Hormones and Behavior 80 (2016) 76–81

Contents lists available at ScienceDirect

Hormones and Behavior

journal homepage: www.elsevier.com/locate/yhbeh

Everyday discrimination and diurnal cortisol during adolescence☆

Virginia W. Huynh [a,*], Shu-Sha Angie Guan [a], David M. Almeida [b], Heather McCreath [c], Andrew J. Fuligni [d,e,f]

[a] *Department of Child and Adolescent Development, California State University, Northridge, United States*
[b] *Department of Human Development and Family Studies, Pennsylvania State University, United States*
[c] *David Geffen School of Medicine, University of California, Los Angeles, United States*
[d] *Department of Psychology, University of California, Los Angeles, United States*
[e] *Department of Psychiatry and Biobehavioral Sciences, University of California, Los Angeles, United States*
[f] *Semel Institute for Neuroscience and Human Behavior, University of California, Los Angeles, United States*

ARTICLE INFO

Article history:
Received 28 May 2015
Revised 15 December 2015
Accepted 29 January 2016
Available online 4 February 2016

Keywords:
Everyday discrimination
Adolescents
HPA activity
Cortisol
Ethnicity

ABSTRACT

Purpose: To examine the associations of the frequency and type of everyday discrimination with diurnal cortisol and whether those associations depend upon adolescents' ethnicity and gender.
Methods: Adolescents ($N = 292$, $M_{age} = 16.39$ years, $SD = 0.74$; 58% female) reported the frequency of perceived everyday discrimination and whether they attributed that discrimination to race, gender, age, or height and weight. Five saliva samples were collected per day across 3 days and assayed for cortisol.
Results: Higher frequency of everyday discrimination was associated with greater total daily cortisol output (area under the curve; AUC), lower wake and bedtime levels of cortisol, and less of a decline in cortisol across the day. These associations generally did not depend upon ethnicity or gender and attributions for the discrimination were not as consequential as the actual frequency of any type of unfair treatment.
Conclusion: Everyday discrimination, regardless of its type, may contribute to heightened HPA activity among adolescents of different ethnic backgrounds and genders.

As a period marked by sensitivity to social evaluation, adolescence represents a time when differential treatment according to social categories such as race and gender is of particular concern. Recent research on discrimination and health—long dominated by studies of adults—has documented how perceptions of unfair treatment have negative implications for psychological and physical well-being during the teenage years (Huynh, 2012; Huynh and Fuligni, 2010). A candidate biological system for understanding these effects is the hypothalamic-pituitary-adrenal (HPA) axis. HPA activity, as measured by the stress hormone cortisol, is particularly reactive during the adolescent years and is sensitive to the social-evaluative stress that characterizes discrimination (Dickerson and Kemeny, 2004; Romeo, 2013). Dysregulated HPA activity predicts chronic psychological (e.g., depression; Pariante, 2003) and physical (e.g., cardiovascular disease; Kumari et al., 2011) problems later in adulthood, highlighting the value of examining the link between discrimination and cortisol during adolescence.

In this current study, we explore associations between discrimination and HPA regulation by including measures of total cortisol output and examining the pattern across a day to provide insight to when dysregulation may take place. A typical cortisol pattern across the day is characterized by high morning wake levels, increasing to a peak 30 min after wake (i.e., cortisol awakening response [CAR]), a subsequent steep decline across the day, and ending with bed time levels much lower than that of wake levels (J. C. Pruessner et al., 1997; Wüst et al., 2000). We assess total daily cortisol output by measuring the area under the curve (AUC), which is the average total cortisol output during the day and may reflect past exposure to frequent or severe stress. AUC has been found to be associated with individual level stressors (e.g., lower SES and immigrant status; Gustafsson et al., 2006) and daily stressors (e.g., spent more time than usual in school; McHale et al., 2012) among adolescents. An increased CAR suggests anticipation of negative, stressful events (Kunz-Ebrecht et al., 2004; Schlotz et al., 2004). A flatter decline has been found to be associated with worse psychological (e.g., more depressive symptoms and lower feelings of control; Cohen et al., 2006) and physical adjustment (e.g., risk for cardiovascular disease; Matthews et al., 2006).

Although recent work has suggested that racial discrimination during adolescence is predictive of cortisol levels during adulthood (Adam et al., 2015), only three recent studies have examined the existence of a link between discrimination and dysregulated HPA activity during adolescence. Zeiders et al. (2012) observed that Mexican American adolescents who reported frequent racial discrimination showed higher levels of total cortisol daily output. Examining the

☆ Implications and contributionAdolescents who perceive discrimination in their daily lives—whether because of their race, gender, age, or physical size—experience elevated levels of HPA activity. Such perceptions of unfair treatment have potential implications for health.

* Corresponding author at: 18111 Nordhoff Street, Northridge, CA 91330-8263, United States.
E-mail address: Virginia.huynh@csun.edu (V.W. Huynh).

http://dx.doi.org/10.1016/j.yhbeh.2016.01.009
0018-506X/

dynamic change in cortisol across the day, Skinner et al. (2011) reported that among a sample of White and Black young adults (ages 19–22) greater perceived discrimination was associated with a flatter diurnal rhythm of cortisol, a deviation from the typical steep daily decline. An additional study noted that ethnically-diverse adolescents who experienced more discrimination showed exaggerated cortisol elevations in response to negative daily affect (Doane and Zeiders, 2014).

Previous research has established a link between discrimination and HPA activity. What remains to be discovered is whether the type of discrimination matters. Studies with both adult and adolescent populations primarily focus on gender or racial discrimination. However, unfair treatment also can arise from factors such as age and physical stature. Numerous pejorative labels surround the adolescent period (e.g., untrustworthy, unmanageable, and lazy) and teenagers may report feeling mistreated because of these stereotypes (Gross and Hardin, 2007; Zebrowitz and Montepare, 2003). Those who are overweight or of short stature can experience unfair treatment because of the social value placed on thinness and height (Andreyeva et al., 2008). A recent meta-analysis (Schmitt et al., 2014) found concealable (e.g. mental illness) and controllable (e.g., weight) stigmas had stronger effect sizes on psychological well-being than unconcealable and uncontrollable stigmas (e.g., race and gender). Two of the previously-mentioned studies of discrimination and cortisol among adolescents examined only racial and ethnic discrimination, an unconcealable and uncontrollable stigma (Skinner et al., 2011; Zeiders et al., 2012) and one did not specify (Doane and Zeiders, 2014). This current study considers other categories of unfair treatment and their implications for HPA activity. Further, research on discrimination in general have only examined attributions at a scale level (i.e., asked "What do you think is the main reason for these experiences?"). Examining whether unfair treatment is attributed to different reasons offers the opportunity to determine the differential effects on HPA activity. This current study is one of the first to examine whether attributions of discrimination are differentially associated with adolescent HPA activity.

It is also unclear whether the impact of discrimination is unique to some ethnic and gender groups. A study of young adults suggested that the implications of discrimination for HPA activity was specific to ethnic minorities (Zeiders et al., 2014), but previous studies of adolescents from a single ethnic group observed linkages in several ethnic groups (i.e., African American, European American, Latino) and both genders (Doane and Zeiders, 2014; Skinner et al., 2011; Zeiders et al., 2012). We aimed to contribute to the literature by directly examining variations across multiple ethnic and gender groups within the same study.

Materials and methods

Sample

Participants were recruited though mailings and presentations made in 10th and 11th grade classrooms in four public high schools in the Los Angeles area. These schools were chosen because they were composed of a large population of students from either Asian, European or Latin American backgrounds. In the first two schools, there was a majority of Asian (43%, 57%) and Latino (50%, 40%) students. In the third and fourth schools, there was a majority of Latino (38%, 23%) and White (51%, 63%) students. All 10th and 11th graders and their parents were invited to participate and notified via classroom presentations and family mailings. Of the 316 adolescents who provided assent and parental consent, 293 ($M_{age} = 16.39$ years, $SD = 0.74$; 58% female) provided adequate saliva samples and had complete data for key variables. Adolescents came from Latin American (42%), European (29%), Asian (23%), and other ethnic backgrounds (6%), and according the primary caregivers, the families had a range of household incomes (M = \$71,374, median = \$51,500, SD = \$78,322, range = \$0–\$825,000). Median income was 10% lower than that of the Los Angeles area (\$57,271) at the time of the study in 2012 (U.S. Census Bureau, 2013).

Procedures

All procedures were approved by the UCLA Institutional Review Board. During a home visit, adolescents completed a computer-assisted questionnaire and interviewers measured height and weight. Adolescents were provided with saliva collection kits that included labeled and color-coded Salivettes (Sarstedt, Nümbrecht, Germany), a kitchen timer to assist with the timing of morning samples, an electronic date/time stamper (Dymo, Berkeley, California), a stamping booklet to document saliva collection, and a morning checklist to report wake times.

Saliva collection began on the following day, for three consecutive days. Participants were instructed about providing saliva samples and recording the collection time in the stamping booklet with the time stamper. They were also instructed not to eat, drink or brush their teeth 30 min before collection. During the initial visit, participants reported their expected schedules for the week. Using this information, interviewers scheduled and sent text message reminders through a commercial, bulk text messaging service (Red Oxygen, San Francisco, CA). Upon completion of the protocol, interviewers picked up the completed kits and adolescents received \$50 and two movie tickets. A total of 98% of participants ($n = 308$) provided at least one saliva sample and 96.2% ($n = 304$) provided all 5 saliva samples for at least one day.

Measures

Everyday discrimination

Participants responded to 10 items with the prompt, "In your day-to-day life, over the last 12 months, how often have any of the following things happened to you" (Williams et al., 2008) on a four-point scale (1 = never, 2 = once, 3 = 2 or 3 times, 4 = 4 or more times). Example questions include "You have been treated with less courtesy than other people" and "You have received poorer service than other people at restaurants or stores." This expanded version of the original 9-item measure (Williams et al., 1997), which included the item "you are followed around in stores", has been validated with Latino populations (Krieger et al., 2005). Because we were interested in actual frequency in the past year, we used different anchors from the original measure (a 6-point scale ranging from never to almost everyday). We computed an average frequency of general everyday discrimination by taking the mean of the scores on the 10 items. The measure demonstrated good internal consistency ($\alpha = 0.84$) in the current study.

In prior uses of this measure, respondents typically have been asked one question at the end about their primary attribution (e.g., ethnicity and gender) for all of the discriminatory experiences listed in the measure. We were interested in the variability of different types of attributions, so we revised the measure to ask an attribution for every single item. For each item rated "2" or above, participants indicated whether they attributed the discrimination to one of the following categories that we selected from attributions in the original scale to be the most common and salient to adolescents: gender, race, age, or height or weight. We calculated the number of times across the 10 items participants attributed discrimination to each particular category (e.g., a participant who attributed two discrimination experiences to gender received a score of 2 for gender discrimination). Attribution scores, therefore, could range from 0 to 10 and those who never reported a particular attribution and those who reported "never" for all of the 10 items were scored 0.

Salivary cortisol

Adolescents provided five saliva samples at designated times for three consecutive days: wake (sample 1), 15 min after wake (sample

2), 30 min after wake (sample 3), before dinner (sample 4), and at bed time (sample 5). Participants recorded samples in their stamping booklet with the electronic date/time stamper.

Saliva samples were frozen and stored at −20 degrees C until shipped on dry ice to be assayed by Biochemisches Labor, Unversitaet Trier, Germany. After thawing, salivettes were centrifuged at 3000 rpm for 5 min, which resulted in a clear supernatant of low viscosity. Salivary concentrations were measured using commercially available chemiluminescence-immunoassay with high sensitivity (IBL International, Hamburg, Germany). The intra and interassay coefficients for cortisol were below 8%. Samples with cortisol values over 60 ($n = 14$) were removed (Stawski et al., 2013) and raw cortisol values were log-transformed. Morning samples in which participants reported more than 30 min between sample 1 and sample 2 ($n = 12$) or more than 60 min between collecting sample 1 and sample 3 ($n = 10$) for a particular day were flagged. Analyses excluding these cases did not change the results, therefore these samples were not excluded from the final analyses.

Adolescents provided three days of cortisol samples on different days of the week. Only weekday samples were included in the analyses. In addition to examining associations with cortisol levels at wake and bedtime, we calculated the cortisol awakening response (CAR), the linear decline from wake, and total daily cortisol output (AUC). AUC with respect to ground was only calculated for days where participants had all five cortical samples across the day, and used the trapezoid formula (Jens C Pruessner et al., 2003). CAR was calculated by subtracting sample 3 (30 min after wake) from sample 1 (wake), and dividing by the time between samples. To calculate decline from wake, sample 5 (bed) was subtracted from sample 1 (wake), and this was divided by the time between samples. CAR and decline represent the average hourly rate of change in cortisol. Our cortisol parameters were log transformed and then averaged across the three days.

Wake time

Participants reported when they awoke in the morning of each study day. Wake times were converted to hours in military time ($M = 6.95$, $SD = 1.37$) and controlled for in all models given that cortisol rhythms are significantly influenced by sleep-wake cycles (Adam and Kumari, 2009).

Body mass index (BMI)

Research staff assessed participants' height and weight. BMI was calculated by dividing weight by the square of height (i.e., kg/M^2).

Results

Descriptive statistics and correlations

As shown in the last row of Table 1, everyday discrimination was infrequent (42 participants reported “never” on all items) and adolescents were more likely to attribute discrimination to their age and race than to their gender or height/weight, $ts(292) = 3.13–5.84$, $ps < 0.05$ after Bonferroni correction. Discrimination frequency was associated with lower waking levels of cortisol, less of a daily decline, and greater bedtime levels. Attributions to gender were associated with greater AUC and bedtime levels of cortisol.

There were no gender or ethnic differences in the frequency of everyday discrimination (see Table 2). Females were more likely to attribute discrimination to gender than males, $t(291) = 4.77$, $p < 0.001$. Adolescents from Latin American and Asian backgrounds were more likely to attribute discrimination to race than those with European backgrounds, and adolescents from European and Asian backgrounds were more likely to attribute discrimination to age than their Latin American peers, $F(3, 289) = 4.91–7.63$, $ps < 0.01$.

Discrimination frequency, attributions, and cortisol

Multiple regressions estimated the association between frequency of discrimination and the parameters of diurnal cortisol after controlling for average wake time, ethnicity, gender, age, and BMI ($ns = 255–286$). As shown in the last row of Table 3, a higher frequency of discrimination was associated with greater AUC, lower waking cortisol, greater bedtime cortisol, and a flatter daily decline. Girls evidenced higher AUC, waking, and bedtime levels of cortisol.

Attributions were added to the model in order to estimate whether they predicted levels of cortisol above and beyond the average frequency. Out of a total of 20 estimates across all attributions and cortisol parameters, only one was statistically significant. Attributing discrimination to ethnicity ($b = -0.14$, $SE = 0.06$, $p = 0.03$) was associated with lower bedtime cortisol. All of the originally significant associations between frequency of discrimination and cortisol shown in Table 3 remained significant with all attributions in the models (see Table 4), and the link between frequency and CAR became marginally positive after the inclusion of attributions.

Ethnic and gender variability in the associations

We first examined the interactions of discrimination frequency with ethnicity and gender by adding appropriate interaction terms to the

Table 1
Descriptive statistics and bivariate correlations.

	1	2	3	4	5	6	7	8	9	10
Discrimination										
1. Frequency	1									
2. Age att	0.36^{***}	1								
3. Race att	0.51^{***}	−0.05	1							
4. Gender att	0.32^{***}	0.06	0.00	1						
5. Height/weight att	0.28^{***}	0.07	0.01	0.04	1					
Cortisol parameters										
6. Total output (AUC)	0.12+	−0.00	0.02	0.13^{*}	−0.04	1				
7. Wake	-0.18^{**}	−0.09	−0.04	0.03	−0.11+	0.12+	1			
8. Bed	0.13^{*}	0.05	−0.06	0.15^{*}	−0.01	0.52^{***}	0.02	1		
9. CAR	0.06	−0.07	0.02	0.08	−0.04	0.32^{***}	-0.53^{***}	−0.09	1	
10. Decline	-0.14^{*}	−0.02	0.03	−0.11+	−0.06	-0.47^{***}	0.47^{***}	-0.63^{***}	-0.41^{***}	1
M(*SD*)	1.74(0.60)	1.24(1.60)	1.00(1.79)	0.61(1.23)	0.60(1.12)	27.47(8.81)	2.77(0.54)	0.63(0.93)	0.50(1.50)	0.15(0.07)
N	293	293	293	293	293	258	292	292	268	268

Note. “Frequency” refers to the overall frequency of discrimination, regardless of attribution, on a scale from 1 to 4. “Att” refer to the number of discrimination experiences attributed to a particular reason, with a potential range of 0–10. All cortisol parameters are log-transformed values.
* $p < 0.05$.
** $p < 0.01$.
*** $p < 0.001$.

Table 2
Gender and ethnic differences.

	Gender M (SD)		Ethnic background M (SD)			
	Male ($n = 123$)	Female ($n = 170$)	Latin American ($n = 123$)	Asian ($n = 67$)	European ($n = 86$)	Other ($n = 17$)
Discrimination frequency	1.75 (0.66)	1.73 (0.56)	1.76 (0.64)	1.79 (0.59)	1.66 (0.54)	1.74 (0.67)
Discrimination attributions						
Age	1.25 (1.66)	1.23 (1.55)	0.83 (1.36)	1.57 (1.75)	1.49 (1.60)	1.65 (1.97)
Race	1.08 (2.02)	0.95 (1.60)	1.36 (2.28)	1.24 (1.49)	0.26 (0.81)	1.29 (1.36)
Gender	0.22 (0.64)	0.89 (1.46)	0.62 (1.11)	0.64 (1.29)	0.63 (1.41)	0.29 (0.85)
Height/Weight	0.67 (1.30)	0.54 (0.98)	0.52 (0.92)	0.63 (0.97)	0.64 (1.41)	0.76 (1.44)

Note. "Discrimination frequency" refers to the overall frequency of discrimination, regardless of attribution, on a scale from 1 to 4. "Attributions" refer to the number of discrimination experiences attributed to a particular reason, with a potential range of 0–10.

models tested in Table 3. Out of a total of 35 interactions (6 ethnicity and 1 gender interactions × 5 cortisol parameters), only three were significant. Results indicate that the association between discrimination and wake and decline significantly differed between Latino and European youth ($ps < 0.05$). Simple slope analyses indicated that whereas more discrimination was associated with lower waking cortisol and flatter decline among teenagers from European backgrounds ($b = -0.20$, $SE = 0.06$, $p = 0.002$; $b = -0.02$, $SE = 0.01$, $p = 0.04$, respectively), these associations were not present among Latino youth ($b = -0.04$, $SE = 0.05$, $p = 0.38$; $b = 0.00$, $SE = 0.01$, $p = 0.76$).

The association between discrimination frequency and decline differed by gender ($p = 0.009$). Simple slope analyses indicated that the association between discrimination frequency and a flatter decline was significant for males ($b = 0.02$, $SE = 0.01$, $p = 0.02$), but not females ($b = -0.00$, $SE = 0.01$, $p = 0.78$).

In order to test ethnic and gender variability in the associations between attributions and the cortisol parameters, we focused on only attributions to race/ethnicity and gender because (a) they were most theoretically-meaningful for potential variations by ethnicity and gender and, (b) to avoid chance findings that could occur from testing all of the possible interactions with all attributions measures. Out of 30 possible interactions between race/ethnicity attributions and ethnicity, a total of 4 were significant. Ethnic attributions were associated with lower AUC for Latino adolescents ($b = -1.35$, $SE = 0.49$, $p = 0.007$), who differed from other ethnic teens ($b = 7.54$, $SE = 2.32$, $p = 0.02$) and Asian teens ($b = 1.64$, $SE = 0.95$, $p = 0.09$). Ethnic attributions were also associated with steeper decline for Latino adolescents ($b = 0.01$, $SE = 0.00$, $p = 0.02$), who differed from their other ethnic peers ($b = -0.05$, $SE = 0.01$, $p = 0.01$). Other ethnic minority youth also differed on decline from their peers from European backgrounds ($b = 0.02$, $SE = 0.02$, $p = 0.17$).

None of the 5 interactions between attributions to gender and gender were significant.

Discussion

Everyday discrimination occurred relatively infrequently, but adolescents who perceived higher rates of such unfair treatment evidenced elevated levels of cortisol across the day. This is consistent with three recent studies (Doane and Zeiders, 2014; Skinner et al., 2011; Zeiders et al., 2012), providing converging evidence that the discrimination-health risk link during adulthood may begin as early as adolescence. The heightened cortisol output was due largely to less of a decline in cortisol across the day as evidenced by lower wake and higher bedtime levels. A flatter decline has been linked to psychological stress (Emma K Adam et al., 2006) and maladjustment (e.g., depressive symptoms and lower feelings of control; Cohen et al., 2006). There are also health implications given associations between a flatter decline and cardiovascular risk and breast cancer mortality (Emma K. Adam and Kumari, 2009; Cohen et al., 2006; Matthews et al., 2006; Sephton et al., 2000).

Our novel measurement of different types of discrimination is an improvement from prior studies that ask participants to identify the main reason for unfair treatment because we examined what attributions are more frequent and whether they differentially impact HPA activity. Our results indicate that attributions may not matter as much as the frequency of any type of discrimination. Although attributions to age and race were most common, there was no clear pattern associated with the type of attributions and the cortisol parameters (e.g., age

Table 3
Associations between frequency of discrimination and cortisol.

	AUC		Wake		Bed		CAR		Decline	
	b	*SE*	*b*	*SE*	*b*	*SE*	*b*	*SE*	*b*	*SE*
Intercept	26.59***	1.2	2.70***	0.07	0.58***	0.12	0.36+	0.20	0.16***	0.01
Wake time	−1.56**	0.55	−0.02	0.03	0.10+	0.06	−0.08	0.09	0.00	0.00
Asian	−1.68	1.62	−0.15	0.10	−0.08	0.16	−0.15	0.27	−0.01	0.01
Latino	−1.56	1.38	0.02	0.08	−0.18	0.14	−0.06	0.24	0.00	0.01
Other	−4.16+	2.5	−0.26+	0.15	−0.26	0.25	0.16	0.43	0.02	0.02
Female	3.52**	1.09	0.22**	0.06	0.27*	0.11	0.29	0.19	−0.01	0.01
Age	−1.07+	0.55	−0.04	0.03	−0.05	0.05	−0.11	0.09	0.00	0.00
Income	0.54	0.58	−0.01	0.04	0.03	0.06	0.04	0.10	0.00	0.01
BMI	−0.06	0.57	−0.01	0.03	0.14*	0.06	−0.12	0.10	0.00	0.01
Discrimination	1.23*	0.53	−0.09**	0.03	0.11*	0.05	0.10	0.09	−0.01*	0.00
N	255		286		286		263		264	

Note. Cortisol values were log-transformed. CAR (cortisol awakening response) and decline were centered at waking, and represent the hourly rate of change in cortisol levels. Ethnicity and gender were dummy-coded with youth with European backgrounds and males as the baseline. Wake time, age, income and discrimination variables were centered at the sample mean.

+ $p < 0.10$.
* $p < 0.05$.
** $p < 0.01$.
*** $p < 0.001$.

Table 4
Associations between attributions of discrimination and cortisol.

	AUC		Wake		Bed		CAR		Decline	
	b	*SE*	*b*	*SE*	*b*	*SE*	*b*	*SE*	*b*	*SE*
Intercept	26.52***	1.25	2.72***	0.07	0.57***	0.12	0.40+	0.21	0.16***	0.01
Wake time	−1.59**	0.56	−0.02	0.03	0.10+	0.06	−0.06	0.10	0.01	0.00
Asian	−1.20	1.67	−0.18+	0.10	0.01	0.16	−0.11	0.28	−0.01	0.01
Latino	−1.45	1.47	−0.01	0.08	−0.14	0.14	−0.10	0.25	0.00	0.01
Other	−3.42	2.56	−0.28+	0.15	−0.14	0.25	0.26	0.44	0.01	0.02
Female	3.38**	1.14	0.21**	0.07	0.22+	0.11	0.25	0.20	−0.01	0.01
Age	−1.04+	0.55	−0.05	0.03	−0.04	0.05	−0.10	0.09	0.00	0.00
Income	0.58	0.58	−0.01	0.04	0.03	0.06	0.05	0.10	0.00	0.01
BMI	0.14	0.60	0.00	0.04	0.17**	0.06	−0.11	0.10	0.00	0.01
Discrimination	2.10**	0.80	−0.12*	0.05	0.22**	0.08	0.24+	0.14	−0.02*	0.01
Attributions										
Age	−0.59	0.62	0.01	0.04	−0.06	0.06	−0.19+	0.11	0.01	0.01
Race	−0.89	0.69	0.05	0.04	−0.16*	0.07	−0.09	0.12	0.01*	0.01
Gender	0.02	0.62	0.02	0.04	0.05	0.06	0.01	0.10	0.00	0.01
Height/weight	−0.80	0.57	−0.02	0.03	−0.10+	0.06	−0.09	0.10	0.00	0.01
N	255		286		286		263		265	

Note. Cortisol values were log-transformed. CAR (cortisol awakening response) and decline were centered at waking, and represent the hourly rate of change in cortisol levels. Ethnicity and gender were dummy-coded with youth with European backgrounds and males as the baseline. Wake time, age and discrimination variables were centered at the sample mean.
+ $p < 0.10$.
* $p < 0.05$.
** $p < 0.01$.
*** $p < 0.001$.

attributions associated with lower CAR; race attributions associated with lower bedtime levels). This finding is noteworthy because much of the scholarship on the implications of discrimination on health has focused on ethnic or racial discrimination. Our results suggest that that unfair treatment due to a variety of reasons—age, race, gender, height or weight—could be consequential for adolescent health. This generalized reaction to any type of unfair treatment may be particular to adolescence because (a) cortisol responses are stronger in response to social-evaluative threat in which individuals could be negatively judged by others (Dickerson and Kemeny, 2004), (b) social evaluation is particularly salient during adolescence (Somerville, 2013), and (c) HPA reactivity is heightened during this period (Romeo, 2013). Alternatively, there may be other unmeasured person characteristics (e.g., external attribution style) that may explain why there were no differences by attribution category. Future work should include person characteristics (e.g., negative affect and attribution tendencies), examine whether some attributions are more important than others among other populations, and include other categories (e.g., religion, sexual orientation, and social class). For instance, there is some evidence that unfair treatment due to race is more salient than other social identities (e.g., social class, age, and gender) among Asian American college students (Wang et al., 2011).

Further, our study directly compared the implications of discrimination for HPA activity among adolescents from multiple ethnic groups. We conducted a total of 65 gender and ethnic interactions, and the 7 significant results were inconsistent. At times Latino youth appear to be less affected by discrimination (e.g., general discrimination associated with lower wake cortisol and marginally flatter among White but not Latino youth), but more affected by ethnic attributions specifically (e.g., associated with lower AUC and a steeper decline). Given the risk of Type I error, more studies need to replicate these results before further interpretation. Our findings suggest that the association between discrimination and various cortisol parameters is generally the same across groups. Despite Latino and Asian American adolescents attributing more discrimination to race than their European American peers, and females attributing more discrimination to gender than males, the associations between discrimination and atypical cortisol patterns were not stronger for ethnic minority and female adolescents.

These results suggest that even ethnic discrimination can be consequential for members of the majority group if they feel that they are not being treated fairly because of their race. In contrast, a recent study of young adults ($M_{age} = 22.8$ years) reported that the association between discrimination and cortisol existed only for members of ethnic minority groups, not European Americans (Zeiders et al., 2014). One explanation for these divergent findings is that, compared to adolescents, ethnic minority young adults may differentially attribute unfair treatment to race (Wang et al., 2011), but also may be differentially impacted by discrimination. Zeiders et al. (2014) did not measure racial discrimination specifically, but found that whereas 24% of ethnic minority young adults attributed discrimination to race, only 5% of ethnic majority young adults did (gender was the most common attribution by ethnic majority young adults). By sampling multiple ethnic groups and explicitly testing for variation according to ethnicity, our results suggest that ethnic differences may be present, but not in an obvious way. Indeed, others have observed the association between discrimination and cortisol parameters regardless of the specific ethnic group included (Doane and Zeiders, 2014; Skinner et al., 2011; Zeiders et al., 2012). Further, studies on the associations of discrimination with psychological and academic outcomes also did not find moderation by ethnic group (Huynh and Fuligni, 2010). Taken together, these ideas indicate that any kind of unfair treatment can trigger the HPA axis and can be similarly consequential for teenagers from different backgrounds. Yet, because ethnic minority youth report more frequent discrimination, they may be more impacted by it over time. Consistent with this, a recent study found higher racial discrimination during adolescence is associated with stress biology in adulthood, and these effects were more pervasive for Black than White adults (Adam et al., 2015).Future research should examine whether clear patterns emerge, over time, regarding the effects of discrimination on cortisol parameters of different ethnic groups.

Limitations

Daily reports of discrimination and cortisol would provide stronger evidence for this association than our measure of discrimination that assesses frequency over 12 months. However, one daily diary study found that ethnic discrimination occurred < 1% of days over a two-week period (Huynh and Fuligni, 2010). Given how infrequent everyday discrimination is, measuring daily discrimination may be resource intensive because it would require at least one month of daily reports and the corresponding cortisol measures. Another limitation is how attributions are measured. Adolescents can attribute unfair treatment to categories other than ones we listed, and it is also likely that multiple social categories (e.g., being a woman and Latina) contribute collectively to the experiences of individuals (Cole, 2009). Nevertheless, our study is one of the first to examine how discrimination may be attributed to different categories and how these attributions may be associated to adolescent health. Because adolescents contend with multiple social identities, it was valuable to examine how attributions to discrimination were distributed rather than simply asking the main reason for these experiences. Finally, our results may be unique to our sample in Southern California, as our participants were drawn from areas with a high percentage of Latino youth and few African American youth. The frequency of discrimination and attributions to race or ethnicity may be higher in areas where youth are the clear ethnic minority or when differential treatment by ethnicity and race is made more salient by social movements and historical events. It is also possible that with larger subsamples, we would have more power to detect differences in the effect of attributions by gender and ethnicity.

Conclusions

In conclusion, the current study adds to the small, emerging body of research on discrimination and HPA activity during adolescence by suggesting that perceiving unfair treatment due to one's membership in several social categories (e.g., race, gender, age, and weight) can elevate diurnal cortisol levels among adolescents from different ethnicities and genders. Continuing research should focus on potential psychological mediators of this dynamic, but our study joins other recent research to suggest that HPA dysregulation may be a key pathway by which everyday discrimination can get under the skin and compromise adolescent health.

Acknowledgements

This research was supported by funding from the Eunice Kennedy Shriver National Institute of Child Health and Human Development (R01-HD062547), the UCLA California Center for Population Research, which is supported by the National Institute of Child Health and Human Development (R24-HD04102r2), the UCLA Older Americans Independence Center, which is supported by the National Institute of Aging (P30-AG028748), and the by NIH Research Infrastructure in Minority Institutions from the National Institute of Minority Health and Health Disparities (P20 MD003938). The content does not necessarily represent the official views of the National Institute of Child Health and Human Development, the National Institute of Aging, or the National Institutes of Health.

References

Adam, E.K., Kumari, M., 2009. Assessing salivary cortisol in large-scale, epidemiological research. Psychoneuroendocrinology 34 (10), 1423–1436.
Adam, E.K., Heissel, J.A., Zeiders, K.H., Richeson, J.A., Ross, E.C., Ehrlich, K.B., ... Malanchuk, O., 2015. Developmental histories of perceived racial discrimination and diurnal cortisol profiles in adulthood: A 20-year prospective study. Psychoneuroendocrinology 62, 279–291.
Adam, E.K., Hawkley, L.C., Kudielka, B.M., Cacioppo, J.T., 2006. Day-to-day dynamics of experience—cortisol associations in a population-based sample of older adults. Proc. Natl. Acad. Sci. 103 (45), 17058–17063.
Andreyeva, T., Puhl, R.M., Brownell, K.D., 2008. Changes in perceived weight discrimination among Americans, 1995–1996 through 2004–2006. Obesity 16 (5), 1129–1134.
Cohen, S., Schwartz, J.E., Epel, E., Kirschbaum, C., Sidney, S., Seeman, T., 2006. Socioeconomic status, race, and diurnal cortisol decline in the Coronary Artery Risk Development in Young Adults (CARDIA) study. Psychosom. Med. 68 (1), 41–50.
Cole, E.R., 2009. Intersectionality and research in psychology. Am. Psychol. 64 (3), 170.
Dickerson, S.S., Kemeny, M.E., 2004. Acute stressors and cortisol responses: a theoretical integration and synthesis of laboratory research. Psychol. Bull. 130 (3), 355.
Doane, L.D., Zeiders, K.H., 2014. Contextual moderators of momentary cortisol and negative affect in adolescents' daily lives. J. Adolesc. Health 54 (5), 536–542.
Gross, E.F., Hardin, C.D., 2007. Implicit and explicit stereotyping of adolescents. Soc. Justice Res 20 (2), 140–160.
Gustafsson, P.E., Gustafsson, P.A., Nelson, N., 2006. Cortisol levels and psychosocial factors in preadolescent children. Stress. Health 22 (1), 3–9.
Huynh, V.W., 2012. Ethnic microaggressions and the depressive and somatic symptoms of Latino and Asian American adolescents. J. Youth Adolesc. 1-16.
Huynh, V.W., Fuligni, A.J., 2010. Discrimination hurts: the academic, psychological, and physical well being of adolescents. J. Res. Adolesc. 20 (4), 916–941.
Krieger, N., Smith, K., Naishadham, D., Hartman, C., Barbeau, E.M., 2005. Experiences of discrimination: validity and reliability of a self-report measure for population health research on racism and health. Soc. Sci. Med. 61 (7), 1576–1596.
Kumari, M., Shipley, M., Stafford, M., Kivimaki, M., 2011. Association of diurnal patterns in salivary cortisol with all-cause and cardiovascular mortality: findings from the Whitehall II study. J. Clin. Endocrinol. Metab. 96 (5), 1478–1485.
Kunz-Ebrecht, S.R., Kirschbaum, C., Marmot, M., Steptoe, A., 2004. Differences in cortisol awakening response on work days and weekends in women and men from the Whitehall II cohort. Psychoneuroendocrinology 29 (4), 516–528.
Matthews, K., Schwartz, J., Cohen, S., Seeman, T., 2006. Diurnal cortisol decline is related to coronary calcification: CARDIA study. Psychosom. Med. 68 (5), 657–661.
McHale, S.M., Blocklin, M.K., Walter, K.N., Davis, K.D., Almeida, D.M., Klein, L.C., 2012. The role of daily activities in Youths' stress physiology. J. Adolesc. Health 51 (6), 623–628.
Pariante, C.M., 2003. Depression, stress and the adrenal axis. J. Neuroendocrinol. 15 (8), 811–812.
Pruessner, J.C., Wolf, O.T., Hellhammer, D.H., Buske-Kirschbaum, A., Von Auer, K., Jobst, S., ... Kirschbaum, C., 1997. Free cortisol levels after awakening: a reliable biological marker for the assessment of adrenocortical activity. Life Sci. 61 (26), 2539–2549.
Pruessner, J.C., Kirschbaum, C., Meinlschmid, G., Hellhammer, D.H., 2003. Two formulas for computation of the area under the curve represent measures of total hormone concentration versus time-dependent change. Psychoneuroendocrinology 28 (7), 916–931.
Romeo, R.D., 2013. The teenage brain the stress response and the adolescent brain. Curr. Dir. Psychol. Sci. 22 (2), 140–145.
Schmitt, M.T., Branscombe, N.R., Postmes, T., Garcia, A., 2014. The Consequences of Perceived Discrimination for Psychological Well-Being: A Meta-Analytic Review. Psychological Bulletin.
Schlotz, W., Hellhammer, J., Schulz, P., Stone, A.A., 2004. Perceived work overload and chronic worrying predict weekend–weekday differences in the cortisol awakening response. Psychosom. Med. 66 (2), 207–214.
Sephton, S.E., Sapolsky, R.M., Kraemer, H.C., Spiegel, D., 2000. Diurnal cortisol rhythm as a predictor of breast cancer survival. J. Natl. Cancer Inst. 92 (12), 994–1000.
Skinner, M.L., Shirtcliff, E.A., Haggerty, K.P., Coe, C.L., Catalano, R.F., 2011. Allostasis model facilitates understanding race differences in the diurnal cortisol rhythm. Dev. Psychopathol. 23 (4), 1167.
Somerville, L.H., 2013. The teenage brain sensitivity to social evaluation. Curr. Dir. Psychol. Sci. 22 (2), 121–127.
Stawski, R.S., Cichy, K.E., Piazza, J.R., Almeida, D.M., 2013. Associations among daily stressors and salivary cortisol: findings from the national study of daily experiences. Psychoneuroendocrinology 38 (11), 2654–2665.
U.S. Census Bureau, 2013. Household income 2012 (ACSBR/12-02) American Community Survey Briefs.
Wang, J., Leu, J., Shoda, Y., 2011. When the seemingly innocuous "stings": racial microaggressions and their emotional consequences. Personal. Soc. Psychol. Bull. 37 (12), 1666–1678.
Williams, D.R., Yu, Y., Jackson, J.S., Anderson, N.B., 1997. Racial differences in physical and mental health: socio-economic status, stress and discrimination. J. Health Psychol. 2 (3), 335–351.
Williams, D.R., Gonzalez, H.M., Williams, S., Mohammed, S.A., Moomal, H., Stein, D.J., 2008. Perceived discrimination, race and health in South Africa. Soc. Sci. Med. 67 (3), 441–452.
Wüst, S., Federenko, I., Hellhammer, D.H., Kirschbaum, C., 2000. Genetic factors, perceived chronic stress, and the free cortisol response to awakening. Psychoneuroendocrinology 25 (7), 707–720.
Zebrowitz, L.A., Montepare, J.M., Hull, J.G., 2003. Too young, too old: stigmatizing adolescents and elders. In: Heatherton, T.F., Kleck, R.E., Hebl, M.R. (Eds.), The Social Psychology of Stigma. Guilford Press, pp. 334–373.
Zeiders, K.H., Doane, L.D., Roosa, M.W., 2012. Perceived discrimination and diurnal cortisol: examining relations among Mexican American adolescents. Horm. Behav. 61 (4), 541–548.
Zeiders, K.H., Hoyt, L.T., Adam, E.K., 2014. Associations between self-reported discrimination and diurnal cortisol rhythms among young adults: the moderating role of racial-ethnic minority status. Psychoneuroendocrinology 50, 280–288.