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Associations Between Self-Reported Discrimination and Diurnal Cortisol Rhythms Among Young Adults: The Moderating Role of Racial-Ethnic Minority Status

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Abstract

Discrimination is theorized to set in motion a neuroendocrine response, which includes cortisol secretion from the hypothalamic-pituitary-adrenal axis. Repeated exposure to perceived discrimination is thought to contribute to alterations in diurnal cortisol rhythms and to have implications for health. Discrimination may have particularly strong effects on racial/ethnic minority individuals, based on histories of past exposure and/or greater perceived implications of discriminatory events. Utilizing an ethnically and racially diverse sample of young adults ($N = 140$; $M_{age} = 22.8$ years) and a multiple-day naturalistic cortisol protocol, the present study examined associations between self-reported discrimination and cortisol diurnal rhythms, and whether this relation was moderated by racial/ethnic minority status. Results revealed that self-reported discrimination predicted flatter diurnal cortisol slopes for racial/ethnic minority individuals only. These findings align with theory suggesting that discrimination experiences are important among racial/ethnic minorities.

Keywords

HPA axis; diurnal cortisol; discrimination; racial/ethnic minority young adults

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Discrimination is a common stressor for ethnic/racial minority individuals in the US (Williams and Mohammed, 2009; Priest et al., 2012). Chronic exposure to discrimination can set in motion a series of cardiovascular and neuroendocrine responses that may contribute to widening health disparities in the US (Meyers, 2009). While previous studies have linked self-reported discrimination and cardiovascular functioning (Harrell et al., 2003; Steffen et al., 2003; Mendes et al., 2008), very few studies have examined the relation between discrimination and one of the body's major stress response systems, the hypothalamic-pituitary-adrenal (HPA) axis. The current study examined associations between self-reported discrimination and HPA axis functioning in a diverse sample of young adults.

The biopsychosocial model of cumulative vulnerability and minority health suggests that discrimination activates a range of physiological processes, including the HPA axis (Clark et al., 1999; Meyers, 2009). When a stressor is perceived, a complex cascade of events occurs, involving the hypothalamus, the pituitary gland, and the adrenal cortex, resulting in the release of *cortisol* (Johnson et al., 1992; Kloet and Derijk 2004). The HPA axis is equipped with feedback mechanisms that reduce the stress-related release of cortisol when the individual no longer perceives the situation to be stressful (Chrousos and Gold, 1992). In addition to responding to environmental stimuli, cortisol levels are also released according to a strong diurnal rhythm; levels are high upon waking, increase by 50-60% in the first 30-40 minutes after waking [known as cortisol awakening response (CAR)], and then rapidly decline throughout the day, reaching their lowest point around midnight (Pruessner et al. 1997). Periodic activation of the HPA axis is considered adaptive and necessary to cope with acute stress; however, when the HPA axis response is persistent, both acute and chronic alterations in diurnal cortisol rhythms can be found.

Changes in the rate of decline in cortisol from waking to bedtime (referred to as the diurnal cortisol slope; Adam and Kumari, 2009) represent an important indicator of a stress-related alteration of the diurnal cortisol rhythm. Both acute and chronic stress exposures have been linked to flatter diurnal cortisol slopes (Steffen et al., 2003; Miller, et al., 2002; Miller et al., 2007; Suglia et al. 2010; Adam, 2012) and flatter cortisol slopes have been linked to worse mental health (Havermans et al., 2011), higher fatigue (Bower et al. 2005), increased breast cancer mortality (Sephton et al., 2000) and cardiovascular disease (Matthews et al., 2006). These findings are in line with theoretical models suggesting that environmental factors contribute to alterations in the diurnal functioning of the HPA axis, and that changes in diurnal slopes are likely key mediators linking environmental stressors to health outcomes (e.g., Gunnar and Quevedo, 2007; Adam and Kumari, 2009).

Very few empirical studies have examined the link between self-reported discrimination and diurnal cortisol slopes. This is surprising given that prior work suggests that stressors that are characterized as uncontrollable and socially evaluative, both of which apply to perceptions of discrimination, are some of the strongest activators of the HPA axis (Dickerson and Kemeny, 2004). In a study of young adults, Skinner and colleagues (2011) examined the relation between a variety of environmental stressors, which included discrimination, and diurnal cortisol among White and African American adolescents and found that perceived discrimination related to flatter diurnal cortisol slopes among all youth.

In contrast, a study examining White and African American adults found that discrimination related to flatter diurnal cortisol slopes in White adults, but steeper diurnal cortisol slopes in African American adults (Fuller-Rowell et al., 2012).

From a general stress and coping perspective (Compas, 1987; Trawalter et al., 2009), experiences of discrimination should be considered stressful regardless of the group membership upon which that discrimination was based (e.g., gender, race, ethnicity, age). For racial and ethnic minority individuals, however, experiences of discrimination are more common. Estimates among adults suggest that roughly 3% of Non-Hispanic Whites endorsed experiencing day-to-day discrimination as *often*, whereas 25% of African Americans and 17% of other racial/ethnic minorities endorsed experiencing day-to-day discrimination as *often* (Kessler et al., 1999). More recent estimates, that include Hispanic adults, suggest a similar pattern in regards to differences between Non-Hispanic Whites and ethnic/racial minorities; 32% of African American and 27% of US-born Hispanic adults reported experiences of life time discrimination, whereas only 13% of Non-Hispanic Whites reported such experiences (Sternthel et al., 2011). In addition to discrimination being more common, the historical mistreatment, prejudices, and oppression within US society could make experiences of discrimination particularly relevant and impactful among racial and ethnic minority individuals (Branscombe, Schmitt, & Harvey, 1999; Feagin et al., 2001), increasing the extent to which such experiences are embodied as alterations in stress physiology and negative health outcomes.

The current study examined the relation of self-reported discrimination and diurnal cortisol slopes in a multiracial/ethnic young adult sample. We first examined the relation between discrimination and diurnal cortisol slopes for all individuals, hypothesizing that self-reported discrimination would relate to flatter diurnal cortisol slopes. Next, we examined the moderating role of racial/ethnic minority status, hypothesizing that the relation between self-reported discrimination and diurnal cortisol would be stronger for racial/ethnic minority individuals than majority individuals.

Methods

Participants

Data for the current study come from a larger two-site longitudinal project focused on young adults' risk factors for internalizing disorders. A complete description of this project's participants and recruitment procedures are reported by Zinbarg et al. (2010). High school juniors from two diverse public high schools in suburban Chicago and Los Angeles were screened and selected for the study based on their neuroticism score from the Revised Eysenck Personality Questionnaire (Eysenck et al., 1985). Individuals who scored high on the measure were oversampled, resulting in a group of 627 (69% female) who completed baseline interviews and questionnaires. The greater proportion of females over males is accounted for by the fact that individuals with high levels of neuroticism were oversampled, and females are, on average, higher on this personality trait (Costa et al., 2001). Of those participants, two-thirds of individuals were randomly invited to participate in the initial cortisol sampling protocol and 350 participants completed the protocol at Wave 1. Data from the current study come from the 4th wave (W4) of cortisol data collection,

approximately 5 years after baseline. At W4, 192 participants completed the cortisol protocol. Participants who were currently taking corticosteroid based medications ($n = 8$) or had missing data on key study variables ($n = 44$) were excluded from the current analyses, resulting in a final sample of 140 individuals (72.9% female). Individuals were, on average, 22.80 years old at W4 ($SD = .84$) and came from varying racial/ethnic backgrounds. Specifically, individuals identified as Caucasian/White ($n = 76$), African American/Black ($n = 11$), Asian ($n = 8$), Hispanic/Latino ($n = 19$), Pacific Islander ($n = 1$), multiethnic/multiracial ($n = 15$) and other ($n = 10$). The Hollingshead socioeconomic status (SES) score indicated that, on average, individuals came from upper middle class families ($M = 49.09$, $SD = 12.58$; $Range = 13.00$ to 66.00 ; Hollingshead, 1975).

Procedures

Participants were sent a study packet that contained three diary booklets, a mechanical kitchen timer (to assist with the accurate timing for the 40 min post-awakening cortisol sample), straws, vials and labels for collecting cortisol samples, and a health and sleep questionnaire. Study personnel contacted each participant to explain the protocol in detail and reminded them when to start the procedures. Participants provided six salivary cortisol samples and completed six diary entries a day for three consecutive typical weekdays. Participants were paid \$90 for completion of the sampling protocol. All procedures were reviewed and approved by Institutional Review Boards.

Measures

Racial/ethnic minority and majority status—Participants were asked to answer *yes* (1) or *no* (0) to whether the following racial/ethnic categories described them: African American/Black, Caucasian/White, Asian, Native Hawaiian/Pacific Islander, Hispanic/Latino, American Indian/Alaska Native or other. Based on this report, individuals were then classified into racial and ethnic categories, with individuals categorized as multiracial if they responded *yes* to two or more race/ethnic categories. To categorize individuals as racial/ethnic minority and majority, a dummy code was created in which individuals who identified as Caucasian/White only were given a value of 0 and all other individuals were given a value of 1.

Salivary cortisol—Salivary cortisol was gathered six times per day over three consecutive days: wake-up, 40 minutes after waking, three semi-random time points at approximately 2, 8, and 12 hours post-awakening (signaled by the programmed wristwatch), and bedtime. Participants expelled saliva through a straw into a 2 mL polypropylene tube and labeled tubes with the time and date. Participants were instructed not to eat, drink, or brush their teeth 30 minutes before sampling. Samples were returned by mail, refrigerated at -20 degrees Celsius, and then sent on dry ice by courier to Biochemisches Laboratory, Trier, Germany to be assayed for cortisol. Cortisol levels are stable at room temperature for several weeks and are unaffected by the conditions associated with shipping (Clements and Parker, 1998). Assays were conducted in duplicate using a time-resolved immunoassay with fluorometric detection (DELFLIA; Dressendorfer et al., 1992). Intra-assay coefficients of variation (CVs) were between 4.0% and 6.7%, and inter-assay CVs ranged from 7.1% to 9.0%. Consistent with prior cortisol studies (Adam and Kumari, 2009), raw cortisol values

were transformed using the natural log and cortisol values were top coded at 50 nmol/L to reduce the effects of outliers on the analysis.

Discrimination—Discrimination was assessed using the Everyday Discrimination Scale (EDS; Williams et al., 1997). The 10 item scale¹ is intended to measure “more chronic, routine, and relatively minor experiences of unfair treatment” in the past 12 months (Williams et al. 1997, p. 340). Example items include “You were treated with less respect than other people,” and, “People act as if they think you are not smart.” Responses ranged from 1 (*never*) to 4 (*often*). Scores were summed and averaged, with higher scores representing greater self-reported discrimination. Respondents were also asked to identify the main reason for discriminatory experiences (i.e., national origin, gender, race, age, skin color, height or weight, sexual orientation, education or income, or other). The EDS has been utilized in multi-ethnic samples (e.g., Lewis et al., 2012) and demonstrated good internal consistency in the current study ($\alpha = .85$).

Control variables—To account for the daily behaviors associated with cortisol secretion, young adults provided diary reports with each salivary sample that assessed if they had slept (taken a nap), consumed alcohol or caffeine, eaten, smoked, or experienced a stressful event in the past hour. Individuals also reported their typical hours of sleep and use of oral contraceptives (females only) in a health questionnaire. Daily wake times and bed times were also assessed using daily diary measures. Family SES was assessed using the Hollingshead SES index, which was based on parents' income and occupation. Neuroticism risk was assessed using the Revised Eysenck Personality Questionnaire (Eysenck et al., 1985), and was coded 0 = low risk, 1 = moderate risk, 2 = high risk. Each covariate was tested and included in the final model regardless of whether it showed significant associations with our salivary cortisol outcomes.

Analytic Plan

To assess the current study's aims, a 3-level multilevel growth-curve analysis was run in SAS 9.2. These analyses, which have been utilized by other diurnal cortisol researchers (Hruschka et al., 2005; Adam, 2006;), model the non-independence associated with the nested structure of the data (cortisol samples nested within days, nested within individuals; Raudenbush and Bryk 2002) and have the ability to model the complex diurnal rhythm of cortisol while adding in moment-level (Level 1), day-level (Level 2), and person-level (Level 3) predictors. In line with prior work, the current analyses modeled the general decline of cortisol levels across the day (diurnal cortisol slope) by regressing time of day of sampling (calculated as *time since waking* and entered at Level 1) on each individual's cortisol level (the dependent variable). A slowing of the decline was modeled by including quadratic time term (*time since waking squared*, entered at Level 1). Time was centered as hours since waking (e.g., waking time = 0), so that the intercept reflected the cortisol level at waking. To model the size of the CAR (the increase in cortisol from waking to 40 minutes after waking), a dummy variable was added at Level 1 (Sample 2 = 1, all other samples = 0).

¹Since previous research (Reeve et al. 2011) employed a 9-item version of the EDS (removing the item 1 (“*You are treated with less courtesy than other people*”)), we conducted additional analyses eliminating this item. Results did not differ between the 9- and 10-item EDS measure.

Additional Level 1 predictors were exercise, daytime sleep, alcohol use, caffeine use, nicotine use, food consumption, and acute stress level in the past hour. At Level 2, wake time and bedtime for each individual each day were entered. At Level 3, perceived discrimination, racial/ethnic minority status (dummy coded 0 = ethnic/race majority, 1 = racial/ethnic minority), and person-level control variables (i.e., neuroticism risk, typical hours of sleep, SES, oral contraceptive use, gender, and age) were entered.

In line with recommendations (Enders and Tofighi, 2007), all variables (except the racial/ethnic dummy variables and time variables) were grand-mean centered. Analyses proceeded in the following order. First, as a preliminary step, we examined racial/ethnic majority and minority individuals' diurnal cortisol rhythms, including moment, daily, and person level covariates (Model 1). Next, we examined whether self-reported discrimination related, on average, to individual differences in morning cortisol (the intercept), the CAR, and the diurnal slope (Model 2). Finally, to examine whether the effects of self-reported discrimination on cortisol differed by whether or not individuals were members of a racial/ethnic minority group, we examined the interaction between ethnic/race minority status and self-reported discrimination in relation to diurnal cortisol patterns (Model 3).

Results

Table 1 presents sample correlations, means, and standard deviations among the key variables for racial/ethnic majority and minority individuals. Seventy-nine percent of participants ($n = 109$; 58 ethnic majority individuals, 51 ethnic minority individuals) provided an attribution of their experiences of discrimination. An examination of these responses revealed that racial/ethnic majority and minority individuals significantly differed on their responses [$\chi^2(7) = 16.13, p < .05$]. For majority individuals, 5% ($n = 3$) attributed perceived discrimination to race/ethnicity-related reasons (i.e., national origin, race, skin color), 19% ($n = 11$) attributed perceived discrimination to gender, 31% ($n = 18$) to age, 2% ($n = 1$) to religion, 9% ($n = 5$) to height or weight, 3% ($n = 2$) to education or income, and 31% ($n = 18$) to “other”. For minority individuals, 24% ($n = 12$) attributed discrimination to race/ethnicity-related reasons, 18% ($n = 9$) to gender, 14% ($n = 7$) to age, 2% ($n = 1$) to height or weight, 2% ($n = 1$) to sexual orientation, 10% to education or income ($n = 5$), and 31% ($n = 16$) to other. The commonly-selected response of “other” included a wide range of idiosyncratic factors, such as (e.g., “my personality”, “the nature of my job”, “because others are insecure”). We did not see any particular pattern indicating the “other” category was being used differently by minority and majority individuals.

We first examined racial/ethnic minority and majority participants' cortisol diurnal rhythms (See Table 2, Model 1). Results revealed that, as expected, individuals' cortisol values were high upon waking ($b = 1.864$, Standard error (SE) = .07, $p < .001$), exhibited a strong increase after waking ($b = 0.617$, $SE = .07, p < .001$) and then showed a strong decline ($b = -0.160$, $SE = .02, p < .001$) and a slowing of decline across the day ($b = 0.003$, $SE = .001, p < .05$). Model 1 also suggested that racial/ethnic majority and minority participants did not significantly differ in their waking cortisol levels ($b = -0.044$, $SE = .11, ns$), CARs ($b = -0.202$, $SE = .10, ns$), or diurnal slopes ($b = 0.014$, $SE = .03, ns$; $b = 0.000$ (.001), ns).

Next, we examined how self-reported discrimination related to diurnal cortisol rhythms for the full sample (Table 2, Model 2). Results revealed no significant associations between discrimination and any of the cortisol parameters. Next, we examined if the association between discrimination and diurnal cortisol rhythms was moderated by racial/ethnic minority status (Table 2, Model 3). Results revealed no moderation by minority status on waking cortisol or on the CAR. There was, however, significant moderation of the association between discrimination and diurnal cortisol slope (times since waking and time since waking²) by racial/ethnic minority status. Specifically, the association between discrimination and the initial linear decline in cortisol was different for racial/ethnic minority and majority members ($b = 0.077$, $SE = .04$, $p < .05$), as was the association between discrimination and the curvature in cortisol decline across the day ($b = -0.005$, $SE = .002$, $p < .01$), after controlling for momentary and daily health behaviors (i.e., exercise, naps, food and alcohol consumption, nicotine use, caffeine, wake time, bedtime), daily stress, neuroticism risk, hours of sleep, oral contraceptives, gender, and age. Following Aiken and West (1991) procedures for probing interactions, we examined the cortisol slope of racial/ethnic minority and majority members at high (1 standard deviation (SD) above the mean) and low (1 SD below the mean) levels of discrimination. Probing of the interaction revealed that for minority members, but *not* majority members, diurnal slopes and curvature varied at low and high levels of discrimination. Specifically, minority members who reported higher discrimination exhibited flatter diurnal cortisol patterns ($b_{tsw} = -.11$, $SE = .03$, $p < .001$; $b_{tsw}^2 = .001$, $SE = .001$, ns) as compared to minority members who reported lower discrimination ($b_{tsw} = -0.19$, $SE = .03$, $p < .001$; $b_{tsw}^2 = 0.005$, $SE = .002$, $p < .01$). For majority members, diurnal cortisol patterns did not differ by levels of discrimination. The pattern is presented visually in Figure 1.

Given that our racial/ethnic minority group was comprised of individuals from varying ethnic and racial minority groups, we performed follow-up analyses to examine if the relationship between discrimination and diurnal cortisol slopes operated similarly across specific racial/ethnic minority groups or if there were certain racial/ethnic groups driving the results. To do this, we created a series of dummy codes that distinguished if individuals identified as African American, Asian American, Hispanic, multi-ethnic/multi-racial, or other, differed from individuals who identified as Caucasian/White (the reference group). Results revealed that, as compared to majority members, discrimination was related to flatter linear declines in cortisol among African Americans ($b = 0.13$, $SE = .07$, $p = .08$; marginally significant), Asian Americans ($b = 0.24$, $SE = .09$, $p < .01$), and multi-ethnic/multi-racial participants ($b = 0.11$, $SE = .05$, $p < .05$), but not among Hispanic young adults ($b = -0.14$, $SE = .11$, $p = .20$) or individuals who were classified as other ($b = -0.05$, $SE = .10$, $p = .45$). Given the small number of individuals representing each specific racial/ethnic group, however, these findings should be viewed with caution.

Discussion

Utilizing a racially and ethnically diverse sample, the current study examined associations between self-reported discrimination and individuals' diurnal cortisol slopes and whether these associations differed by majority and minority racial/ethnic status. Results revealed that for racial/ethnic majority young adults (those identified as Caucasian/White), self-

reported discrimination was unrelated to diurnal cortisol slopes. For racial/ethnic minority young adults, however, greater levels of discrimination related to significantly flatter diurnal cortisol slopes after controlling for momentary and daily health behaviors, daily stress, and individual characteristics.

This association is in line with prior empirical studies examining the relation between chronic stressors and diurnal cortisol slopes (Miller et al., 2007) and a study examining the relation between self-reported discrimination and cortisol slopes in young adults (Skinner et al., 2011). As expected, based on the biopsychosocial model of cumulative vulnerability and minority health (Clark et al., 1999; Meyers, 2009), our findings suggest that for racial and ethnic minority young adults, discrimination is related to a pattern of neuroendocrine activity that has previously been associated with chronic stress exposure, which has known associations with adverse health outcomes. From the current data, we cannot conclude whether flattened cortisol rhythms reflect acute responses to current or recent discrimination, or reflect the cumulative effect of a long history of past exposure to discrimination among minority individuals. We suspect the latter explanation is more likely to be the case, but these two explanations should be distinguished empirically in future research.

From a traditional stress and coping perspective (Compas, 1987; Trawalter et al., 2009), which suggests that experiences like discrimination would impact all individuals, we were surprised to find no relation between self-reported discrimination and diurnal cortisol slopes among individuals who identified as Caucasian/White. The limited prior empirical work examining self-reported discrimination and cortisol among White young adults has found a significant positive association (greater discrimination related to flatter diurnal cortisol; Skinner et al., 2011). Thinking about the specific types of discrimination might help understand why the relation did not emerge. Studies examining different forms of discrimination have suggested that race-based forms are important (Grollman, 2012), particularly among racial minority individuals (e.g., Gyll et al., 2001). For the current study, very few White young adults attributed their experiences of discrimination to race-related issues, whereas a significantly greater number (albeit, still a relatively low number) of ethnic and racial minority individuals attributed their experiences to race-related issue. This may account for why associations were significant for the latter group, but not the former.

Further, from a physiological perspective, not all environmental stressors elicit the same response from the HPA axis. Rather, environmental stressors that are characterized as uncontrollable have been found to be the key activators of cortisol secretion (Dickerson and Kemeny, 2004). Applied to perceptions of discrimination, certain forms of discrimination may be viewed as more controllable than others. For instance, age discrimination, which nearly a third of White young adults in the current study gave as the reason attributed to discrimination, is subject to change as an individual ages. If an individual feels as though the experiences were tied to a specific developmental time and discriminatory experiences did not exist prior to that age and/or would not persist as time progressed (e.g., discrimination attributed to pubertal changes or immaturity), then discrimination may be perceived both as more controllable, and in turn, less physiologically activating. In contrast, an individuals'

racial or ethnic identification may be viewed as more stable and less apt to change over time. To the extent that this is true, individuals experiencing discrimination attributed to their race/ethnicity could view this as uncontrollable and in turn, particularly physiologically activating. It is important to note, however, that although race or ethnic identification may be viewed as more stable than other characteristics (e.g., age), self-identification is influenced by individuals' internal processes, other's perceptions of race/ethnicity, and the larger societal views. Thus, over time, individuals' racial/ethnic identification and the social implications of race/ethnicity can be subject to change. In sum, explanation of findings suggests that different forms of discrimination might be differentially linked to the HPA response, depending on their controllability and chronicity. Future longitudinal studies focused on individuals' racial and ethnic identification and self-reports of differing forms of discrimination in a larger sample would help uncover these answers. Further, the inclusion of health outcomes in future longitudinal work focused on discrimination and HPA axis activity would expand our understanding of the long-term health-related toll of these experiences over time.

It is worth noting that the current analyses grouped numerous ethnic and racial minority individual into the minority status group, and some minority groups were not represented (i.e., Native Americans, Pacific Islanders). Ethnic and racial minorities within the US vary in racial/ethnic backgrounds, cultural values, and migration patterns and history (Knight et al., 2009). Given this, we further explored the moderation between discrimination and diurnal cortisol, by examining specific racial/ethnic groups represented in the current study. Results suggested that the relation between discrimination and diurnal cortisol slopes was largely driven by Asian American and multi-racial/ethnic individuals, and to a lesser extent, African Americans. No relation between perceived discrimination and diurnal cortisol emerged among Hispanic individuals or individuals categorized as other. We believe these findings do not necessarily suggest discriminatory experiences are unrelated to HPA axis activity in Hispanic individuals or other racial/ethnic minority members, as theory would suggest that perceived discrimination has the ability to illicit a cortisol response across all ethnic and racial groups. In fact, recent work has found a positive relation between self-reported discrimination and cortisol across the day among Mexican American adolescents (Zeiders et al., 2012) and among Native Hawaiian adults (Kaholokula et al., 2012). Rather, the lack of association in the current study could be related to the limited sample of individuals within each group and/or our inability to measure distinctive characteristics and constructs (e.g., country origin, cultural values, acculturation level) known to be important among minority populations (Knight et al., 2009). Thus, future studies with a larger representation of ethnic/racial minority populations that are more representative in ethnic origin, cultural values, and acculturation levels are greatly needed.

A related limitation in the current study's sample is the overrepresentations of young adults at risk for neuroticism, and in turn, an overrepresentation of female young adults. Prior work suggests that self-reported discrimination is related to personality characteristics, that include neuroticism (Huebner et al., 2005), and some work suggests gender differences in the response to discrimination, with males reporting a stronger association between discrimination and psychosocial outcomes compared to females (Alfaro et al., 2009; Wiehe et al., 2010). In the current study, we had equal representation of gender across the racial/

ethnic majority and minority groups² and we controlled for gender in all analyses. Similarly, we had equal representation of neuroticism risk across the racial/ethnic majority and minority groups³ and we controlled for neuroticism risk in all analyses. Thus, we do not believe the differences we observed between racial/ethnic majority and minority young adults in the relation between discrimination and cortisol slopes is primarily driven by either gender or neuroticism risk. We do, however, believe the generalizability of our findings is limited and future work should include a greater number of males and a greater representation of young adults with varying personality characteristics.

Finally, the current study focused on between-person relations and was cross-sectional in nature, limiting our understanding of within-person processes and the directionality of experiences of discrimination and cortisol. Although our results support numerous theories suggesting that discrimination has the ability to impact physiological functioning (Clark et al., 1999; Miller et al., 2007), future work examining how this process plays out over time and whether changes in diurnal cortisol patterns could affect subsequent perceptions of discrimination is greatly needed.

In sum, the current study makes an important contribution in our understanding of the physiological processes underlying young adults' experiences of discrimination. Our study represents one of the first studies examining the relation of self-reported discrimination and young adults' cortisol levels within a diverse sample of individuals and points to the importance of discriminatory experiences for racial/ethnic minority young adults' stress biology.

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²Percentage of females within majority group = 70%, within minority group = 77%, $\chi^2(1) = .45, ns$.

³Percentage of young adults classified as high risk in majority group = 59%, within minority group = 58%, $\chi^2(2) = .79, ns$

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Highlights

- We examined the link between young adults' discrimination and cortisol diurnal slopes
- We explored the moderating role of racial/ethnic (r/e) minority status
- Discrimination related to flatter cortisol slopes in r/e minority young adults
- No association emerged among r/e majority young adults

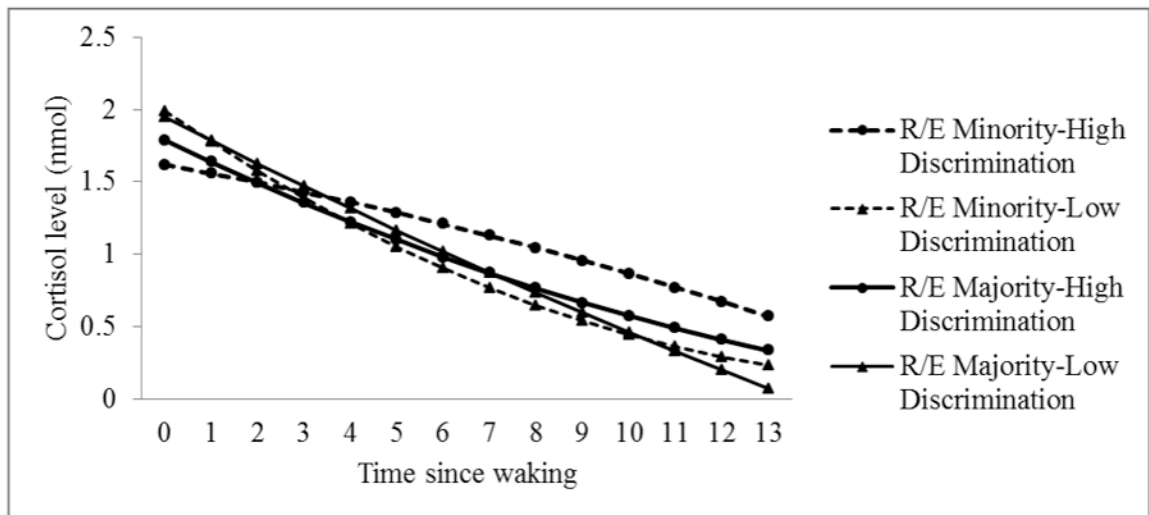


Figure 1.

Diurnal cortisol slope for racial/ethnic minority and majority members at high (1 SD above the mean) and low (1 SD below the mean) levels of perceived discrimination.

Table 1
Bivariate correlations, means, and standard deviations for key study variables by majority ($n = 76$) and minority status ($n = 64$)

Variables	1.	2.	3.	4.	5.	6.	7.	8.	9.
1. Discrimination	--	-.01	-.01	.07	.21	.09	.08	.00	.03
2. Waking Cort	-.21	--	.20	-.12	.03	-.04	.08	-.42***	-.67***
3. Cort (S2)	-.05	.14	--	.34***	.13	.20	.36**	.81***	.06
4. Cort (S3)	.08	.05	.33**	--	.30**	.24*	.10	.38**	.13
5. Cort (S4)	-.05	.27*	.27*	.52***	--	.36**	.21	.11	.14
6. Cortisol (S5)	.17	.04	.23	.33**	.36**	--	.14	.20	.12
7. Bedtime Cort	.13	.08	.01	.14	.38**	.52***	--	.29*	.62***
8. CAR	.07	-.50***	.78***	.26*	.05	.18	-.07	--	.45**
9. Cort Slope	.27*	-.79***	-.14	.01	-.05	.25	.50***	.36**	--
Means (SD)									
R/E Majority	1.77 (.66)	6.87 (3.14)	11.85 (4.99)	5.44 (2.78)	2.81 (1.71)	1.99 (1.60)	2.15 (3.18)	5.03 (5.38)	-.31 (.30)
R/E Minority	1.58 (.56)	7.63 (3.27)	10.21 (4.76)	5.33 (3.40)	3.08 (1.73)	2.33 (2.32)	2.24 (2.10)	2.68 (5.26)	-.34 (.24)

Note. Correlations above the diagonal are for racial/ethnic majority individuals; Below the diagonal are for racial/ethnic minority individuals.

* $p < .05$,

** $p < .01$,

*** $p < .001$.

Cort = Cortisol ($nmol/L$); R/E = race/ethnic; SD = Standard deviation; S2 – S5 = sample 2 – sample 5. Means and standard deviations are aggregated across each individual's multiple days of data collection.

Table 2
Three-level multi-level growth model examining the effect of ethnic/racial minority status (majority vs. minority), discrimination, and the interaction on individuals' log transformed cortisol (nmol/L). N = 140

	Model 1 β (SE)	Model 2 β (SE)	Model 3 β (SE)
Waking Cortisol (Intercept)	1.864 (.07)***	1.832 (.05)***	1.867 (.07)***
R/E Minority member	-0.044 (.11)		-0.079 (.10)
Discrimination (Disc)		-0.120 (.08)	-0.063 (.11)
R/E Minority member X Disc			-0.108 (.16)
CAR	0.617 (.07)***	0.531 (.05)***	0.611 (.07)***
R/E Minority member	-0.202 (.10)		-0.190 (.10)
Discrimination (Disc)		0.070 (.08)	0.045 (.10)
R/E Minority member X Disc			0.009 (.17)
Time Since Waking	-0.160 (.02)***	-0.150 (.01)***	-0.159 (.02)***
R/E Minority member	.014 (.03)		0.020 (.03)
Discrimination (Disc)		0.033 (.02)	0.005 (.02)
R/E Minority member X Disc			0.077 (.04)*
Time Since Waking ²	0.003 (.001)*	0.002 (.001)**	0.002 (.001)*
R/E Minority member	0.000 (.002)		0.000 (.001)
Discrimination (Disc)		-0.001 (.001)	0.001 (.001)
R/E Minority member X Disc			-0.005 (.002)*

Note. R/E = racial/ethnic. Reference group is R/E majority members (i.e., Non-Hispanic White) participants. In all models, the following covariates were added in at Level 1 (moment-level): exercise, daytime sleep, alcohol consumption, cigarette use, caffeine consumption, food consumption, and stress level. Daily wake time and bedtime were included as a Level 2 covariate. At Level 3, neuroticism risk, average hours of sleep, SES, oral contraceptives, gender, and age were included as covariates.

* $p < .05$,

** $p < .01$,

*** $p < .001$.