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Association between perceived racism and physiological stress indices in Native Hawaiians

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Abstract The association between racism and the physical health of native U.S. populations has yet to be examined despite their high risk for stress-related disorders and a history of discrimination toward them. We examined the correlation between perceived racism and the two physiological stress indices of cortisol level and blood pressure in 146 adult Native Hawaiians. Attributed and felt racism were assessed with a 10-item shortened version of the Oppression Questionnaire. Height, weight, blood pressure, and salivary cortisol samples (AM and PM) were collected and analyzed along with information on Hawaiian ancestry, BMI, age, sex, marital status, education level, general psychological stress, and ethnic identity. The results indicated that Native Hawaiians reporting more attributed racism had significantly ($P < .05$) lower average cortisol levels than those reporting less attributed racism, after adjusting for socio-demographic, biological, and psychosocial confounders. Native Hawaiians reporting more felt racism had a significantly higher systolic blood pressure than those reporting less, but this association was not significant after adjusting for the aforementioned confounders. Racism appears to be a chronic stressor that can "get under the skin" of Native Hawaiians by affecting their physical health and risk for stress-related diseases, possibly, through mechanisms of cortisol dysregulation.

Keywords Native Hawaiian · Racism · Discrimination · Physiological stress · Salivary cortisol · Blood pressure

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Introduction

Racism, also referred to as racial/ethnic discrimination or oppression, is the beliefs, acts, and institutional measures that devalue people because of their phenotype or ethnic affiliation (Clark et al. 1999). It is a social stressor that threatens the physical health of many racial/ethnic minority groups in the U.S. (Harrell et al. 2003). Perceived racism in African-Americans and Hispanics is associated with stress-related diseases and their risk factors, such as hypertension and heart disease (Brondolo et al. 2003; Lewis et al. 2006; Paradies 2006; Salomon and Jagusztyn 2008). The association between racism and the physical health of native U.S. populations, such as American Indians, Alaska Natives, and Native Hawaiians, has yet to be examined despite decades of discrimination against them and compulsory assimilation policies (Haas 1992; Belcourt-Dittloff and Stewart 2000).

Native Hawaiians make up a majority of Pacific Islanders (46%) in the U.S. (Greico 2001). Like American Indians and Alaska Natives, they are descendants of the original inhabitants of territories now under U.S. control. Compared to other racial/ethnic groups, Native Hawaiians are disproportionately affected by obesity (44%), hypertension (40%),

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diabetes (19%), and coronary heart disease mortality (135.4 per 100,000; Balabis et al. 2007; Mau et al. 2009). They are also more likely to have low paying jobs, to be undereducated, and to have substandard living conditions (Office of Hawaiian Affairs 2006). Despite comprising 22% of the population in Hawaii, where no one racial/ethnic group holds the majority, it is reported that Native Hawaiians continue to be socially alienated and stigmatized by other ethnic groups (Okamura 2008), and that their medical disparities may be related to their social disparities and lower social status as an ethnic group (Kaholokula 2007). Examining how perceived racism may impact the physical health of Native Hawaiians can inform preventive measures to reduce their risk for stress-related disorders with implications for other native and Pacific Islander populations.

An approach to understanding how racism "gets under a person's skin" is to examine its association with physiological stress indices related to disease etiology. Two interacting biological systems involved in the human stress response are the sympathetic-adrenal-medullary system and the hypothalamic–pituitary–adrenal (HPA) axis (Chrousos and Gold 1992). Blood pressure is a common physiologic indicator of sympathetic-adrenal-medullary activity, and cortisol is the primary measured hormone of the HPA axis system. Environmental stressors mediated by psychological processes, or psychological processes acting alone, can cause the normal reaction of increased blood pressure and cortisol release for the body to deal effectively with stressors. Prolonged sympathetic-adrenal-medullary and HPA activation due to chronic psychological stress can lead to abnormal physical responses, such as metabolic dysregulation, hypertension, and changes in cortisol homeostasis (DeSantis et al. 2007; Miller et al. 2007). Studies have linked certain patterns of cortisol output and elevated blood pressure to issues of racism in African-Americans and Hispanics (Matthews et al. 2006b; Williams and Neighbors 2001) and to the development of hypertension, obesity, diabetes, and heart disease (Bjorntorp et al. 1999; Rosmond and Bjorntrop 2000).

Other variables need to be considered when examining the association between perceived racism and the physiological variables of cortisol and blood pressure (Paradies 2006). Studies reveal that variables such as age, sex, education level, body-mass-index (BMI), and degree of racial/ethnic identity and general psychological stress are correlates of cortisol level and blood pressure (Brondolo et al. 2009; Cohen et al. 2006; Smyth et al. 1998; Zhao et al. 2000; Thompson et al. 2002; Tull et al. 2005; Reynolds and Walker 2007; Gasperin et al. 2009). These variables are also associated with the degree to which persons report racism (Chambers et al. 2004; Tull et al. 2005; Vines et al. 2006; Stevenson and Arrington 2009). Certain socio-demographic, biological, and psychosocial variables could thus confound the association between perceived racism and physiological stress and elucidate alternative pathways by which a person's health is affected.

There is no indication from the extant literature that any of the variables of age, sex, education level, BMI, degree of racial/ethnic identity, and general psychological stress would serve other than potential confounders in the relationship between perceived racism and physiological stress indices. There is also no theoretical model, currently, to guide the selection of appropriate confounders or mediators to aid in explaining the association perceived racism might have with cortisol and blood pressure. Thus, to avoid any overestimating of the correlations between measures of perceived racism and the physiological variables of cortisol and blood pressure, the potential confounding effects of the aforementioned socio-demographic, biological, and psychological variables should be considered.

To date, only one study empirically examined perceived racism in relation to a health indicator in Native Hawaiians. In a convenience sample of 94 adult Native Hawaiians, Kaholokula et al. (2010) found those who had higher perceptions of racism were more likely to report having hypertension after adjusting for age, sex, education level, and degree of Hawaiian and American cultural identities. Their finding supports the idea that perceptions of racism in Native Hawaiians could be adversely affecting their physical health. However, several methodological issues limit the confidence placed in their findings, such as the use of a non-random convenience sample and self-reported hypertension and not considering other potential confounders (e.g., BMI).

In considering the issues reviewed here, we conducted a pilot study to address the general question: Is there an association between perceived racism and common physiological indices of stress in Native Hawaiians? Specifically, we examined the correlations between measures of perceived racism and measures of cortisol activity and blood pressure in a community-based sample of adult Native Hawaiians, after adjusting for the potential confounding effects of selected socio-demographic (i.e., age, sex, education, and marital status), biological (i.e., degree of Hawaiian ancestry and BMI), and psychosocial (i.e., ethnic identity and general psychological stress) factors.

Methods

Study design and participants

We recruited and assessed 146 adult (≥18 years of age) Native Hawaiians (104 females and 42 males) from a rural community in Hawaii for this pilot study using a cross-sectional correlational study design. Native Hawaiians are

the descendants of the original peoples of Hawaii (Office of Hawaiian Affairs 2006). The participants were recruited from a previously studied cohort of the Kohala Health Research Project, which was a five-year community-based epidemiological study of diabetes and cardiovascular risk factors (Grandinetti et al. 2007). The Kohala Health Research Project's database had contact information for 494 (270 females and 224 males) Native Hawaiian adults, from which we generated a random list of 200 for recruitment into our study. From this list, it was our intention to recruit 160 participants; however, we were only able to recruit 146 of the 160 (enrollment rate of 91%) within the short 5-month recruitment time period of our pilot study. In comparing our sub-sample ($n = 146$) to the larger Native Hawaiian sample ($n = 526$) of the Kohala Health Research Project, notable differences in age and gender were identified. The participants of this study tended to be older (55.1 vs. 44.3 in mean age) and female (71.2% vs. 56%) but did not differ in BMI and in distribution across educational attainment, marital statuses, and degree of Hawaiian ancestry (see Kaholokula et al. 2006).

Assessment instruments

Socio-demographic data collected were sex, age, educational attainment (no high school diploma; high school diploma or its equivalent; some college, technical, or vocational training; or college graduate), marital status (never married; currently married; separated/divorced; or widowed), and self-reported ethnic identification. Because most Native Hawaiians are multi-racial/ethnic, self-reported information about participants' degree of Native Hawaiian ancestry (<25, 25, 50, 75, and 100%) was also collected.

Perceived racism was assessed based on the concept of racial oppression (Feagin 2006) as measured by a 10-item shortened version of the original 32-item Oppression Questionnaire (Victoroff 2005). The 10-item Oppression Questionnaire measures two aspects of perceived oppression: (1) *Felt* oppression, which considers the respondent's subjective experience of *feeling* oppressed (four items) and (2) *attributed* oppression, which is oppression *attributed* to an oppressive social group by the respondent (six items). Example items of the *felt* oppressed subscale include "We are not considered to be as good as others" and "My group is often looked down upon." Example items of the *attributed* oppression subscale include "They keep us from living the way we want" and "Some people look down on me and my group." With responses ranging from 1 (not at all) to 4 (a great deal), participants were asked to respond in the context of how they perceived other social groups treated or thought of them as a Native Hawaiian and other Native Hawaiians over the past year. The four items that measure *feeling* oppressed were calculated to create participants' Felt Oppression scores while the six items that measure *attributed* oppression were calculated to create participants' Attributed Oppression scores, and transformed so that scores range from 0 to 100, with higher scores indicating more perceived racism. The Oppression Questionnaire has been used in a previous study of Native Hawaiians where higher scores were significantly associated with hypertension prevalence and positively correlated with Hawaiian ethnic identity (Kaholokula et al. 2010).

Global psychological stress was assessed using the 10-item Perceived Stress Scale (Cohen et al. 1983; Cohen and Williamson 1988). It assesses perceived stress on a global level over the previous month. Example items include "In the last month, how often have you felt that you were unable to control the important things in your life?" and "In the last month, how often have you felt nervous and 'stressed'?" with responses ranging from 0 ('never') to 4 ('very often'). The Perceived Stress Scale scores range from 0 to 40, with higher scores indicating greater perceived stress. The construct validity of the Perceived Stress Scale has been demonstrated in different populations (Cole 1999; Roberti et al. 2006).

Hawaiian and American identity was measured using an 8-item cultural affiliation questionnaire designed by the Kohala Health Research Project, which consists of two scales: a 4-item Hawaiian Cultural Identity scale and a 4-item American Cultural Identity scale (Kaholokula et al. 2008). They assess the four same aspects of Hawaiian and American cultural identities: Degree of affiliation with each cultural group, feelings toward each cultural group, knowledge about each cultural group, and the impact each cultural group has on the respondent's lifestyle. The responses range from 1 (very knowledgeable, very positive, or very involved) to 5 (not knowledgeable at all or very negative), which were reversed scored and summed so that scores range from 4 to 20 with higher scores indicating a stronger identity. These subscales were used in previous studies of Native Hawaiians in which they were found to have significant correlations with diabetes and hypertension prevalence (Kaholokula et al. 2008, 2010).

Body weight in kilograms (kg) was measured twice without shoes using a calibrated balance beam scale, with the average of the two measurements used as the final weight. Participants' heights in meters (m) were documented in the Kohala Health Research Project's database and originally measured without shoes using a wall-mounted stadiometer. BMI was calculated as weight (kg)/height $(m)^2$. Systolic blood pressure and diastolic blood pressure were taken twice from each participant using a mercury sphygmomanometer and the Korotkoff sound technique (Pickering et al. 2005). Blood pressures were taken (1-min intervals) in the sitting position from the

participant's right arm after a five-min period of acclimation to the setting. The average of the two blood pressure measurements was calculated.

Two saliva samples were obtained from each participant to assess their salivary cortisol levels: one AM sample (taken between 6:30 AM and 8:30 AM) and one PM sample (taken 12 h later) collected in the same day. Cortisol levels during the waking hours are often highest in the early morning hours (peaking about 30–40 min after waking) and lowest in the late afternoon/evening hours (Miller et al. 2007). The AM and PM samples were also used to estimate average diurnal cortisol output and degree of diurnal variability based on the difference between AM and PM cortisol levels (i.e., degree of slope). Similar salivary cortisol measurements (i.e., daily average and slope), based on one AM and one PM sample, were employed in another study examining the association between change in cortisol levels and internalized racism in a sample of 53 Dominica women (Tull et al. 2005). In our study, saliva samples were collected from participants using a standardized technique in which a clean cotton roll was inserted sublingually for 1 min to absorb a sample of 0.5–1 ml of saliva and then was immediately placed in a clean tube and frozen at −20°C. Frozen samples were then batched and sent to Salimetrics, LCC lab, for measurement of cortisol performed in duplicate using a highly sensitive enzyme linked immunoassay (ELISA) with a lower detection limit of 0.003 μg/dl. The test uses 25 μl of saliva per determination with a standard distribution curve from 0.012 to 3.0 μg/dl, and intra-and inter-assay coefficients of variation 3.5 and 5.1%, respectively. Salivary cortisol levels are positively correlated with serum cortisol, $r = 0.89$, $P < 0.0001$ (Lo et al. 1992).

Procedures

The study was approved by the University of Hawaii Institutional Review Board. Given the number of assessments, short versions of the psychosocial measures were used for ease of administration and feasibility. Using a random generated list of former participants of the Kohala Health Research Project, a community health nurse recruited participants for the present study by phone and/or mail-out invitations sent to their home address. A $20.00 gift card to a local store was offered to each participant upon completion of data collection. Other than being a former participant of the Kohala Health Research Project, no other inclusion/exclusion criteria were applied to this study. The inclusion criteria of the Kohala Health Research Project were as follow: (1) 18 years of age and older, (2) resident of the North Kōhala community, and (3), if female, not pregnant.

For those who agreed to participate, a data collection appointment was made for the morning hours between 6:30 AM and 8:00 AM at the community clinic. Informed consent was obtained from each participant prior to data collection. The participant's socio-demographic information was collected first by the nurse followed by their weight and blood pressure. The AM saliva sample was then collected from the participant by the research nurse according to standardized methods. The participant was instructed on how to collect his/her own PM saliva sample the same evening, 12 h from the collection of the morning sample. Verbal and written instructions explaining the saliva collection and storage procedures and a saliva collection kit were given to the participant. Arrangements were made for a drop-off or pick-up of the participant's PM sample the next morning to ensure that it was collected the night before and to ensure it was processed immediately. Following the AM saliva collection, the participant completed the Hawaiian Cultural Identity scale, American Cultural Identity scale, Oppression Questionnaire, and Perceived Stress Scale.

Data reduction and statistical analyses

Analyses were conducted using JMP statistical software (version 7.0) with an alpha level of .05. Descriptive statistics were generated and Pearson product-moment correlation coefficients were calculated for all variables. A nonparametric test (Kendall tau) was done to ensure linearity in the associations between cortisol measures and other study variables. The categorical variables of sex (1 = male; 2 = female), educational attainment (1 = no high school diploma or its equivalent; 2 = high school diploma or its equivalent; 3 = some college, technical, or vocational training; or 4 = college graduate), and degree of Native Hawaiian ancestry (1 = <25%, 2 = 25%, 3 = 50%, 4 = 75%, 5 = 100%) were dummy coded for bivariate and multivariate analyses. The separated/divorced and widowed martial statuses were aggregated and referred to as "disrupted marital status" from here on. Bivariate associations with marital status were conducted either by analysis of variance (ANOVA) or chi-square (χ^2) analysis.

To evaluate the internal consistency of the psychosocial measures a Cronbach's α was calculated for all multi-item measures. The average diurnal cortisol level (referred to as diurnal cortisol from here on) was calculated as AM value + PM value/2 and the degree of cortisol variability (i.e., slope of change) was calculated as the difference between the AM and PM values (referred to as cortisol_{Δ} from here on). Inspection of scatterplots for cortisol measurement revealed no distinguishable outliers but to reduce the positive skewness of the cortisol measurements, natural logarithmic transformation was conducted (Matthews et al. 2006a). Seven participants did not complete their PM saliva collection and the cortisol levels for 12 participants could not be obtained by the lab because of inadequate

saliva quantity. Of the 146 participants, AM cortisol data on 132, PM cortisol data on 138, average diurnal cortisol and cortisol$_\Delta$ data on 127 were available.

Because the scales of the Oppression Questionnaire were modified, we examined their internal consistency (Cronbach's α), convergent validity, and factor loadings. They were considered to have acceptable internal reliability if their Cronbach's α was >.70 (Cronbach 1970). Their convergent validity was supported if they showed a significant positive correlation with the Hawaiian Cultural Identity scores. Findings from other studies supported a positive correlation between racial/ethnic identity and perceived racism (Kaholokula et al. 2010; Stevenson and Arrington 2009). A principal component factor analysis (varimax orthogonal rotation method) of the ten Oppression Questionnaire items was undertaken (data not reported here), which supported the expected 2-factor solution.

Multiple regression analyses were used to examine the correlation between Attributed Oppression scores and Felt Oppression scores (independent variables) and cortisol levels and blood pressure (dependent variables). In each regression analysis, we systematically adjusted for sociodemographic (Model 1: age, sex, education level, and marital status), biological (Model 2: addition of Hawaiian ancestry, BMI, and systolic and diastolic blood pressure), and psychosocial (Model 3: addition of Hawaiian Cultural Identity scale, American Cultural Identity scale, and Perceived Stress Scale scores) variables identified as potential confounders from the extant literature (see introduction).

Table 1 Participants' characteristics ($N = 146$)

Characteristics	Mean (SD) or %
Age (years)	55.1 (14.0)
Female (vs. male)	71.2
Educational attainment	
No HS diploma	5.5
HS diploma/GED/CBase	55.5
Some college/technical/vocational	27.4
College graduate	11.6
Marital status	
Never married	10.3
Currently married	67.8
Divorced/separated/widowed	21.9
Degree of Hawaiian ancestry	
≤24%	19.2
25–49%	32.2
50–74%	34.2
75–99%	11.0
100%	3.4
Body mass index (kg/m^2)	30.4 (6.3)
AM cortisol (μg/dl)[a]	0.30 (0.27)
PM cortisol (μg/dl)[a]	0.12 (0.25)
Diurnal cortisol (μg/dl)[a]	0.21 (0.18)
Cortisol$_\Delta$ (μg/dl)[a]	0.18 (0.36)
Systolic blood pressure (mmHg)	130.4 (7.4)
Diastolic blood pressure (mmHg)	78.3 (11.1)
Perceived stress scale scores	15.4 (6.5)
Attributed oppression scores	23.8 (19.0)
Felt oppression scores	22.9 (21.1)
Hawaiian cultural identity scores	15.5 (2.7)
American cultural identity scores	15.9 (2.3)

SD standard deviation

[a] Cortisol values before logarithmic transformation

Results

Participants' characteristics

As summarized in Table 1, the participants mean age was 55.1 (SD = 14) and most were female (71.2%), currently married (67.8%), and had a high school diploma or its equivalent as their highest educational attainment (61%). Half (49%) reported ≥50% Hawaiian ancestry. On average, the participants were obese (≥30 kg/m^2) with blood pressures within the normal range (systolic blood pressure < 140 mmHg and diastolic blood pressure < 90 mmHg). As expected, average cortisol levels were higher in the morning than in the evening.

Bivariate and psychometric analyses

Table 2 shows the inter-correlations among study variables and the Cronbach's α for psychosocial measures. Of the variables with significant correlations ($P < .05$), Attributed Oppression scores had a negative correlation with diurnal cortisol levels ($r = -.21$) and a positive correlation with Hawaiian Cultural Identity scores ($r = .17$). Felt Oppression scores had a positive correlation with degree of Hawaiian ancestry ($r = .24$), systolic blood pressure ($r = .22$), and Hawaiian Cultural Identity scores ($r = .21$). Diurnal cortisol levels had a negative correlation with age ($r = -.23$), education level ($r = -.18$), and DBP ($r = -.20$). Systolic blood pressure had a positive correlation with age ($r = .51$), degree of Hawaiian ancestry ($r = .35$), BMI ($r = .23$), and diastolic blood pressure ($r = .60$). Diastolic blood pressure had a negative correlation with sex ($r = -.26$) and a positive correlation with BMI ($r = .20$). AM and PM cortisol levels had a negative correlation ($r = -.22$) and both had a positive correlation with diurnal cortisol levels ($r = .79$ and .59, respectively). AM cortisol levels had a positive correlation with cortisol$_\Delta$ ($r = .44$) while PM cortisol levels had a negative

correlation with cortisol$_\Delta$ ($r = -.53$). The patterns of these correlations were confirmed using non-parametrical methods.

Marital status (not shown in Tables) was significantly associated with age, sex, systolic and diastolic blood pressure, and Felt Oppression scores. Never married individuals were younger [F (2, 143) = 15.43, $P < .01$] and had lower systolic blood pressure [F (2, 142) = 3.93, $P < .05$], diastolic blood pressure [F (2, 142) = 5.10, $P < .01$] and Felt Oppression scores [F (2, 141) = 3.31, $P < .05$] than participants who were currently married or had a disrupted marital status. Women were more likely to have a disrupted marital status [χ^2 (2, $N = 146$) = 8.84, $P < .05$] than men.

The Cronbach's α was acceptable for all the psychosocial measures, ranging from .73 to .94 as shown in Table 2. For the Oppression Questionnaire measures, their Cronbach's α were very good at .87 (Attributed Oppression scores) and .94 (Felt Oppression scores). Convergent validity was found for the two Oppression Questionnaire measures in which they had significant positive correlations with Hawaiian Cultural Identity scores, $r = .17$ (Attributed Oppression scores) and .21 (Felt Oppression scores).

Multivariate analyses

Of the two Oppression Questionnaire measures and the three cortisol measures, only the Attributed Oppression scores had a significant bivariate association with diurnal cortisol levels (dependent variable) and thus entered into a hierarchical multiple regression analyses. As shown in Table 3, the negative correlation between Attributed Oppression scores and diurnal cortisol levels remained significant with the additive inclusion of each group of potentially confounding variables.

Of the two Oppression Questionnaire measures, only the Felt Oppression scores had a significant bivariate association with systolic blood pressure (dependent variable) and thus entered into a hierarchical multiple regression analyses. As shown in Table 4, the significant positive correlation between Felt Oppression scores and systolic blood pressure remained after adjusting for socio-demographics (Model 1), but this relationship was negated by the inclusion of the biological variables (Model 2).

Discussion

We examined the association between perceived racism and indices of physiological stress—cortisol levels and blood pressure—in a sample of adult Native Hawaiians. To date, this is the first study to examine such an association in any U.S. native and Pacific Islander ethnic group. A methodological strength of this study was the consideration

Table 2 Intercorrelation matrix of study variables

Variables	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
1. Age	1.0															
2. Sex	−.03	1.0														
3. Education level	−.11	−.02	1.0													
4. Hawaiian ancestry	.36***	−.02	−.08	1.0												
5. BMI	−.12	−.02	−.08	.17*	1.0											
6. Systolic blood pressure	.51***	−.07	−.10	.35***	.23**	1.0										
7. Diastolic blood pressure	.07	−.26**	.04	.15	.20*	.60***	1.0									
8. AM cortisol	−.16	−.01	−.11	−.10	−.03	−.13	−.22*	1.0								
9. PM cortisol	.06	−.11	−.07	.03	.06	.06	−.08	.10	1.0							
10. Diurnal cortisol	−.22*	−.10	−.18*	−.07	.05	−.11	−.20*	.79***	.59***	1.0						
11. Cortisol$_\Delta$	−.14	.10	.01	−.15	−.05	−.12	−.13	.44***	−.53***	−.03	1.0					
12. Hawaiian cultural identity	.00	.04	.06	−.00	.02	.10	.00	.00	.06	−.04	−.05	1.0				
13. American cultural identity	.01	.13	.11	−.02	−.09	.07	.01	−.03	−.02	.04	−.06	.42***	1.0			
14. Perceived stress scale	−.28**	.07	−.05	−.01	.11	−.03	.08	−.05	−.02	.04	−.09	−.00	−.03	1.0		
15. Attributed oppression	.05	−.14	.07	.13	−.03	.01	.06	−.15	−.15	−.21*	.03	.17*	−.02	.15	1.0	
16. Felt oppression	.11	−.10	−.07	.24**	.08	.22**	.13	−.08	−.11	−.12	.05	.21*	−.03	.08	.78***	1.0
Cronbach's α	–	–	–	–	–	–	–	–	–	–	–	.76	.73	.84	.87	.94

BMI body mass index. Sex is dummy coded as 1 = male, 2 = female

* $P < .05$; ** $P < .01$; *** $P < .0001$

Table 3 Multiple regression analysis of attributed oppression scores predicting diurnal cortisol levels, adjusting for socio-demographic, biological, and psychosocial variables

Variables	*B*	SE	*F*-ratio	$P > F$
Attributed oppression scores				
Model 1*	−.29	.12	6.23	.0139
Model 2**	−.28	.12	5.45	.0213
Model 3***	−.27	.12	4.83	.0301

* Model 1: inclusion of socio-demographic variables (age, sex, education level, marital status); $R^2 = .20$, F (6, 125) = 4.82, $P = .0002$

** Model 2: inclusion of socio-demographic and biological variables (Hawaiian ancestry, body mass index, systolic and diastolic blood pressure): $R^2 = .23$, F (10, 123) = 3.35, $P = .0008$

*** Model 3: inclusion of socio-demographic, biological, and psychosocial variables (Hawaiian and American cultural identity and perceived stress scale scores); $R^2 = .24$, F (13, 123) = 2.66, $P = .0028$

Table 4 Hierarchical regression analysis of felt oppression scores predicting systolic blood pressure, adjusting for socio-demographic, biological, and psychosocial variables

Variables	*B*	SE	*F*-ratio	$P > F$
Felt oppression scores				
Model 1*	4.77	2.32	4.23	.0417
Model 2**	1.83	2.39	0.59	.4443
Model 3***	0.63	2.47	0.06	.7999

* Model 1: inclusion of socio-demographic variables (age, sex, education level, marital status); $R^2 = .28$, F (6, 142) = 9.03, $P < .0001$

** Model 2: inclusion of socio-demographic and biological variables (Hawaiian ancestry, BMI, cortisol level); $R^2 = .36$, F (9, 123) = 7.22, $P < .0001$

*** Model 3: inclusion of socio-demographic, biological, and psychosocial variables (Hawaiian and American cultural identity and perceived stress scale scores); $R^2 = .38$, F (12, 123) = 5.79, $P < .0001$

of socio-demographic, biological, and psychosocial variables that may have served as confounders in the relationship between perceived racism and physical health. The inclusion of a population-based sample of Native Hawaiians also strengthened this study, which provides increased confidence in the validity of our findings and their generalizability to the larger Native Hawaiian population.

For Native Hawaiians, it appears that perceived racism can "get under their skin" by affecting their physical health, and it appears to do so across those with different socio-demographic, biological, and psychosocial characteristics. That is, Native Hawaiians who reported more attributed racism (versus those who reported less) had lower diurnal cortisol levels, after considering the potential effects of age, sex, education level, martial status, degree of Hawaiian ancestry, BMI, blood pressure, ethnic and mainstream identification, and general psychological stress. Attributed racism, as defined and measured in this study, is the degree to which a person perceives other social groups as having discriminatory beliefs (i.e., they are not as good as us) and practices (i.e., restricted rights) toward his or her racial/ethnic group.

The lower diurnal cortisol levels found in Native Hawaiians who report more attributed racism might suggest attenuation in HPA activity. At first glance, this result may appear counterintuitive: Exposure to stress usually causes heightened HPA activity and, thus, an increase in cortisol output as part of the normal human stress response. However, many researchers have explained how a lower, flattened, or blunted cortisol output (due to down regulation of hormone secretion) can occur after a prolonged period of HPA axis hyperactivity (i.e., long period of elevated cortisol levels) due to chronic stress (Fries et al. 2005; Susman 2007). They further theorize that an attenuated HPA activity is an adaptive response to the experience of prolonged environmental stressors Animal models demonstrate how prolonged exposure to a stressor (i.e., being restrained) can initially raise corticosterone levels during the stressful event, but exhibit blunted corticosterone levels post-stressor (Fries et al. 2005). Studies indeed find lower or blunted cortisol output in people with stress-related disorders, such as post-traumatic stress disorder, burnout, and atypical depression (Heim et al. 1998; Gold and Chrousos 2002; Pruessner et al. 1999; Rohleder et al. 2004). Similar cortisol activity are also observed in victims of domestic violence, orphans, and caregivers for ill family members (Miller et al. 2002; Seedat et al. 2003; Yehuda et al. 2000).

Recognizing that there have been disparate findings in the relationship between cortisol and stress across studies,

Miller et al. (2007) conducted a meta-analysis of studies linking chronic stress and HPA activity. As expected, they found considerable variation in this relationship (i.e., high vs. low HPA activity in response to stressors), but attributed this variability to differences in person variables and the features of the stressor. Thus, the current available evidence suggest that the effects of psychosocial-related stressors on HPA activity, elevated or diminished activity, depends on multiple factors to include type of stressor (e.g., controllable vs. uncontrollable), the frequency, duration and intensity in experiencing the stressor (e.g., acute versus chronic), and how an individual reacts, perceives, or manages (e.g., coping style) the stressor. In our study, the lower diurnal coritsol output found in Native Hawaiians who report more attributed racism could be the result of prolonged exposure to discrimination and/or prolonged perceptions of racism. However, longitudinal prospective cohort and experimental studies using time-series data collection strategies are needed to more definitively test this hypothesis.

Caution must be taken, however, in interpreting what the lower diurnal cortisol levels actually mean in this study. Because we based the daily average on only two cortisol samples, albeit they were taken at the supposed highest and lowest points of the waking day, we are limited in the interpretations we can draw. Cortisol samples collected at multiple points throughout the average day would have provided a better estimate of the average total cortisol output and diurnal pattern (Fekedulegn et al. 2007). However, this was a pilot study for which extensive sampling was not feasible. The observed negative correlations between both the AM and PM cortisol values and the measure of attributed racism in our study, albeit non-significant, are also consistent with a reduced or suppressed cortisol output. When compared to our finding of a significant negative correlation between average diurnal cortisol levels and the measure of attributed racism, the notion of a flattened diurnal cortisol rhythm is further supported. In any case, these findings provide sufficient justification for further examination into the relationship between cortisol activity and perceived racism in native and Pacific Islander populations. This is particularly important given that low cortisol output and attenuated cortisol activity is associated with an increased risk for atherosclerosis, hypertension, obesity, and diabetes (Bjorntorp et al. 1999; Matthews et al. 2006a; Rosmond and Bjorntrop 2000), which are highly prevalent medical conditions in native and Pacific Islander populations (Mau et al. 2009).

Because of the limited studies that specifically examined perceived racism in relation to cortisol activity, and because different racism-related variables were measured in prior studies that did, it remains unresolved how our findings may fit into the larger context of the evolving science of how stress and racism may influence physical and psychosocial health. Numerous studies have examined the association between racism and blood pressure in experimental and non-experimental conditions (Harrell et al. 2003), but few have considered the association between racism and cortisol activity. However, the negative correlation between cortisol output and indices of perceived racism appears to be a shared finding among the few available studies. Tull et al. (2005) found a significant negative correlation between cortisol change in slope (difference between an AM and PM value) and higher levels of internalized racism (i.e., extent to which blacks agree with racist stereotypes about blacks) in 53 women from Dominica, after adjusting for age and education. Again, it is difficult to compare their findings to those of our study because of differences in the measure of perceived racism (i.e., internalized racism vs. externalized racism). In a community sample of 255 adolescents, DeSantis et al. (2007) found a significantly flatter diurnal cortisol slope among African-Americans and Hispanics than Caucasians. They also found that a flatter diurnal cortisol output was associated with higher levels of negative emotions in all adolescents. Collectively, these studies support the notion of HPA activity attenuation as a result of racism-related variables and ethnic minority status.

In examining the association between perceived racism and blood pressure, we found that Native Hawaiians with higher levels of felt racism had higher systolic blood pressure than those with lower levels of felt racism. This relationship persisted across Native Hawaiians with different socio-demographic characteristics but was negated primarily by differences in degree of Hawaiian ancestry and BMI. This finding is somewhat consistent with other studies of Native Hawaiians in which a positive correlation between blood pressure and degree of Hawaiian ancestry was found independent of other covariates (Grandinetti et al. 2002). Felt racism, as defined and measured in this study, is a person's subjective experience of feeling oppressed and could be related to psychological or emotional distress. Other studies have found an association between perceived racism and psychological distress (Carter 2007). However, global psychological stress was not significantly correlated with the measures of perceived racism or blood pressure in this study.

A possible explanation as to why degree of Hawaiian ancestry and BMI negated the relationship between felt racism and systolic blood pressure in our study is that one or both could be markers of other discriminatory-related factors experienced by Native Hawaiians. Native Hawaiians with a higher degree of Hawaiian ancestry are more likely to have darker skin or other Polynesian phenotypic characteristics. Those with darker skin tones could be exposed to, and/or perceive, more race-related

mistreatments and discrimination. We did find a significant positive correlation between felt racism and degree of Hawaiian ancestry in our sample. Other studies have found an association between skin tone and blood pressure in African-Americans (Sweet et al. 2007).

Alternatively, obesity has been found associated with perceptions of racism and with elevated systolic blood pressure and dietary beliefs and behaviors in studies of African-Americans (Manuel 2004; Tull et al. 1999). Obesity is associated with the insulin resistance syndrome, which has been characterized in Native Hawaiians (Mau et al. 1997). The insulin resistance syndrome may be the unifying hypothesis between HPA dysregulation caused by chronic stressors, such as perceived racism leading to elevated blood pressure, obesity, diabetes, dyslipidemia, and heart disease. It was not possible from the information collected in our study to characterize the link between the insulin resistance syndrome and HPA dysregulation due to racism. However, future studies examining racism and the insulin resistance syndrome in Native Hawaiians may offer novel approaches to ameliorate their disparities in heart disease and diabetes.

In addition to the limitation of our cortisol measures mentioned earlier, other methodological issues are also worth noting. A limitation is that we had no information on the study participants' medication use, especially hypertension medication that might affect the relationship between systolic blood pressure and felt racism. However, if hypertension medication was influencing the relationship between perceived racism and blood pressure, we would expect it to have masked any association between these two variables because the medication would lower people's blood pressure. The fact that we found a significant positive correlation between felt racism and systolic blood pressure suggest that, regardless of hypertension medication use, an association exists. Adjusting for medication use (if we were able to) would probably only strengthen the correlation rather than weaken it. Another limitation is that a majority of our sample were female (71%). Although we recruited from a random list of former Native Hawaiian participants of the Kohala Health Research Project, more females than males were willing to participate in this study. However, males and females in this study differed only in marital status and diastolic blood pressure. Although there is no evidence to suggest gender-effects in the relationships we examined, future studies should have a balance between these two sexes. Finally, the correlational nature and cross-sectional design of our study does not allow for causal inferences and introduces other methodological limitations, such as providing only a snap-shot measurement of the study variables.

In conclusion, our findings lend support to the idea that perceived racism can adversely affect the health and well-being of Native Hawaiians. They also support the need for further investigation into the relationship between racism and health indicators in Native Hawaiians as well as in other native and Pacific populations. Although our study indicate a statistically significant correlation between attributed racism and cortisol output, the clinical significance of this relationship, such as whether or not perceptions of racism directly increases the risk of heart disease, has yet to be elucidated. Future studies can be methodologically strengthened by measuring individuals' cortisol output multiple times in a single day and do so over several days for more precise characterizations of cortisol activity (i.e., diurnal rhythm and degree of fluctuations). In the case of blood pressure, it would be wise to collect information on hypertensive medication use. Future investigation into this area should use prospective longitudinal (with larger sample sizes) and experimental study designs to allow for causal inferences and examination of clinical significance.

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