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Discrimination and hair cortisol concentration among asian, latinx and white young adults

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ABSTRACT

Discrimination is a form of chronic stress and hair cortisol concentration is an emerging biomarker of chronic stress. In a sample of 83 first-year college students (age $x\cdot\cdot = 17.65$, $SD = 48$, 69% female, 84% United States-born, 24% Asian, 21% Latinx, and 55% White), the current study investigates associations between hair cortisol concentration with discrimination stress assessed across two timeframes: past year and past two weeks. Significant associations were observed for past year discrimination and hair cortisol concentration levels, but not for discrimination over the past two weeks. The current study contributes to a growing body of evidence linking discrimination stress exposure to neuroendocrine functioning.

1. Introduction

Discrimination is a form of chronic stress. The negative health impact of discrimination has been well documented in meta-analyses and systematic reviews among youth and adults [1–5] Physiological stress responses have been theorized to be the mediating pathway through which social experiences of discrimination are biopsychosocially transmitted "under the skin" and embodied to influence health and contribute to health disparities [6–8]. Research on discrimination has focused on acute biological markers such as real-time heart rate [9] and salivary cortisol [10] which are important for documenting the immediate impact of discrimination on psychophysiological markers. However, there is increasing recognition that discrimination is not only a form of acute, but also chronic, stress and the breadth of biological markers of chronic discrimination is a growing area of inquiry [8,11,12]. For example, Geronimus and colleagues [13] have proposed that chronic stress exposure contributes to health patterns and disparities through the process of "weathering" [14].

To better assess how chronic discrimination may be implicated in health, interest in appropriate biomarkers has increased. Hair cortisol concentration (HCC) level is a novel and increasingly popular biomarker for quantifying chronic stress levels [15–20]. Cortisol is a stress hormone that is gradually deposited into the hair shaft, remaining in the hair as it grows from the scalp. As a result, HCC levels are less susceptible to immediate environmental influences or diurnal patterns that influence heart rate and salivary cortisol [20]. Assaying hair cortisol concentration has become a reliable and objective indicator of retrospective chronic stress [17]: 1) HCC analysis is widely deployed as a technique for assay of chronic stress and, 2) HCC bypasses issues in self reports of chronic stress; and meta-analytic techniques evidence HCC analysis from infants to primates, bypassing biases in participant self-report [20].

1.1. Discrimination

Discrimination is a source of acute and chronic stress, and is considered to be enduring and pervasive unfair treatment that is inextricably embedded in social structures and institutions [21–24]. The everyday prevalence of discrimination and the structural and institutionalized inequality that perpetuate discrimination constitute a clear pattern of chronic stress [22]. Discrimination can be linked to a variety of reasons including weight, age, language, gender, sexual minority status, socioeconomic status, immigration status, and race/ethnicity [24]. Discrimination has been moderately and robustly linked retrospectively, concurrently, and prospectively to a host of physical and mental health outcomes across childhood to adulthood [3,4,25]. In particular, the college transition may introduce shifting diversity contexts and increase discrimination experiences for young adults [26], which in turn, impacts immediate and longer-term psychological well-being, academic

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outcomes, and health [48,49].

There is growing interest in the physiological mechanisms underlying the pathway between social experiences of discrimination and health. Similar to research on biological markers, research on discrimination has also employed various time scales to assess stress. The most common measures of discrimination ask participants to provide retrospective reports of discrimination over the past six months, or over the past year [1]. More recently, researchers have begun to take frequent, more proximal, assessments of discrimination using experience sampling methods where participants report their discrimination experience once daily, or repeatedly across days [27–31]. There is an emerging literature associating discrimination and hair cortisol. In previous work, lifetime discrimination was positively associated with HCC in a racially diverse sample of young adults [32]. More recently, racial differences were found to characterize the association between everyday discrimination and HCC in a sample of African American and White young adults [33]. This study contributes to the current science by being the first to examine discrimination at the daily and annual level in relation to HCC.

1.2. Hair cortisol concentration (HCC)

Hair grows at a rate of approximately 1 cm/month [34] and the 1 cm of hair closest to the scalp indexes an individual's production of cortisol over the past month [19]. Since cortisol deposits in the hair begin to degrade after approximately three months [35], researchers typically sample the 3 cm-segment closest to the scalp to estimate the past three months of cortisol levels. Assaying cortisol concentration from hair samples is considered to be a viable, stable, and non-invasive method for approximating chronic stress levels which is not subject to time-sensitive, diurnal fluctuations in cortisol levels associated with salivary or urinary samples [17]. HCC has been considered to be a reliable method for assessing psychosocial sources of stress-in this case, discrimination [17,19,36].

1.3. The current study

This study investigates the association between discrimination and HCC with special attention given to how the timing of discrimination affects this relationship. While existing research has linked discrimination with HCC [32,33], no studies to our knowledge have conducted a comparative investigation of how the timeframe of discrimination (i.e., concurrent or retrospective) is differentially related to HCC [32,38,39]. By comparing the associations between discrimination across two different time frames, the current study contributes to understanding how everyday discrimination "gets under the skin" and is implicated in longer-term health outcomes. The primary aim is to investigate concurrent and retrospective associations between HCC levels and self-reported discrimination in diverse samples of young adults and to validate HCC as a biomarker of chronic discrimination. Discrimination was assessed longitudinally at two non-overlapping time points with a well-validated measure across various time scales (e.g., daily, past year) to chart time-contingent associations between discrimination and HCC levels. The study elucidates whether HCC is a viable indicator of chronic stress due to discrimination, taking into consideration the corresponding timeframe of the discrimination assessment. Because HCC is intended to indicate retrospective cortisol levels, we hypothesize that HCC will index chronic discrimination (e.g., past year) and that HCC levels will not be associated with daily reports of concurrent discrimination. There are conceptual debates about whether discrimination is "real" or if it only exists as "perceived" experiences; observing an association between HCC and chronic, but not current, discrimination will contribute to recognizing discrimination is not an individual characteristic, but rather a product of the interaction of a person in their environment.

2. Material and methods

2.1. Study design

Data for this study come from students at a predominantly White, mid-sized private university in the northeastern United States. The study focused on the college transition experiences of first-year students and collected measures of discrimination at two time points. During the summer before their first year of college, the participants of this study were recruited during first-year orientations held in June and July of 2019. These students completed an online measure of discrimination experienced over the past year (i.e., summer discrimination). Next, during the fall orientation, which was held in August of 2019 just before the first day of classes, the students were instructed to start their 14-day daily reports on their daily experiences. During these first two weeks of college, participants completed daily reports of discrimination (i.e., fall discrimination), and at the end of the two weeks, they visited the research lab to provide hair samples. The researchers recruited as many participants of all racial/ethnic backgrounds as possible during the summer orientation. While both transfer students and first-year students were present, data collected only for first-year students were used in this study. Informed consent was obtained from all participants and the protocol was approved by the University Institutional Review Board.

2.2. Participants

The study included 83 first-year college students with a mean age of 17.65 (SD = 0.48). Two participants did not complete daily diary measures and were not included in those analyses. The sample was predominantly female (69%; 31% male). The sample was diverse: 24% Asian, 21% Latinx, and 55% White. The majority of students were born in the United States (84%). Unfortunately, there was insufficient sample to include Black respondents in the current study.

2.3. Measures

2.3.1. Discrimination

Discrimination was assessed with a well-validated and popular measure before first-year student orientation (i.e., summer discrimination). Participants completed the short version of the commonly-used Everyday Discrimination Scale EDS [40], which includes 5 items [41] such as "you were threatened or harassed" experienced *over the past year* on a 6-point scale ranging from 0 = never to 5 = almost every day. Responses were averaged across the 5 items ($x_{\cdot\cdot}$ = 1.21, SD = 0.99, min = 0, max = 5, α = 84) and most participants reported discrimination (90%).

In addition, the EDS was modified to assess *daily* experiences of discrimination (e.g., "today, you were threatened or harassed") and was administered daily for 14 days with a binary response scale: 0 = no, 1 = yes ($x_{\cdot\cdot}$ = 02, SD = 0.03, min = 0, max = 0.14). The participants were instructed to complete daily reports before going to bed. The daily measurements were administered online with daily reminders sent to participants each night to insure a high rate of compliance. On average, the participants completed 11.77 days (SD = 3.19 days) out of 14 days. Responses were averaged across the 5 items for the 14 days.

2.3.2. Hair cortisol concentration (HCC)

Hair samples were obtained using validated procedures [35]. All samples were placed in folded pouches of aluminum foil, noting the scalp end, and stored for later analysis. Samples were cut to obtain the basal 3 cm of hair using a caliper, hemostat, and scissors. Next, samples (N = 83, weighing: 6.3–100.4 mg) were washed twice with 1 mL isopropanol. All samples were left to dry, uncovered, in a clean fume hood for 48 h. Next, *MP Biomedicals™ Lysing Matrix I* (Fisher Scientific Company L.L.C.; catalog #MP116918100) beads were placed into sample tubes and a *BioSpec Mini-BeadBeater-16* (BioSpec Products, Bartlesville, OK, USA; catalog #607) was used to grind the hair into a fine powder. Cortisol was

extracted from the powdered hair in methanol and quantified using standard, validated assay procedures (Salimetrics, LLC, State College, PA, USA; catalog #1–3002). The intra-assay and inter-assay coefficients of variation were acceptable ($x\cdot\cdot = 6.35\%$, $SD = 5.69$, $range = 24.62$). Raw concentration of hair cortisol in solution values were converted to pg cortisol/mg hair, Winsorized and log transformed for analyses and interpretation ($x\cdot\cdot = 2.40$, $SD = 0.52$, $range = 2.74$).

2.3.3. Covariates

According to a recent meta-analysis on HCC, it is important to covary demographic characteristics and behavioral indicators [20]. Participants were asked about recent hair treatments: 16 reported dyeing their hair in the past three months, 4 reported chemically strengthening their hair (i.e., keratin treatments), 8 reported bleaching their hair, 4 reported chemically perming/straightening treatments, and 5 indicated other cosmetic hair treatments. Gender (male/female), hair treatment (yes/no), and ethnicity/race (Asian/Latinx/White) were covaried.

3. Results

3.1. Descriptives

Before exploring the association between discrimination and HCC, we report descriptive statistics for all key variables (Table 1). Differences in discrimination across ethnic/racial groups were explored with ANOVA techniques and any significant differences were explored using Scheffé posthoc analyses given the unequal group sizes. There were no significant differences in the retrospective measure of the EDS, but the daily EDS measure revealed significant differences ($F(2) = 4.57$, $p = .013$), such that Latinx students ($x\cdot\cdot = 02$) reported significantly higher levels of discrimination than White students ($x\cdot\cdot = 01$), with Asian students not significantly different from either group ($x\cdot\cdot = 02$). In comparison to White students, effect sizes for the retrospective EDS were higher for Asian students than Latinx students (.34 and .28 respectively) and for the daily measure of EDS were lower for Asian students than Latinx students (0.38 and 0.61 respectively).

There were no gender differences in discrimination measures. There were no differences in HCC by ethnicity/race or gender, however, based on meta-analytic work [20] both were covaried in the analyses. In comparison to White students, effect sizes for HCC levels were higher for Asian students than Latinx students (0.68 and 0.21 respectively). Correlations for the key study variables can be found in Table 2.

Table 1
Study descriptives.

	N = 83			
	N	%	M	SD
Age	83		17.65	.48
Gender	83			
Female	57	68.7		
Male	26	31.3		
Other	–	–		
Ethnicity/Race	83			
Asian	20	24.1		
Latinx	17	20.5		
White	46	55.4		
Nativity	83			
Born in the U.S.	70	84.3		
Discrimination measures				
EDS Baseline	83		1.21	.99
No discrimination	8	9.6		
Discrimination	75	90.4		
EDS Daily	81		.02	.03
No discrimination	41	50.6		
Discrimination	40	49.4		
Hair cortisol				
Raw (pg/mg Winsorized)	83		12.52	6.52
Winsorized and log transformed	83		2.40	.52

3.2. Association between discrimination and hair cortisol concentration

To test the primary aim of the study, investigating associations between discrimination and HCC, two multivariable regression models were estimated with HCC as the outcome and gender, hair treatment status, and ethnicity/race as covariates, the first model including past year discrimination as an independent variable (See Table 3) and the second model including daily discrimination (See Table 4). As hypothesized, discrimination *over the past year* significantly predicted HCC ($\beta = 0.224$, $p = .045$).; however, daily discrimination was not associated with HCC ($\beta = 0.162$, $p = .151$).

4. Discussion & conclusion

Discrimination remains a pervasive and chronic threat. Hair cortisol concentration is an emerging indicator of the chronic stress related to discrimination. The current study presents some of the first evidence linking different time frames of self-reported discrimination with HCC levels, and contributes to existing research that links lifetime discrimination to HCC levels [32]. Taking into account gender, hair treatment status, and ethnicity/race, retrospective self-reported discrimination measured over the past year was significantly associated with chronic stress assessed via hair cortisol concentration. On the other hand, daily experiences of discrimination were not associated with HCC.

It is important to note that there are currently only a handful of studies linking discrimination with HCC levels and neuroendocrine functioning [32,37,38,42]. The current study contributes to this growing body of evidence by trying to pinpoint the timeframe of discrimination exposure and HCC levels. This observation contributes to a growing interest in social determinants of health by providing researchers with the appropriate methodological tools for mapping their timeframe of interest with the appropriate biological assessment. For example, a researcher who is interested in acute discrimination stress may opt for more real-time assessments such as heart-rate variability, salivary cortisol, blood pressure or galvanic skin response [27,43–45]. In contrast, a researcher interested in chronic discrimination stress might consider assessing HCC, telomeres or inflammatory markers [11,32,46,47]. Taken together, the results provide support for incorporating HCC assessment as a biological marker of retrospective discrimination. We did not find HCC differences by ethnic/racial group; however, our sample size was limited to detect possible differences. While it is possible this indicates that our findings are not due to differences at this person level and rather due to a link with self-reported discrimination experiences, further research is necessary to confirm these findings.

This study included limitations. The demographic makeup of our sample, with half identifying as White and recruited from only one school, limit the generalizability of our findings beyond this context, particularly as reasons for discrimination were not assessed and cannot be attributed exclusively to ethnicity/race [38]. Our sample size also limits our ability to consider interaction effects by ethnicity/race and has implications for testing statistical significance. Future research, with larger samples, are necessary to elucidate these relationships. The 14-day data collection window for daily discrimination was not long enough to observe associations with HCC, raising the possibility that longer-term (e.g., 1–3 month) daily assessments should observe a stronger association with HCC levels.

Despite these limitations, this study offers a glimpse into neuroendocrine pathways that may link individual-level social experiences with population-level health patterns. Shorter telomere length has been tied to racial discrimination over a ten-year period among African Americans [11], indicating that these targeted negative interpersonal experiences can, over time, accumulate and lead to premature biological aging. Our findings indicate that even for young adults, reports of discrimination over the past year are associated with objective evidence of stress.

Table 2
Correlation table.

	Age	Gender	Ethnicity	Hair treatments	EDS Baseline	EDS Daily	Hair cortisol
Age	–						
Gender	.159	–					
Ethnicity	.002	.019	–				
Hair treatments	-.224*	.186^{+}	-.211^{+}	–			
EDS Baseline	-.157	.138	-.145	.147	–		
EDS Daily	-.068	-.057	-.226*	.062	.301**	–	
Hair cortisol	.201^{+}	.031	-.242*	.031	.250*	.209^{+}	–

$^{+}$ $p < .10$ *$p < .05$ **$p < .01$.

Table 3
Multivariate linear regression with past-year EDS as a predictor.

	Unstandardized B	Standardized β	95% CI		p
Hair treatment status	-.059	-.051	-.315	.197	.648
Gender	.015	.014	-.227	.258	.899
Ethnicity	-.092	-.220	-.184	.000	.050
EDS Baseline	.116	.224	.003	.230	.045

Table 4
Multivariate linear regression with daily EDS as a predictor.

	Unstandardized B	Standardized β	95% CI		p
Hair treatment status	-.062	-.054	-.325	.201	.639
Gender	.072	.064	-.175	.318	.566
Ethnicity	-.099	-.237	-.194	-.004	.042
EDS Daily	2.976	.162	−1.115	7.068	.151

Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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