Exam 3 (Table 1). The average self-reported sleep duration was 6.4 hours (1.4) at Exam 1; and remained consistent at Exam 3 and in the Sleep Exam. Baseline discrimination and stress were moderately correlated, r = 0.35. Baseline sleep quality and sleep duration were negatively and weakly correlated with stress r = −0.24 and r = −0.10, respectively. These correlations were similar at the Sleep Exam. Overall, discrimination scores and average sleep duration decreased over the 8 years, consistent with an aging effect, as noted in other cohorts [55]. Whereas, sleep quality increased. Of note, those who experience an increase in everyday discrimination had shorter sleep duration and worse sleep quality over time.

There were gender differences in the sample. The average perceived everyday discrimination score was 2.0(1.0) and 2.2(1.1) for women and men, respectively at baseline. Perceived discrimination scores were slightly lower at Exam 3 (Table 1). In general, the proportion of men and women in the change in perceived discrimination groups were similar, except for the consistently high group, which was more common for men than women (20.6% vs. 16.1%) (Table 1). The average self-reported sleep duration was 6.5(1.5) and 6.3(1.5) hours for women and men at Exam 1; and remained consistent at Exam 3 and in the Sleep Exam. For women and men, actigraphy-based sleep duration was 6.7(1.1) and 6.5(1.2) hours, respectively. There was no difference in sleep quality between men and women. Data not shown.

In fully adjusted models, participants in the increasing group had worse self-reported sleep quality compared to those in the low stable (Table 2). There were no observed associations between change in perceived everyday discrimination and change in self-reported sleep duration.

Among participants who did not have short sleep duration at Exam 1, change in perceived discrimination categories was not associated with odds of incident short sleep duration at Exam 3 in the overall sample. Perceived everyday discrimination (continuous) at baseline was associated with higher risk of short sleep, but this association was attenuated after adjusting for stress (Table 3).

In secondary analyses, we investigated the independent associations of perceived stress and perceived discrimination (continuous) with self-reported and actigraphy-measured sleep (Table 4). Higher levels of perceived discrimination and stress were independently associated with shorter self-reported sleep duration. Neither stress nor perceived discrimination was associated with actigraphy-measured sleep duration. There was no evidence of interaction between stress and perceived discrimination in predicting self-reported sleep duration. However, there was an interaction between stress and perceived discrimination in predicting odds of actigraphy-measured short sleep ($P_{interaction}$ = 0.02). Among participants reporting low stress, a SD increase in perceived discrimination was associated with 40% higher odds of short sleep duration (95% CI: 1.09, 1.80) (data not shown). There was no association between perceived discrimination and odds of short actigraphy-measured sleep among those reporting high stress. Also, there were no observed associations

Table 1. Participant characteristics in the main analytic sample, total, and by discrimination change categories (*N* = 3404), the Jackson Heart Study

	Total (*N* = 3404, 100%)	Low stable (*N* = 1843, 54.1%)	Increasing (*N* = 464, 13.6 %)	Decreasing (*N* = 496, 14.6%)	High stable (*N* = 601, 17.7%)
Exam 1					
Age (years), mean (*SD*)	54.1 (12.0)	56.6 (11.9)	51.6 (12.3)	52.9 (11.4)	49.1 (10.4)
Age > 50 years, *N* (%)	2117 (62.2%)	1283 (69.6%)	248 (53.4%)	308 (62.1%)	280 (46.6%)
Male, *N* (%)	1230 (36.1%)	613 (33.3%)	161 (34.7%)	202 (40.7%)	254 (42.3%)
Family income ($10,000), median (IQR)	4.25 (4.0)	4.25 (4.0)	4.25 (4.0)	4.25 (4.5)	4.25 (4)
Education, *N* (%)					
< High school	542 (15.9%)	354 (19.2%)	61 (13.1%)	71 (14.3%)	56 (9.3%)
High school or GED	599 (17.6%)	334 (18.1%)	84 (18.1%)	99 (20.0%)	82 (13.6%)
Some college/training	755 (22.2%)	352 (19.1%)	108 (23.3%)	115 (23.2%)	180 (30.0%)
College degree	1508 (44.3%)	803 (43.6%)	211 (45.5%)	211 (42.5%)	283 (47.1%)
Currently employed, *N* (%)	1895 (55.7%)	904 (49.1%)	288 (62.1%)	273 (55.0%)	430 (71.5%)
BMI (kg/m^2), mean (*SD*)	31.7 (7.0)	31.6 (6.7)	31.8 (7.1)	31.7 (7.1)	32.2 (7.6)
Physical activity, *N* (%)					
Poor health	1588 (46.7%)	905 (49.1%)	183 (39.4%)	239 (48.2%)	261 (43.4%)
Intermediate health	1124 (33.0%)	580 (31.5%)	172 (37.1%)	160 (32.3%)	212 (35.3%)
Ideal health	692 (20.3%)	358 (19.4%)	109 (23.5%)	97 (19.5%)	128 (21.3%)
Ever smoked cigarettes, *N* (%)	1001 (29.4%)	507 (27.5%)	131 (28.2%)	162 (32.7%)	201 (33.4%)
Current alcohol yes, *N* (%)	1615 (47.4%)	817 (44.3%)	222 (47.8%)	249 (50.2%)	327 (54.4%)
Hypertension, *N* (%)	1805 (53.0%)	1040 (56.4%)	244 (52.6%)	253 (51.0%)	268 (44.6%)
Diabetes, *N* (%)	644 (19.1%)	380 (20.6%)	75 (16.2%)	83 (16.7%)	106 (17.6%)
Perceived stress, mean (*SD*)	0.7 (0.5)	0.5 (0.5)	0.7 (0.5)	0.8 (0.6)	1 (0.6)
Social support score, mean (*SD*)	4.3 (0.8)	4.3 (0.7)	4.3 (0.8)	4.2 (0.9)	4.2 (0.9)
Depression, CESD score, mean (*SD*)*	8.6 (7.8)	8.0 (7.3)	8.5 (7.7)	8.3 (7.6)	10.3 (8.8)
Everyday discrimination, mean (*SD*)	2.1 (1.0)	1.5 (0.4)	1.7 (0.4)	3.1 (0.7)	3.5 (0.9)
Self-reported sleep quality, mean (*SD*)	3 (1.1)	3.1 (1.1)	3 (1.1)	2.9 (1.1)	2.8 (1.1)
Self-reported sleep duration (mins), mean (*SD*)	385.7 (84.7)	389.0 (84.9)	388.1 (81.2)	384.2 (93.3)	370.4 (85)
Short sleep (< 7 hours), *N* (%)	1869 (54.4%)	962 (52.2%)	251 (54.1%)	285 (57.5%)	371 (61.7%)
Exam 3					
Everyday discrimination, mean (*SD*)	1.8 (0.9)	1.3 (0.3)	2.7 (1.0)	1.4 (0.3)	2.9 (0.9)
Self-reported sleep quality, mean (*SD*)	3 (1.0)	3.2 (1.0)	2.9 (1.0)	3 (1.0)	2.8 (1.1)
Self-reported sleep duration (mins), mean (*SD*)	383.4 (86.5)	389.5 (84.4)	388.4 (81.3)	386.7 (89.5)	371.2 (83.0)
Short sleep (< 7 hours), *N* (%)	1847 (54.3%)	953 (51.7%)	248 (53.4%)	278 (56.0%)	368 (61.2%)
Change from Exam 1 to Exam 3					
Follow-up years, mean (*SD*)	8.0 (0.9)	8.0 (0.9)	8.0 (0.9)	8.1 (0.9)	8.1 (0.8)
Everyday discrimination, mean (*SD*)	−0.3 (1.0)	−0.2 (0.5)	1 (1.1)	−1.7 (0.8)	−0.6 (1.0)
Self-reported sleep quality, mean (*SD*)	0.05 (1.1)	0.07 (1.1)	−0.04 (1.1)	0.06 (1.2)	0.06 (1.1)
Self-reported sleep duration (min), mean (*SD*)	−0.04 (91.7)	1.2 (92.4)	−5.6 (87.8)	−1.7 (97.4)	1.7 (87.4)

*Sample size = 805.

between discrimination and sleep efficiency or WASO (Tables 5 and 6).

There were no observed gender differences in the associations between perceived discrimination or stress with sleep duration or quality.

The sensitivity analyses among participants with depressive symptoms data yielded different results than the main analyses (Supplementary Tables S1–S2). Change in discrimination was not associated with sleep quality. In fully adjusted models, participants in the decreasing perceived discrimination category slept 41 min longer on average and had 61% lower risk of short sleep duration (0.17, 0.89) compared to those who were in the stable low category.

Discussion

In our study of African-Americans, we found that (1) the change in perceived everyday discrimination scores from low (2000–2004) to high (2008–2013) was associated with greater decrease in self-reported sleep quality over the study period; (2) Perceived everyday discrimination at Exam 1 was associated with a higher odds of self-reported short sleep at Exam 3, but the association was attenuated after adjustment for stress; (3) Among the subsample of Sleep Exam participants with objective measurements of sleep, higher perceived stress and perceived discrimination were independently associated with lower average self-reported sleep duration but not objectively measured sleep over a one week period. Among participants with low stress, higher perceived discrimination was associated with shorter sleep; no association was observed among those with high levels of stress. These findings highlight the importance of both stress and perceived discrimination on sleep.

Consistent with prior studies among African-Americans, [13] we found a high prevalence of short sleep duration; i.e. 54.5% slept <7 hours (subjective) and 61.5% slept <7 hours (objective). The proportion of shorter sleepers in JHS is higher than among adults in the US.[56] Prior studies have identified psychosocial factors such

as perceived stress and perceived discrimination as determinants of insufficient sleep among African-Americans.[13, 16] However, few have investigated longitudinal associations linking perceived discrimination with sleep. Given the high prevalence of poor sleep among African-Americans and this group's exposure to perceived discrimination, it is important to assess change in reports of perceived discrimination and its association with sleep.

In the current study, increasing perceived discrimination from low-to-high over time was associated with developing poorer sleep quality compared to those in the low stable group. Changes in experiences with discrimination may be the result of work-related changes such as retirement. For example, individuals that are retired may have less encounters with discrimination due to being home more often. Also, research demonstrates that reports of discrimination are lower among older people, due to "socioemotional selectivity," where older adults choose their social circles carefully, and in the case of African-American older adults, may avoid settings and occasions where they will face discrimination. Over half our sample was employed, and may have encountered different experiences of discrimination over time, such as discrimination due to age. We did not find that the continuous change in perceived discrimination was associated with sleep quality nor duration. It may be that the average difference does not identify individuals with sufficient change in perceived discrimination. Higher baseline perceived discrimination was associated with lower odds of short sleep at Exam 3, but this association was attenuated and no longer significant with adjustment for stress. However, in sensitivity analyses among a sub-set of participants, we found that individuals in the decreasing discrimination group from Exam 1 to Exam 3 slept longer on average. We also tested a possible alternative hypothesis that changes in sleep may lead to discrimination. Baseline nor the change in sleep quality or duration were associated with changes in discrimination, thus ruling out the alternative. Results from prior longitudinal studies of perceived discrimination and sleep are inconsistent, with some suggesting an association [24–26, 32, 33], while others found no association [57]. In a sample of college students, perceived discrimination accounted for racial differences in self-reported sleep problems over time.[24] Based on the prior study, and consistent with the current study, perceived discrimination is particularly relevant for the sleep of African-Americans.

In general, our finding of a cross-sectional association of higher perceived discrimination and shorter sleep duration was consistent with prior studies.[16, 17, 20, 58–60] Lewis et al. found that experiences of chronic perceived everyday discrimination were associated with subjective and objective measures of poor sleep among a sample of African-American, White and Chinese women (n = 368).[18] The prior study was conducted among women only; thus, we were able to expand the literature on perceived discrimination and objective sleep with the inclusion of men. In comparing our results to Lewis et al., [18] our null finding of perceived discrimination with sleep duration over time may be due to the high proportion of sleep apnea in our sample, [48] perhaps influencing objective measures of sleep. Contrary to the findings of Lewis et al., we found an association with subjective sleep quality but not objectively measured sleep continuity, which suggests sleep quality—which is best conceptualize as a participant-reported outcome—as more associated with discrimination than are actigraphy-based measures of sleep continuity. We also found that the association between perceived discrimination and sleep was independent of stress, which is consistent with the findings of Slopen and colleagues.[17] However, we found that adjustment for stress attenuated some of the associations. It is important to note that the measure of stress in the current paper was a global measure, whereas Slopen and colleagues used specific indicators of acute and chronic stress. The rationale for the findings regarding discrimination and sleep among those with low stress is unclear. However, high stress is a strong predictor of poor sleep and the presence of high stress may mask the effects of discrimination. Future studies should work to understand the physiologic response of discrimination on sleep across stress levels.

We observed no gender differences in the association between perceived discrimination and sleep. The measure of perceived everyday discrimination included in the current study, may not capture some of the aspects of perceived discrimination that are most pertinent to men such as experiences involving criminal profiling.[61] Future studies should measure and investigate other forms of perceived discrimination (e.g. major, vicarious) to determine associations with sleep as well as understand potential gender differences.

There are a number of plausible mechanisms that may link perceived discrimination to sleep duration and quality. Perceived discrimination attributed to race can evoke psychosocial distress which can result in changes in physiological arousals/dysregulation that can impair sleep,[44, 62] thus affecting the initiation and maintenance of sleep.[63] African-Americans may also engage in unhealthy coping mechanisms to manage the stress from perceived discrimination such as sedentary lifestyles and unhealthy eating, [41] which are associated with poor sleep.[64] This stress pathway could also involve consuming a high caloric diet or alcohol use as a coping mechanism, which can result in obesity, a correlate of short sleep and poor sleep quality.[65] BMI was a covariate in the study, and associations persisted with adjustment for BMI. Psychosocial factors such as anxiety and worry may also be on the pathway between perceived discrimination and sleep outcomes, by causing rumination (e.g. recurrent negative thoughts), which impacts sleep.[66] While we adjusted for stress in our statistical models, because of the close inter-relationships between stress and perceived discrimination, those models may have been over-adjusted. For example, our cross-sectional analyses showed that the strongest association between short sleep and perceived discrimination was among those with lowest stress levels, possibly reflecting that the shared variance between these exposures obscured the independent contribution of perceived discrimination in individuals with high stress levels.

Overall, we found stronger associations between perceived discrimination and self-reported sleep than objectively measured sleep. Subjective measures reflect perceptions, therefore perceived discrimination and stress may map more closely with self-reported sleep as opposed to actual sleep. Sleep quality is inherently measuring a value a person ascribes to their sleep, which is not well captured by objective assessments of movement indices during the night.[67] Actigraphy only provided 7 days of data; it is possible that questionnaire-based sleep assessments provide a more representative measure of sleep than measured over one discrete time period. Nonetheless, there are measurement biases in using either questionnaires or actigraphy, [68, 69] and the extent to which neurophysiological measures of sleep vary with stress and discrimination requires further study.

There are several noteworthy strengths of our study. This study utilized both subjective and objective measures of sleep,

Table 2. Mean differences in changes in self-reported sleep quality and duration associated with changes in reported everyday discrimination between Exams 1 and 3 (*N* = 3,404), the Jackson Heart Study

	Model 1		Model 2		Model 3	
	Coefficient	*SE*	Coefficient	*SE*	Coefficient	*SE*
Change in self-reported sleep quality score						
Categories of change in everyday discrimination from Exam 1 to Exam 3						
Low stable (ref)						
Increasing	−0.12**	0.06	−0.12**	0.06	−0.13***	0.06
Decreasing	−0.01	0.06	−0.02	0.06	−0.04	0.06
High stable	−0.02	0.06	−0.02	0.06	−0.06	0.06
Exam 1 stress					0.09***	0.04
Everyday discrimination at Exam 1 (per *SD*)	−0.01	0.02	-0.01	0.02	−0.02	0.02
Exam 1 stress					0.09***	0.04
Residualized change in everyday discrimination from Exam 1 to Exam 3 (per *SD*)	−0.02	0.02	−0.02	0.02	0.02	0.02
Exam 1 stress					0.08***	0.04
Change in self-reported sleep duration (in min)						
Categories of change in everyday discrimination from Exam 1 to Exam 3						
Low stable (ref)						
Increasing	−4.81	4.81	−4.50	4.81	−4.89	4.83
Decreasing	−1.22	4.67	−0.89	4.67	−1.53	4.72
High stable	3.85	4.43	3.87	4.45	2.71	4.61
Exam 1 stress					3.12	3.25
Everyday discrimination at Exam 1 (per *SD*)	0.63	1.62	0.61	1.63	0.07	1.71
Exam 1 stress					3.44	3.28
Residualized change in everyday discrimination from Exam 1 to Exam 3 (per *SD*)	0.26	1.57	−0.02	0.02	0.27	1.58
Exam 1 stress					3.44	3.14

Model 1: adjusted for follow-up years, age, gender; Model 2: Model 1 + education, income, employment, physical activity, alcohol, smoking, BMI, social support; Model 3: Model 2 + Exam 1 stress.
Categories of change in everyday discrimination from Exam 1 to Exam 3, everyday discrimination at Exam 1 and change in everyday discrimination from Exam 1 to Exam 3 (per *SD*) were modeled separately.
Models are fit using FIML estimation method.
**$P < 0.10$; ***$P < 0.05$.

Table 3. Risk ratios of self-reported short sleep (< 7 hours) at Exam 3 associated with changes in everyday discrimination between Exams 1 and 3 (*N* = 1,557), the Jackson Heart Study

	Model 1		Model 2		Model 3	
	RR	95% CI	RR	95% CI	RR	95% CI
Categories of change in everyday discrimination						
Low stable (ref)						
Increasing	1.06	0.88–1.29	1.04	0.84–1.28	1.01	0.82–1.24
Decreasing	1.08	0.89–1.31	0.96	0.78–1.19	0.92	0.74–1.15
High stable	1.13	0.95–1.35	1.11	0.92–1.35	1.02	0.82–1.24
Exam 1 stress					1.23**	1.07–1.42
Everyday discrimination at Exam 1 (per *SD*)	1.10**	1.03–1.17	1.07***	1.00–1.15	1.04	0.96–1.39
Exam 1 stress					1.20**	1.04–1.39
Residualized change in everyday discrimination (per *SD*)	0.97	0.91–1.04	0.97	0.91–1.04	0.96	0.90–1.03
Exam 1 stress					1.24**	1.09–1.41

Model 1: adjusted for age, gender; Model 2: Model 1 + education, income, employment, physical activity, alcohol, smoking, BMI, social support; Model 3: Model 2 + stress.
**$P < 0.05$; ***$P < 0.10$.

which provided a comprehensive assessment of sleep in a large African-American sample. The longitudinal nature of our data, allowed us to examine changes over time between perceived discrimination and sleep, which is understudied, particularly among African-Americans who are most vulnerable to discrimination. There are also limitations. The JHS was restricted to a single geographical site, which limits generalizability to other populations in the US. Perceived everyday discrimination does not capture all dimensions of discriminatory experiences as well as other types of discrimination such as institutional and vicarious. The longitudinal analyses included only self-reported sleep, which tends to be an overestimate of actual sleep duration.[12, 69] Therefore, self-reported sleep duration may misclassify actigraphy-based estimation of sleep duration. In the JHS sample, we previously found that self-reported habitual sleep underestimated sleep

Table 4. Cross-sectional associations of everyday discrimination and perceived stress with self-reported and actigraphy-measured sleep duration (*N* = 755), the Jackson Heart Sleep Study

Outcome: Continuous sleep duration						Outcome: Short sleep vs. recommended sleep duration					
Model 1		Model 2		Model 3		Model 1		Model 2		Model 3	
β	*SE*	B	*SE*	β	*SE*	OR	95% CI	OR	95% CI	OR	95% CI
Self-reported sleep											
Everyday discrimination (per *SD*) at Exam 3											
–6.73**	3.30	–7.54***	3.31	–5.79***	3.37	1.13	0.97–1.32	1.14***	0.98–1.34	1.11	0.95–1.30
PSS-10 (per point)											
				–1.46*	0.49					1.03**	1.00–1.05
Actigraphy-measured sleep											
Everyday discrimination (per *SD*) at Exam 3											
–4.37***	2.41	–4.40***	2.43	–3.78	2.48	1.08	0.94–1.27	1.09	0.92–1.28	1.10	0.93–1.30
PSS-10 (per point)											
				–0.57	0.36					1.00	0.97–1.02

Model 1 adjusted for [Exam 1] age, gender; Model 2: Model 1 + [Exam 1] education, [Exam 1] income, [Exam 1] employment, [Exam 1] physical activity, [Exam 1] alcohol, [Exam 1] smoking, [Exam 3] BMI, [Exam 1] social support; Model 3: Model 2 + PSS-10 (Sleep Exam).
**$P < 0.05$; ***$P < 0.10$; *$P < 0.01$.

Table 5. Cross-sectional associations of everyday discrimination and perceived stress with actigraphy-measured sleep efficiency, the Jackson Heart Sleep Study

	Outcome: Continuous sleep efficiency								Outcome: Sleep efficiency <85% vs. sleep efficiency >= 85%							
	Model 1		Model 2		Model 3		Model 4		Model 1		Model 2		Model 3		Model 4	
	β	*SE*	β	*SE*	β	*SE*	β	*SE*	OR	95% CI	OR	95% CI	OR	95% CI	OR	95% CI
Everyday discrimination (per *SD*) at Exam 3	–0.04	0.18	–0.005	0.18	0.02	0.19	0.02	0.19	1.02	0.87–1.20	1.02	0.87–1.20	1.04	0.87–1.22	1.04	0.88–1.23
PSS-10 (per point)					–0.01	0.03	–0.008	0.03					0.99	0.97–1.01	0.98	0.95–1.01

Model 1: adjusted for [Exam 1] age, gender; Model 2: Model 1 + [Exam 1] education, [Exam 1] income, [Exam 1] employment, [Exam 1] physical activity, [Exam 1] alcohol, [Exam 1] smoking, [Exam 3] BMI, [Exam 1] social support; Model 3: Model 2 + PSS-10 (Sleep Exam); Model 4: Model 3 + depressive symptoms.

Table 6. Cross-sectional associations of everyday discrimination and perceived stress with actigraphy-measured WASO, the Jackson Heart Sleep Study

	Outcome: Continuous WASO							
	Model 1		Model 2		Model 3		Model 4	
	β	*SE*	β	*SE*	β	*SE*	β	*SE*
Everyday discrimination (per *SD*) at Exam 3	–0.40	0.89	–0.55	0.89	–0.49	0.91	–0.60	0.91
PSS-10 (per point)					–0.04	0.14	–0.08	0.16

Model 1: adjusted for [Exam 1] age, gender; Model 2: Model 1 + [Exam 1] education, [Exam 1] income, [Exam 1] employment, [Exam 1] physical activity, [Exam 1] alcohol, [Exam 1] smoking, [Exam 3] BMI, [Exam 1] social support; Model 3: Model 2 + PSS-10 (Sleep Exam); Model 4: Model 3 + depressive symptoms.

duration (in contrast to self-reported differences in the time in bed, which over-estimated sleep duration).[69] Sleep duration was asked slightly differently at Exam 1 and Exam 3, with Exam 1 specifically stating to exclude naps and referenced the last month. However, given the self-reported nature of sleep duration, we expect the responses to be similar given both responses were total hours as opposed to bed or wake times on weekdays and weekends.[69] Also there is no evidence suggesting that self-reported sleep duration estimates differ based on a reference to the last 30 days or on average. Thus, the sleep duration assessments likely reflect within-individual relative changes in perceived sleep. Note that self-reported sleep quality is considered a participant-centered measurement, which differs from objective measures [67]. Compared to sleep duration, less is known about measurement biases for this construct. The lack of any association between discrimination and actigraphy-based measurements may reflect the greater importance of perceived sleep quality compared to sleep duration (measured objectively or subjectively) or objective sleep continuity. However, longer objective measurements (over several weeks rather than days) may provide better resolution of this relationship. Our objective sleep data was limited to only one-time point; therefore, we were unable to examine changes over time with objective sleep. There may be residual confounding based on unknown confounders or misclassification of known confounders. Of note, information on shift work was not collected in the JHS main study. It is possible that shift work status could confound the association

between discrimination and self-reported sleep outcomes. However, in sensitivity analyses among the Sleep Exam participants, the associations remained the same after excluding shift workers. Therefore, it is likely that shift work status may not be a confounder in this sample.

Overall, higher levels of perceived discrimination were associated with poor sleep quality over time and associated with sleep duration among older adults. This study contributes to the literature by assessing changes over time and providing new knowledge on the social determinants of sleep. The results of the study suggest that perceived discrimination and stress are contributing factors to poor sleep. Future research should identify the effect of different types of discrimination (e.g. interpersonal vs. institutional) as well as assess the attribution of discrimination (e.g. age, socioeconomic status, gender, and sexual orientation) on sleep outcomes. Evidence supports that mitigating effects of interactionally fair treatment on reactions to unfair treatment can improve sleep.[70] Therefore, targeting these factors may help to improve the burden of poor sleep among African-Americans.

Supplementary Material

Supplementary material is available at *SLEEP* online.

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JHS Disclaimer

The views expressed in this manuscript are those of the authors and do not necessarily represent the views of the National Heart, Lung, and Blood Institute; the National Institutes of Health; or the U.S. Department of Health and Human Services.

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