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The cardiovascular conundrum in Non-Hispanic Black emerging adults: multiethnic differences in its association with emotion regulation strategies and socioeconomic status

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ABSTRACT

Previous studies have identified a pattern of jointly elevated sympathetic vasoconstriction (indexed by total peripheral resistance, TPR) and increased cardiac vagal tone (indexed by heart rate variability, HRV) in non-Hispanic Black (NHB) adults relative to non-Hispanic White (NHW) counterparts in the United States, referred to as the cardiovascular conundrum. Whether a similar pattern is observed in other minority ethnic groups, and the role of emotion regulation strategies and socioeconomic status (SES), remains unclear. This study examined ethnic differences in TPR and HRV in emerging adults with Asian ($n = 183$), NHB ($n = 82$), Hispanic/Latino ($n = 228$), and NHW ($n = 554$) backgrounds, and tested the moderating role of emotion regulation strategies (expressive suppression and cognitive reappraisal) and SES. NHB adults showed higher resting TPR (suggesting greater vascular strain) and HRV compared to NHW counterparts and other minority groups. Although all minority groups reported greater use of expressive suppression than NHW adults, this was associated with higher TPR and HRV values only in the NHB group, particularly at lower SES. In contrast, greater use of cognitive reappraisal was associated with lower TPR in NHB individuals. These findings suggest that associations between emotion regulation strategies and cardiovascular parameters may differ across sociocultural contexts. In particular, expressive suppression may be linked to physiological patterns consistent with increased vascular strain among NHB emerging adults, especially under conditions of socioeconomic disadvantage.

1. Introduction

1.1. The cardiovascular conundrum phenotype

The cardiovascular conundrum refers to a paradoxical phenotype observed in Non-Hispanic Black (NHB) adults living the United States. At rest, NHB individuals tend to show higher cardiac vagal modulation, indexed by heart rate variability (HRV) compared to their non-Hispanic White (NHW) counterparts (Hill et al., 2015; Thayer et al., 2020). Under typical physiological conditions, greater vagal modulation may contribute to adaptive cardiovascular regulation by buffering sympathetic activation and helping maintain blood pressure within an optimal range (Hillebrand et al., 2013; Thayer et al., 2012). However, the "conundrum" arises because this apparently adaptive pattern co-occurs with elevated sympathetic vasoconstriction, indexed by total peripheral resistance (TPR), indicating greater vascular strain in NHB individuals relative to NHW counterparts (Brownlow et al., 2020; Carnevali et al., 2019). Critically, elevated TPR has been linked to increased risk for hypertension and other forms of cardiovascular disorders (Hinderliter et al., 2004; Koeners et al., 2016). Consistent with this pattern, NHB individuals experience some of the highest rates of cardiovascular disease incidence and mortality in the United States (Carnethon et al., 2017; Go et al., 2014). Cardiovascular conditions often develop earlier in life and progress more aggressively than in other ethnic groups

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(Carnethon et al., 2017).

Research on the physiological underpinnings of the cardiovascular conundrum has started to identify differences in vasodilator responsivity to acetylcholine and in baroreflex function between NHB and NHW individuals as plausible determinants (Thayer et al., 2020; Williams et al., 2024). However, understanding the cardiovascular conundrum may require moving beyond purely physiological explanations.

1.2. Emotion regulation and the cardiovascular conundrum

Recently, it has been proposed that the cardiovascular conundrum in NHB populations may represent a unique physiological pattern associated with efforts to modulate anger responses to unfair treatment (Thayer et al., 2020).

Individuals differ widely in their preferred or habitual use of emotion regulation strategies such as cognitive reappraisal and expressive suppression (Gross, 2015; Gross and John, 2003). Reappraisal involves reframing a situation to alter its emotional impact, whereas suppression involves inhibiting one's emotional behavior despite internally experiencing an emotion (Gross, 2015; Gross and John, 2003). From a physiological standpoint, and relative to other strategies, expressive suppression is associated with increased cardiovascular activation and maladaptive outcomes (Quartana and Burns, 2010; Roberts et al., 2008), while reappraisal is often linked to adaptive outcomes (Troy et al., 2018; Wolgast et al., 2011). In the United States, NHB individuals learn from an early age to inhibit their anger expression in response to actual or perceived unfair treatment, potentially to reduce or avoid racially charged conflicts (Thayer et al., 2020). Importantly, in this group, anger inhibition following anger instigation has been associated with delayed TPR recovery and greater HRV compared with NHW individuals (Dorr et al., 2007). Thus, it has been hypothesized that the presence of greater TPR and higher HRV in NHB individuals may reflect a sustained physiological response associated with the tendency to inhibit anger responses to experiences of discrimination (Thayer et al., 2020). This is supported by findings of higher resting HRV in minority ethnic groups from other countries (e.g., darker skinned individuals in Brazil) (Kemp et al., 2016).

However, despite studies showing that American individuals from different minority ethnic backgrounds (i.e., NHB, Asian, or Latino) all show greater habitual use of suppression compared with NHW individuals (Finley et al., 2024; Gross and John, 2003), it is unclear if the relation between emotion regulation strategies and specific physiological response patterns (i.e., the cardiovascular conundrum) is consistent among minority ethnic groups in the United States. Indeed, the study of ethnic differences in TPR/HRV measures and their relation to emotion regulation strategies has primarily been conducted in NHB and NHW individuals and has only recently begun to consider other minority ethnic groups, such as Asian and Hispanic or Latino populations. For example, preliminary findings in emerging adults have demonstrated that the association between HRV and suppression is positive in NHB and Asian but not Hispanic emerging adults, and negative in NHW counterparts (Watanabe et al., 2026). Thus, extending the investigation of the relation between emotion regulation strategies and cardiovascular parameters to Asian and Hispanic populations, rather than focusing solely on NHB versus NHW individuals, would allow us to determine whether the cardiovascular conundrum is unique to NHB individuals or reflects more general processes across minority ethnic groups. This question maps onto competing theoretical perspectives that distinguish between a "people of color" perspective, which assumes shared responses and behavior across minoritized groups, and a "black exceptionalism" perspective, which emphasizes the uniquely rigid and enduring nature of the racial color line for the NHB group (Sears and Savalei, 2006).

1.3. The moderating role of socioeconomic status

Socioeconomic status (SES) may be a key moderator of the link between emotion regulation tendencies and specific cardiovascular outcomes, including blood pressure and related indices such as TPR and HRV. Individuals from different SES backgrounds are exposed to distinct social and environment conditions, which may influence both cardiovascular functioning and the use and consequences or emotion regulation strategies (Troy et al., 2018). For example, the ability to regulate one's emotions may be particularly important in lower SES contexts, which tend to be characterized by greater levels of discrimination and marginalization and lower levels of control over one's environment (Gee and Ford, 2011; Yearby, 2020). On the other hand, the ability to use effective emotion regulation may be less important in higher SES contexts, where direct control over the situation is possible (Chen and Miller, 2012; Forsythe and Compas, 1987). This is further emphasized by emerging theoretical perspectives that suggest that physiological correlates of emotion regulation may not operate uniformly across sociocultural contexts (Watanabe et al., 2026). From this perspective, similar behavioral strategies may be associated with distinct physiological profiles, reflecting the chronic demands and social expectations that shape the repeated use of regulatory strategies across sociocultural contexts. Importantly, prior work has shown that SES interacts with ethnicity in predicting cardiovascular risk (Krieger and Sidney, 1996). In the CARDIA study of young adults, authors found that experiences of racial discrimination were associated with elevated blood pressure among NHB individuals, with effects varying as a function of occupational status (Krieger and Sidney, 1996). These findings suggest that SES-related contextual factors can amplify or attenuate ethnic disparities in cardiovascular functioning. Despite this evidence, the moderating role of SES has been examined primarily in comparisons between NHB and NHW individuals, with limited investigation in other ethnic groups. Thus, it seems relevant to investigate the extent to which SES moderates the relationship between emotion regulation tendencies and cardiovascular measures in different ethnic groups.

1.4. The current study

In this study, we tested two competing theoretical perspectives: the "black exceptionalism" model, which predicts a distinct pattern in NHB individuals relative to all other groups, and the "people of color" model, which predicts similar patterns across all minority groups relative to NHW individuals (Sears and Savalei, 2006). First, we examined whether resting HRV and TPR, as well as the habitual use of expressive suppression and cognitive reappraisal, differed among emerging adults who self-identified as having Asian, NHB, Hispanic or Latino, and NHW backgrounds. Based on existing literature (Thayer et al., 2012; Brownlow et al., 2020), our hypothesis was that NHB individuals would show higher resting values of HRV and TPR compared with NHW counterparts. The inclusion of Asian and Hispanic groups allowed us a direct test of the competing theoretical accounts. Specifically, if the "black exceptionalism" model was correct in this context, only NHB individuals would display the cardiovascular conundrum, whereas under the "people of color" model all minoritized groups would exhibit higher HRV and TPR relative to the NHW group. We also expected greater habitual use of expressive suppression in all minority ethnic groups relative to NHW individuals (Finley et al., 2024; Gross and John, 2003). As discussed above, examining individual differences in emotion regulation tendencies can help explain why certain strategies are more strongly or weakly associated with physiological parameters in individuals from different ethnic backgrounds. Therefore, we tested whether emotion regulation strategies moderate the relation between ethnicity and HRV/TPR measures (Fig. 1). In addition, we examined SES as a potential moderator of these associations as previously suggested (Krieger and Sidney, 1996) (Fig. 1).

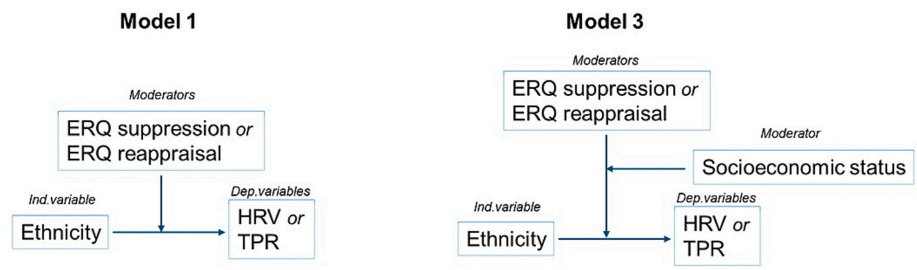

Fig. 1. Conceptual moderation models of the current investigation. Abbreviations: ERQ = emotion regulation questionnaire; HRV = heart rate variability; ln = natural logarithm; TPR = total peripheral resistance. The root mean square of successive differences (RMSSD) was used as HRV index.

2. Methods

The current investigation is based on data that were pooled across four studies conducted in the same laboratory. None of these studies had investigated the associations between resting HRV/TPR, emotion regulation tendencies, and SES. The final sample consisted of 1047 emerging adults (M_{age} = 19.7 yrs. [1.7], 59% women). Across the four studies contributing to the analyzed sample, the majority (n = 890) of the sample was drawn from a large public university in the United States (Baylor University, Texas) and recruited through campus-wide research participant pools and flyers (studies 1, 2, and 4). Participants had to be over 18 years old, with no current illness or infection and no history of cardiovascular disease. The third sample (n = 157) was recruited from the surrounding community through online postings, community center advertisements, and local outreach events (study 3). Additional criteria for these participants included no history of a chronic medical or neurological disorder, no aneurysm clips, pacemaker, cochlear implant, colorblindness, metal exposure, or claustrophobia. Specific procedures of the four studies are described in detail elsewhere (Tyra et al., 2023, 2025). Importantly, a SONA restriction was applied to make sure that there was no overlap among participants. All studies adhered to the Declaration of Helsinki and were approved by the university's Institutional Review Board (protocol numbers: 1149692–3; 1,355,632–7; 1,437,574–10; 1,948,842–7). Written informed consent was obtained from all participants.

2.1. Procedure

Prior to attending the laboratory session, participants were asked to abstain from the following activities: drinking alcohol and engaging in vigorous physical exercise for 12 h, drinking caffeine for 2 h, and consuming food or any other drinks (except water) for 2 h. Upon arrival at the laboratory, participants' waist circumference was measured. Next, a blood pressure cuff was attached to the participant's non-dominant arm for measuring systolic and diastolic blood pressures (SBP, DBP) and mean arterial pressure (MAP) using a standard oscillometric monitor (Carescape, V100, General Electric, El Paso, TX, USA). Then, three spot electrodes (Bio Prontech Inc., Chino, CA) were attached on their upper and lower torso for ECG signal recording using mobile electrocardiography (MindWare Technologies LT; Westerville, OH). After being fitted with the ECG and blood pressure equipment, participants were given 10 min to acclimate to the laboratory environment, followed by a 10-min recorded resting period. At the end of the visit, participants completed a series of questionnaires, including lifestyle scales assessing smoking and alcohol-related behaviors, use of medications, physical activity (Jurca et al., 2005), as well as parent's occupational status and emotion regulation tendencies (see below).

2.2. Ethnicity

Participants were asked to self-identify their race as either Asian, Black or NHB, Native Hawaiian or Other Pacific Islander, Mixed/Other, or White, and their ethnicity as either Hispanic or Latino or not Hispanic or Latino. For clarity, we refer to this combined category as ethnicity, in alignment with terminology recommended by the National Academies of Sciences, Engineering, and Medicine (NASEM, 2025). We use the term Hispanic to refer to individuals who self-identified as Hispanic or Latino for reporting simplicity (Flanagin et al., 2021). Because these categories were derived from participants' self-reported race and/or ethnicity, we acknowledge that both constructs are socially defined rather than biologically/genetically determined. Although these categories are often used in psychophysiological research to examine disparities, their use can unintentionally reinforce false assumptions about biological difference if not carefully contextualized. In this study, we interpret group differences through a social lens, recognizing the role of systemic inequities and racism (Boyd et al., 2020; Wolf et al., 2020; Wright et al., 2022). Note that the current studies were conducted before the updated categories in 2024, which now include Middle Eastern or North African. Also, generational status was not considered because it was collected only in study 4.

2.3. Cardiovascular measures

Raw ECG signals were acquired using BioLab (Mindware acquisition and laboratory integration platform) at a sampling frequency of 500 Hz. Using automated R-peak detection, IBIs (ms) were obtained, written in a text file, and analyzed using Kubios HRV analysis package 3.5.0 (Tarvainen et al., 2014). Artifacts within the IBI series were removed using a threshold-based correction based on a piecewise cubic interpolation method (Tarvainen et al., 2014). The IBI series were detrended using smoothness priors. Mean resting values heart rate (HR, bpm) and HRV were calculated. For HRV analysis, we considered the root mean square of successive differences (RMSSD, ms), which is regarded as a reliable index of cardiac vagal modulation and is less affected by respiratory influences compared to frequency-domain indexes (Laborde et al., 2017). TPR was calculated as MAP/cardiac output (CO), where CO was estimated as mean HR × ([SBP − DBP] / [SBP + DBP]) (Liljestrand and Zander, 1928; Sherwood et al., 1990).

2.4. Socioeconomic status and emotion regulation tendencies

Given the age and primarily student composition of the present sample, we used parent's occupational status as an index of SES (Cirino et al., 2002). The original studies employed a scale based on the British occupational rank that was used in the West of Scotland Twenty-07 studies (e.g., Whitley et al., 2014), which parallels the Hollingshead scale based on US occupation codes (Hollingshead, 1975). Specifically, participants were asked "*How would you best describe your parent's occupational status? Please use the parent who is the main breadwinner. If parents are not living together, put occupation of parent who has highest occupational status.*" Responses were coded using the following semi-ordinal scale: 1 = Armed Forces, 2 = Unskilled, 3 = Partly-skilled (e.g., bus driver/ laborer), 4 = Skilled manual (e.g., craftsman), 5 = Skilled non-manual (e.g., nurse/driver), 6 = Skilled managerial/Technical craftsman, 7 = Professional (e.g., doctor/lawyer/PA).

Emotion-regulation tendencies were measured using the Emotion Regulation Questionnaire (ERQ), which is a 10-item self-report measure of how frequently people use two emotion regulation strategies: cognitive reappraisal (e.g., "When I want to feel less negative emotion, I change the way I'm thinking about the situation") and expressive suppression (e.g., "I keep my emotions to myself") (Gross and John, 2003). Items are answered on a 7-point Likert scale ranging from 1 (strongly disagree) to 7 (strongly agree). In the current study, reappraisal showed good internal consistency by ethnic group (Asian: McDonald's omega (ω) = 0.788, NHB: ω = 0.850, Hispanic: ω = 0.846, NHW: ω = 0.855). Suppression showed acceptable internal consistency by ethnic group (Asian: ω = 0.775, NHB: ω = 0.741, Hispanic: ω = 0.789, NHW: ω = 0.808).

2.5. Statistical analyses

Statistical analyses were conducted using SPSS (version 29, IBM Chicago, IL, USA). The normal distribution of variables was checked by means of the Shapiro Wilk test. Significantly skewed cardiovascular variables were log-transformed (ln) to fit assumptions for linear analyses. Differences among the four ethnic groups in age, gender distribution, body mass index (BMI), SES, and lifestyle variables were analyzed by one-way ANOVA or $\chi2$ tests. Because of significant ethnic differences in waist circumference, alcohol consumption, and physical activity levels (Table 1), these variables were included as covariates. Although the groups did not differ in the use of different medications and gender distribution, these variables were included as covariates because of their potential influence on cardiovascular parameters and ERQ scores (e.g., Koenig and Thayer, 2016; Martin, 2024).

Planned contrasts were specified to test two competing theoretical models. First, the "black exceptionalism" hypothesis was tested using contrast weights of +3 (NHB) and − 1, −1, −1 (NHW, Asian, Hispanic), comparing NHB individuals to the other groups. Second, the "people of color" hypothesis was tested using contrast weights of +1, +1, +1 (NHB, Asian, Hispanic) and − 3 (NHW), comparing all minority groups to NHW individuals. These contrasts were conducted following significant omnibus ANCOVA effects for cardiovascular and ERQ scores. All contrast weights summed to zero and were specified a priori. For comparisons not covered by these hypotheses, Tukey post-hoc tests were conducted. Effect sizes (Cohen's d) and the associated 95% confidence intervals were also calculated.

Pearsons's zero-order correlations were computed between cardiovascular variables of interest (i.e., RMSSD and TPR), SES, and ERQ suppression and reappraisal scores separately for each ethnic group, and the magnitude of difference between the associations were assessed with Fisher's r to z transformation (Steiger, 1980).

Also, to test if ERQ suppression and reappraisal scores moderated the relationship between ethnicity (independent variable) and RMSSD and TPR values (dependent variables), "Model 1" of the SPSS macro-PROCESS (Hayes, 2012) was used. Lastly, to test if these moderations were further moderated by SES, "Model 3" of the SPSS macro-PROCESS (Hayes, 2012) was applied (see Fig. 1 for conceptual moderation models). Conditional effects were used to determine differential relationships using pre-planned simple slope analyses (Robinson et al., 2013). High and low values for the predictor variables were derived using ±1SD from the mean.

3. Results

As listed in Table 1, the distribution of women and men and the mean age of the participants did not differ among the four ethnic groups. NHB and Hispanic young adults had larger waist circumferences compared with age-matched Asian and NHW adults (p < .05), and a relatively higher number of non-alcoholic consumers was found within the Asian group compared with the other groups (p < .05). Also, the relative proportion of individuals engaged in higher levels of physical activity was larger in the NHW group compared with the other ethnic groups (p < .05). Both NHB and Hispanic adults reported significantly lower SES compared to NHW and Asian adults (p < .001 for all).

Table 1
Descriptive statistics for demographic and lifestyle variables.

	Asian (n = 183)	NHB (*n* = 82)	Hispanic (*n* = 228)	NHW (*n* = 554)	F/X^2	p
Gender (% women)	52%	64%	59%	60%	6.3	0.394
Age (years)	19.7 ± 1.7	19.8 ± 1.8	19.7 ± 1.9	19.7 ± 1.7	0.08	0.971
Waist (inches)	31.1 ± 5.3	32.1 ± 4.2	33.1 ± 5.9	31.5 ± 4.3	7.6	<0.001
SES	6.0 ± 1.3	5.5 ± 1.6	5.4 ± 1.7	6.2 ± 1.2	24.0	<0.001
Use of medications	85% N	78% N	82% N	81% N	31.0	0.273
Birth controlling pill (% women)	12.5%	15%	10%	17%		
Endocrine disorders	1.6%	0%	0.4%	0.9%		
Chronic pain	0.5%	2.4%	0%	1%		
Circulatory disorders	0%	0%	0%	0.2%		
Pulmonary disorders	0.5%	1.2%	0%	1.4%		
Mental Health	4.4%	6%	7.5%	6.7%		
Other	1%	2.4%	3.8%	2.7%		
Smoking	4% Y 96% N	100% N	3% Y 97% N	3% Y 97% N	7.4	0.593
Alcohol	52% N 48 Y %	41% N 58% Y	34% N 66% Y	34% N 66% Y	33.4	0.004
Physical activity	Level 1 = 11%	Level 1 = 13%	Level 1 = 10%	Level 1 = 4%	35.3	<0.001
	Level 2 = 26%	Level 2 = 21%	Level 2 = 21%	Level 2 = 18%		
	Level 3 = 18%	Level 3 = 26%	Level 3 = 19%	Level 3 = 19%		
	Level 4 = 19%	Level 4 = 12%	Level 4 = 20%	Level 4 = 25%		
	Level 5 = 26%	Level 5 = 28%	Level 5 = 30%	Level 5 = 34%		

Note. Data are reported as means ± SD. Abbreviations: NHB = Non-Hispanic Black; NHW = non-Hispanic White; N = no; SES = socioeconomic status; Y = yes. Physical activity levels range from 1 (inactive) to 5 (intense aerobic exercise).

3.1. Ethnic differences in mean cardiovascular parameters and ERQ scores

Cardiovascular parameters and results of one-way ANCOVAs are reported in Table 2. Planned contrasts supported the "black exceptionalism" hypothesis (contrast weights: +3 NHB and − 1 NHW, −1 Asian, −1 Hispanic): NHB emerging adults exhibited higher RMSSD ($t_{(1039)}$ = 4.3, p < .001, d = 0.44 [0.21, 0.67]) and TPR ($t_{(1039)}$ = 2.2, p = .03, d = 0.26 [03, 0.48]) compared with all other groups combined. Specifically, NHB adults had significantly higher RMSSD and TPR values compared with NHW (RMSSD: p < .001, d = 0.48 [0.24, 0.71]; TPR: p = .02, d = 0.28 [0.05, 0.51]) and Asian adults (RMSSD: p < .001, d = 0.61 [0.34, 0.87]; TPR: p = .025, d = 0.32 [0.06, 0.58]), and higher RMSSD values compared with Hispanic adults (p < .001, d = 0.43 [0.17, 0.68]) (Fig. 2). On the other hand, we found no evidence for differences in RMSSD and TPR values among Asian, Hispanic, and NHW adults (all p > .05).

Table 2
Ethnic differences in resting cardiovascular parameters.

	Asian (n = 183)	NHB (n = 82)	Hispanic (n = 228)	NHW (n = 554)	$F_{(3,1039)}$	p	η^2
Heart rate (bpm)	77.2 ± 11.2	74.8 ± 12.9	76.0 ± 10.5	77.0 ± 11.3	3.78	0.010	0.009
RMSSD (ms)	41.2 ± 23.7	57.8 ± 34.1 [a,c,d]	45.2 ± 27.6	44.5 ± 26.9	7.47	<0.001	0.019
MAP (mmHg)	84.6 ± 7.3 [d]	88.8 ± 9.4 [a,d]	87.3 ± 9.4	86.5 ± 8.3	5.19	0.001	0.014
SBP (mmHg)	114.3 ± 10.7 [d]	120.1 ± 13.3 [a,d]	117.9 ± 13.1	117.0 ± 12.1	7.01	<0.001	0.020
DBP (mmHg)	67.4 ± 6.7	70.3 ± 8.6	69.2 ± 8.1	68.6 ± 7.3	2.36	0.070	0.006
TPR (dyne/s/cm^5)	357 ± 84	386 ± 102 [a,d]	369 ± 89	362 ± 82	2.74	0.042	0.009
CO (mmHg/l/min)	19.9 ± 4.2	19.5 ± 4.9	19.7 ± 1.9	20.0 ± 4.2	1.70	0.166	0.004

Note. Data are reported as means ± SD. Abbreviations: CO = cardiac output; DBP = diastolic blood pressure; MAP = mean arterial pressure; NHB = Non-Hispanic Black; NHW = Non-Hispanic White; RMSSD = root mean square of successive differences; SBP = systolic blood pressure; TPR = total peripheral resistance. a = $p < .05$ vs Asian; c = $p < .05$ vs. Hispanic; d = $p < .05$ vs. NHW; p values (see text) were calculated using ln-transformed data.

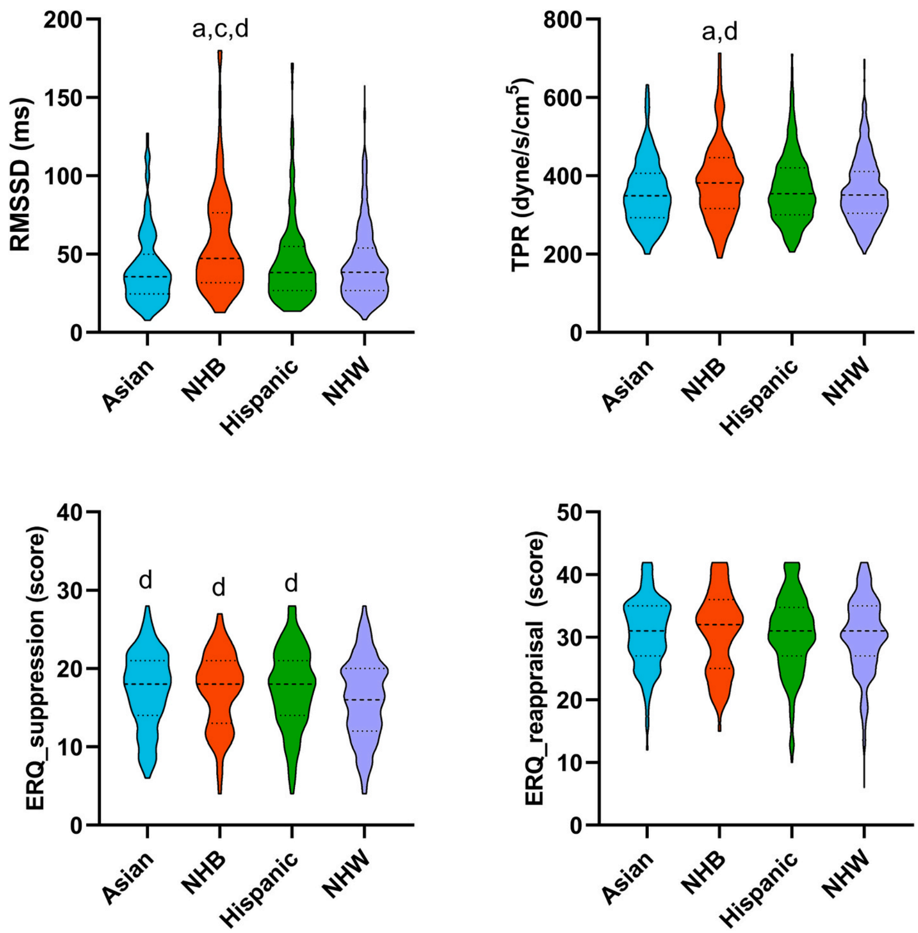

Fig. 2. Ethnic differences in cardiovascular variables of interest and ERQ scores. Abbreviations: ERQ = emotion regulation questionnaire; NHB = Non-Hispanic Black; NHW = Non-Hispanic White; RMSSD = root mean square of successive differences; TPR = total peripheral resistance. a = $p < .05$ vs Asian; c = $p < .05$ vs. Hispanic; d = $p < .05$ vs. NHW; exact p values (see main text) were calculated using ln-transformed data for cardiovascular parameters.

Importantly, to directly evaluate the two competing theoretical models, we tested the contrasts reflecting the difference between the weights of the "black exceptionalism" and the "people of color" hypotheses (Rosnow and Rosenthal, 2002). This analysis indicated that the observed data were more consistent with the "black exceptionalism" hypothesis than with the "people of color" hypothesis (RMSSD: $t_{(1043)} = 3.79$, $p < .001$, d = 0.23 [0.13, 0.34]; TPR: $t_{(1043)} = 1.66$, $p = .048$, d = 0.10 [0.00, 0.20]).

Additionally, NHB adults had significantly higher MAP and SBP compared with NHW (MAP: $p = .016$, d = 0.27 [0.04, 0.50]; SBP: $p = .004$, d = 0.23 [0.02, 0.49]) and Asian (MAP: $p = .001$; d = 0.53 [0.26, 0.79]; SBP: $p = .002$, d = 0.50 [0.24, 0.77) adults (Table 2). Lastly, Asian adults had significantly lower MAP ($p = .042$, d = 0.24 [0.07, 0.40]) and SBP ($p = .05$, d = 0.23 [0.06, 0.40]) compared with NHW adults (Table 2).

For emotion regulation, ANCOVA yielded a significant effect of ethnicity on expressive suppression ($F_{(3,1039)} = 2.66$, $p = .047$, $\eta^2 = 0.009$). Confirming our initial hypothesis, expressive suppression scores were significantly higher in Asian ($p = .008$, d = 0.24 [0.05, 0.39]), NHB ($p = .042$, d = 0.18 [0.00, 0.41]) and Hispanic ($p = .04$, d = 0.17 [0.04, 0.35]) individuals compared to NHW counterparts (Fig. 2). We found no evidence of differences in cognitive reappraisal scores among the four ethnic groups (Fig. 2).

3.2. Correlations between cardiovascular variables of interest and ERQ scores

In all groups, significant positive correlations were found between RMSSD and TPR values ($p < .05$ for all) (Table 3). SES was significantly and negatively correlated with RMSSD only in the NHB group ($p < .05$), and with TPR in NHB and Hispanic individuals ($p < .05$ for all) (Table 3). Also, a significant and negative correlation was found between cognitive reappraisal and TPR only in the NHB group ($p < .05$) (Table 3).

3.3. Moderation models

3.3.1. Expressive suppression as the moderator of the relationship between ethnicity and cardiovascular variables of interest (Model 1)

Results of simple slope analyses are depicted in Fig. 3, conditional effects and statistical details are listed in Supplementary Table 1.

NHB adults had significantly higher RMSSD values compared with Asian and NHW adults at low estimates of expressive suppression ($p =$ .01 and 0.05, respectively) and compared with all the other ethnic groups at mean and high estimates of expressive suppression ($p < .01$ vs all).

Furthermore, NHB adults had significantly higher TPR values compared with Asian and NHW individuals at mean estimates of expressive suppression ($p < .05$) and, to a greater extent, with all the other ethnic groups at high estimates of expressive suppression ($p < .05$ vs all).

3.3.2. Expressive suppression and SES as moderators of the relationship between ethnicity and cardiovascular variables of interest (Model 3)

Results of simple slope analyses are depicted in Fig. 4, conditional effects and statistical details are listed in Supplementary Table 2.

Among individuals with low SES, the NHB group showed significantly higher RMSSD values compared with all the other ethnic groups at any given level of expressive suppression ($p < .01$ vs all). Also, Hispanic adults had higher RMSSD values compared with Asian adults at low ($p = .005$) and mean ($p = .005$) estimates of expressive suppression. Among individuals with mean SES, the NHB group showed significantly higher RMSSD values compared with Asian adults at low levels of expressive suppression ($p = .045$), and with all the other ethnic groups at mean and high levels of expressive suppression ($p < .05$ vs all). No significant ethnic differences in RMSSD values were found among individuals with high SES.

Furthermore, among individuals with low SES, the NHB group showed significantly higher TPR values compared with Asian ($p = .01$) and NHW ($p = .002$) adults at mean estimates of expressive suppression, and with all the other ethnic groups at high estimates of expressive suppression ($p < .01$ vs all). Among individuals with mean SES, the NHB group showed higher TPR compared with NHW adults only at high estimates of expressive suppression ($p = .009$). No significant ethnic differences in TPR values were found among individuals with high SES.

3.3.3. Cognitive reappraisal as the moderator of the relationship between ethnicity and cardiovascular variables of interest (Model 1)

Results of simple slope analyses are depicted in Fig. 5, conditional effects and statistical details are listed in Supplementary Table 1.

NHB adults had significantly higher RMSSD values compared with all the other ethnic groups at any given level of cognitive reappraisal ($p < .01$ vs all). Also, Hispanic adults had significantly higher RMSSD values compared with Asian adults at low estimates of cognitive reappraisal ($p = .002$).

Furthermore, NHB adults had significantly higher TPR values compared with all the other ethnic groups at low estimates of cognitive reappraisal ($p < .05$ vs all) and compared with Asian and NHW counterparts at mean estimates of cognitive reappraisal ($p = .03$ and 0.01, respectively).

3.3.4. Cognitive reappraisal and SES as moderators of the relationship between ethnicity and cardiovascular variables of interest (Model 3)

Results of simple slope analyses are depicted in Fig. 6, conditional effects and statistical details are listed in Supplementary Table 3.

Among individuals with low SES, the NHB group showed significantly higher RMSSD values compared with all the other ethnic groups at any given level of cognitive reappraisal ($p < .01$ vs all). Also, Hispanic adults had significantly higher RMSSD values compared with Asian adults at low estimates of cognitive reappraisal ($p = .03$). Among individuals with mean SES, the NHB group showed significantly higher RMSSD values compared with all the other ethnic groups at low levels of cognitive reappraisal ($p < .05$ vs all) and compared with Asian and Hispanic adults at mean estimates of cognitive reappraisal ($p < .05$ vs both). No significant ethnic differences in RMSSD values were found among individuals with high SES.

Furthermore, among individuals with low SES, the NHB group showed significantly higher TPR values compared with all the other ethnic groups at low and mean estimates of cognitive reappraisal ($p < .01$ vs all). Among individuals with mean SES, the NHB group showed significantly higher TPR values compared with all the other ethnic groups only at low estimates of cognitive reappraisal ($p < .05$ vs all). No significant ethnic differences in TPR values were found among individuals with high SES.

4. Discussion

In this study, we confirmed the presence of jointly elevated resting HRV and TPR values (i.e., the cardiovascular conundrum) in NHB emerging adults compared to NHW counterparts. Importantly, we did not find evidence for this cardiovascular phenotype in the other minority ethnic groups examined (i.e., Asian and Hispanic emerging adults). One of the main findings was that even though all minority ethnic groups reported higher use of expressive suppression compared to NHW counterparts, this habitual use of suppression seemed to impact HRV and TPR values predominantly for the NHB group. Remarkably, this was accentuated for those NHB individuals with lower SES estimates and therefore those most likely to use suppression in response to unfair

Table 3
Partial correlation coefficients between cardiovascular variables of interest, socioeconomic status, and ERQ suppression and reappraisal scores.

Asian	1	2	3	4	5
1. lnRMSSD	–				
2. lnTPR	0.452*	–			
3. SES	0.096	0.052	–		
4. suppression	0.052	−0.025	0.036	–	
5. reappraisal	0.098	0.070	0.097	0.249*	–
NHB	1	2	3	4	5
1. lnRMSSD	–				
2. lnTPR	0.431*	–			
3. SES	−0.334*	−0.250*	–		
4. suppression	0.090	0.137	−0.078	–	
5. reappraisal	−0.107	−0.219*	0.022	−0.155	–
Hispanic	1	2	3	4	5
1. lnRMSSD	–				–
2. lnTPR	0.389*	–			
3. SES	−0.007	−0.138*	–		
4. suppression	0.012	0.000	−0.183*	–	
5. reappraisal	−0.060	−0.036	0.067	−0.060	–
NHW	1	2	3	4	5
1. lnRMSSD	–				
2. lnTPR	0.392*	–			
3. SES	0.041	−0.036	–		
4. suppression	−0.065	−0.064	−0.046	–	
5. reappraisal	0.011	0.015	0.027	0.044	–

Note. Abbreviations: ERQ = emotion regulation questionnaire; ln = natural logarithm; NHB = Non-Hispanic Black; NHW = non-Hispanic White; RMSSD = root means square of successive differences; SES = socioeconomic status; TPR = total peripheral resistance. * $p < .05$.

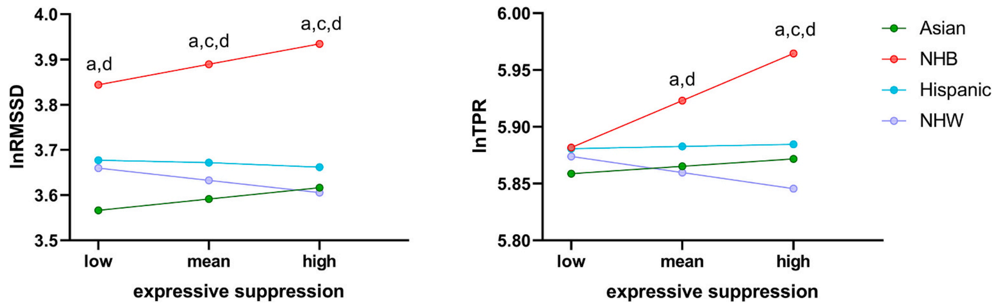

Fig. 3. Ethnic differences in the association between expressive suppression and RMSSD and TPR. Higher and lower estimates of expressive suppression were derived from ±1SD (4.9) from the mean score (16.2) of the suppression scale of the ERQ questionnaire (see "Methods" for details). Abbreviations: ln = natural logarithm; ERQ = emotion regulation questionnaire; NHB = Non-Hispanic Black; NHW = non-Hispanic White; RMSSD = root mean square of successive differences; TPR = total peripheral resistance. a = p < .05 vs Asian, c = p < .05 vs Hispanic, d = p < .05 vs NHW (see exact *p* values in the Supplementary Material).

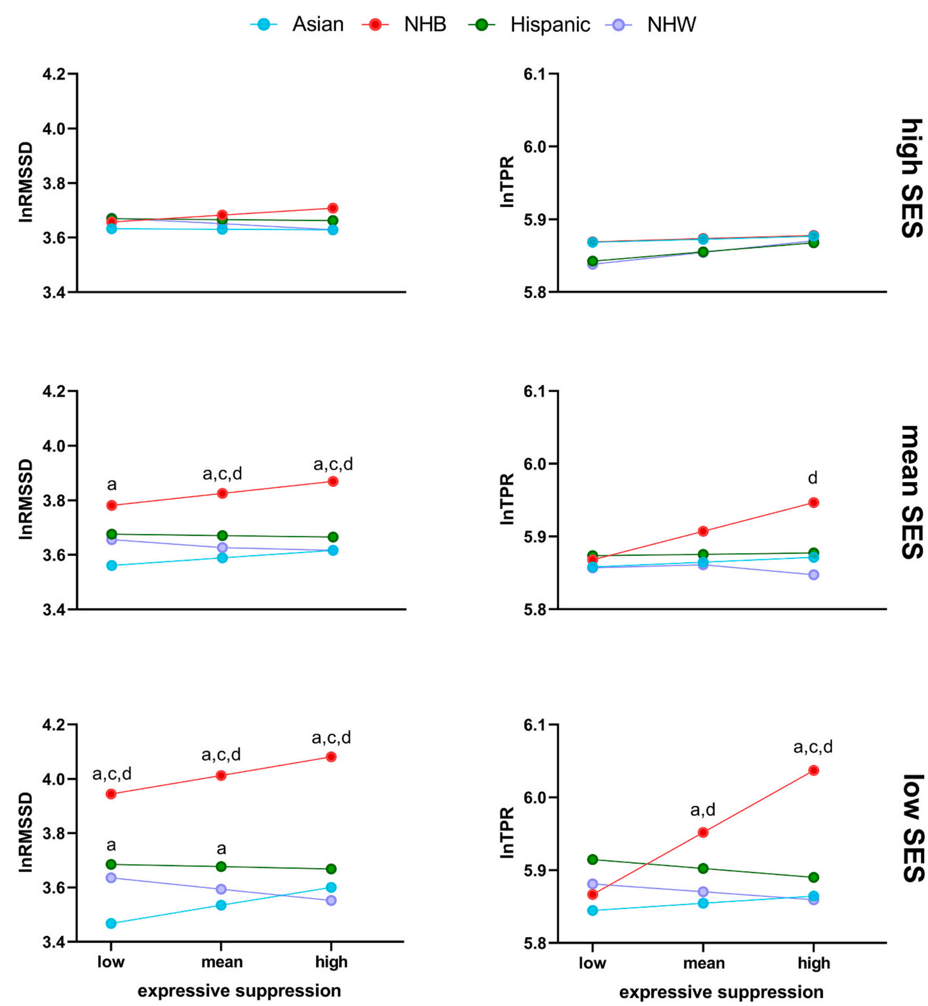

Fig. 4. Ethnic differences in the association between expressive suppression and RMSSD and TPR measures at different levels of SES. Higher and lower estimates of expressive suppression and SES were derived from ±1SD from the respective mean scores (16.2 and 5.9, respectively) (see "Methods" for details). Abbreviations: ln = natural logarithm; NHB = Non-Hispanic Black; NHW = non-Hispanic White; RMSSD = root mean square of successive differences; SES = socioeconomic status; TPR = total peripheral resistance. a = p < .05 vs Asian, c = p < .05 vs Hispanic, d = p < .05 vs NHW (see exact p values in the Supplementary Material).

treatment.

Adjusting for several health-related covariates, NHB emerging adults showed elevated resting RMSSD and TPR compared not only with NHW counterparts, which is consistent with previous meta-analytic evidence (Brownlow et al., 2020; Thayer et al., 2020), but also with Asian adults, and for RMSSD, with Hispanic adults. The medium effect sizes for RMSSD indicate moderate differences in cardiac vagal modulation, whereas the small-to-medium effects for TPR suggest more subtle but potentially clinically relevant vascular strain in NHB individuals. Consistent with this, NHB adults showed higher MAP and SBP compared with Asian and NHW counterparts, with small-to-medium effects. Thus, the present results clearly support the "black exceptionalism" framework, when directly compared with the "peoples of color" framework, to explain how sociocultural context becomes embodied in American

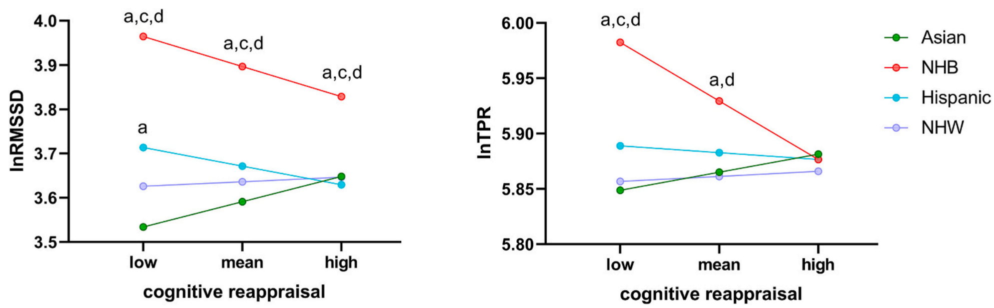

Fig. 5. Ethnic differences in the association between cognitive reappraisal and RMSSD and TPR. Higher and lower estimates of cognitive reappraisal were derived from ±1SD (6.0) from the mean score (30.5) of the reappraisal scale of the ERQ questionnaire (see "Methods" for details). Abbreviations: ERQ = emotion regulation questionnaire; ln = natural logarithm; NHB = Non-Hispanic Black; NHW = non-Hispanic White; RMSSD = root mean square of successive differences; TPR = total peripheral resistance. a = p < .05 vs Asian, c = p < .05 vs Hispanic, d = p < .05 vs NHW (see exact p values in the Supplementary Material).

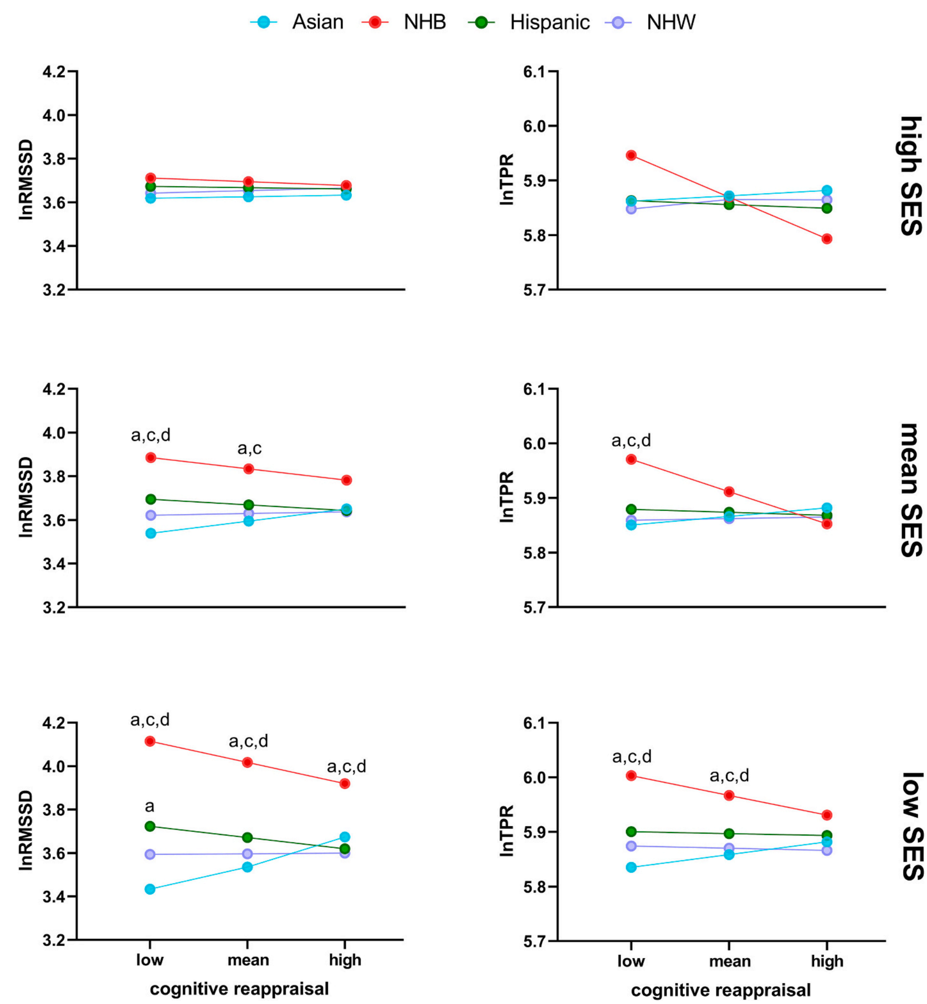

Fig. 6. Ethnic differences in the association between cognitive reappraisal and RMSSD and TPR measures at different levels of SES. Higher and lower estimates of cognitive reappraisal and SES were derived from ±1SD from the respective mean scores (30.5 and 5.9, respectively) (see "Methods" for details). Abbreviations: ln = natural logarithm; NHB = non-Hispanic Black; NHW = non-Hispanic White; RMSSD = root mean square of successive differences; SES = socioeconomic status; TPR = total peripheral resistance. a = p < .05 vs Asian, c = p < .05 vs Hispanic, d = p < .05 vs NHW (see exact p values in the Supplementary Material).

emerging adults of various ethnoracial groups.

Previous studies have suggested that NHB individuals do not have greater sympathetic nervous system activity across all biological systems (Chong et al., 2023, 2025). Therefore, the BP, and especially the TPR, effects that we report here in NHB emerging adults may be specific to elevated vascular sympathetic activation. A previous study in NHB individuals has linked increased sympathetic activation and greater TPR responses to experimentally manipulated expressive suppression (Dorr et al., 2007). Here, a greater usage of habitual suppression was reported by all minority ethnic groups compared to the NHW group, with differences being modest in magnitude but consistent across all minority ethnic groups. Yet, only NHB emerging adults exhibited higher TPR with increased tendency to use suppression. Also, this association seemed to be stronger at lower estimates of SES, suggesting greater vascular strain and physiological cost under the chronic structural stress of low SES. Critically, the magnitude of these moderation effects was generally modest, suggesting that these interactions should be interpreted as incremental rather than large effects. On the other hand, the negative association between cognitive reappraisal and TPR in NHB emerging adults suggests that reappraisal may be physiologically beneficial for this group, consistent with adaptive vascular responses.

These findings align with the Sociocultural Neurovisceral Model, which posits that meaning-making patterns shape how individuals interpret their social environments and guide the use of emotion regulation strategies, which may become embedded in neurovisceral systems over time. As such, these strategies should not be considered as inherently adaptive or maladaptive without considering the sociocultural and structural context in which they are enacted (Watanabe et al., 2025; Watanabe et al., 2026). This includes factors such as SES, discrimination, and chronic racialized vigilance. From this perspective, individuals with limited structural resources tend to form stronger expectations of potential threats and become more alert to their social surroundings, shaping key aspects of their social identity (Kraus et al., 2011, 2012). These meaning-making patterns are especially relevant for NHB emerging adults in the United States, whose developmental contexts are more likely shaped by experiences of discrimination and unfair treatment (Lee et al., 2019). Indeed, NHB individuals learn from an early age to inhibit the expression of anger to avoid exacerbating racially charged conflicts (Thayer et al., 2020). Therefore, consistent with this interpretation, the positive association between habitual use of suppression and resting TPR may reflect the physiological embedding of repeated regulatory demands linked to inhibited anger in response to daily episodes of discrimination (Watanabe et al., 2026), a more prevalent experience among NHB individuals, particularly in lower SES contexts (Lee et al., 2019).

From the perspective of the cardiovascular conundrum, greater HRV (i.e., reflecting greater cardiac vagal control) in NHB individuals may represent a compensatory autonomic response to their greater TPR. Under typical physiological conditions, increased cardiac vagal activity may help buffer sympathetic activation and support cardiovascular homeostasis. Critically, studies have shown that in NHB individuals impaired vascular relaxation is associated with decreased responsivity to acetylcholine, the primary neurotransmitter of the vagus nerve and a potent vasodilator (Jones et al., 1999; Taherzadeh et al., 2010). In this context, greater HRV in NHB individuals may reflect increased regulatory effort to counterbalance elevated vascular resistance. However, a recent study demonstrated that despite greater efforts to compensate (as indexed by greater HRV), this physiological response might not be as effective in properly regulating TPR in NHB as in NHW individuals (Williams et al., 2024). As such, greater vascular strain may predispose NHB emerging adults to greater risk for hypertension and cardiovascular disorders relative to NHW counterparts (Carnethon et al., 2017; Go et al., 2014).

Similar to TPR, differences in resting HRV between the NHB and the other ethnic groups were particularly evident among individuals with lower estimates of SES. Therefore, our hypothesis is that greater HRV in NHB emerging adults, particularly those with lower SES, may reflect heightened effort to regulate one's system in response to disadvantage, vigilance to threat, and persistent structural stress (Watanabe et al., 2025; Watanabe et al., 2026).

Importantly, Asian and Hispanic emerging adults also reported greater habitual use of expressive suppression compared to NHW counterparts, but this emotional regulation strategy did not seem to be as physiologically costly as for the NHB group. In particular, the flatter pattern of association between suppression and physiological measures in Asian American emerging adults mirrors prior findings in Japanese adults, where suppression may be a way to socially connect (maintain social harmony) rather than function defensively (Watanabe et al., 2025). Indeed, Asian Americans with more interdependent self-construal show greater neural efficiency when suppressing negative emotions (Kraus and Kitayama, 2019), suggesting that suppression may serve a culturally congruent regulatory function, especially under structural adversity (i.e., low SES; Kraus and Kitayama, 2019). Other studies on the mental consequences of expressive suppression in Hispanic/Latino and Asian populations have found mixed results. Some studies have found that suppression was related to greater depressive symptoms, anxiety, and internalizing symptoms (Gong et al., 2016; Juang et al., 2016; Park et al., 2010; Zhao and Zhao, 2015) and lower well-being (Cheung and Park, 2010; Su et al., 2015), while other studies have found that suppression was not associated with psychological consequences (Soto et al., 2011; Su et al., 2015). Lastly, expressive suppression was less common in the current sample of NHW emerging adults, which is consistent with the idea that the use of this emotional strategy is less frequent in contexts where autonomous values and open emotional expression are favored (Wierzbicka, 2004). Relatedly, we did not find statistically reliable associations between emotion regulation strategies and HRV and TPR values in the NHW group.

4.1. Limitations

Several limitations must be acknowledged. First, we did not have any measure of racial discrimination. Second, while parents' occupational status represents a good indicator of SES (Cirino et al., 2002), occupational scales might not capture the full complexity of SES. Therefore, these results must be interpreted cautiously, and future studies should include the assessment of perceived racial discrimination and more objective measures of SES. Also, in the United States, exposure to discrimination, racialized emotion socialization, and expectations about vigilance and self-presentation may not be fully captured by ethnoracial categories (Boyd et al., 2020; M. W. Kraus et al., 2011, 2012; Mendoza-Denton and Worrell, 2019; Worrell, 2015). These patterned contexts are especially relevant for young adults, whose social selves are built within environments structured by both SES and racialized stress. Thus, future studies should incorporate direct measures of cultural identity, orientation and practices, and acculturation to better characterize the social contexts and lived experiences that may influence physiological patterns and processes (NASEM, 2025; Watanabe et al., 2025; Watanabe et al., 2026). It is also important to acknowledge that the sample mostly consisted of college students, with a relatively small community representation of emerging adults. Also, the NHB group was much smaller than the other ethnic groups, which may have reduced statistical power for detecting interaction effects and limits the precision of subgroup estimates. Lastly, emotion regulation strategies were assessed using self-report measures that capture trait-like tendencies rather than context-specific regulatory responses. As such, these measures may not fully reflect how individuals regulate emotions in specific situations. However, we have previously reported that habitual use of emotional suppression was associated with decreased corrugator (frown) muscle activity in NHB adults when viewing negative and neutral images in an experimental setting (Finley et al., 2024). Future studies should therefore replicate these findings in larger and more diverse samples and incorporate ecological assessments of emotion regulation to better capture regulatory processes in daily life and to reduce potential shared-method variance associated with self-report measures. This may help clarify how contextual factors shape the associations among physiological measures, emotion regulation strategies, and SES.

5. Conclusion

In this study we provide evidence of elevated resting HRV and TPR (i.e., the cardiovascular conundrum) in NHB emerging adults compared to age-matched individuals of other minority ethnic backgrounds (Asian and Hispanic) and NHW counterparts. This cardiovascular phenotype seems to be associated with habitual use of suppression, particularly among those NHB individuals with lower SES estimates. The current results suggest that ethnic differences in physiological parameters are not solely influenced by SES differences (as has sometimes been proposed) but also associated with specific emotion regulation strategies, which is consistent with the Sociocultural Neurovisceral Model perspective of considering the sociocultural and structural context in which emotion regulation strategies are enacted to better understand their adaptive or maladaptive value (Watanabe et al., 2025; Watanabe et al., 2026). From a developmental perspective, emerging adulthood represents a particularly informative period for examining these processes. This life stage is characterized by continued maturation of neural systems involved in emotion regulation and cardiovascular control, as well as increasing exposure to social environments that shape identity and stress experiences. As such, physiological patterns observed during emerging adulthood may represent early markers of longer-term mental and cardiovascular health trajectories. Understanding the cardiovascular conundrum during this developmental window may therefore provide insight into how structural inequities and sociocultural stressors become biologically embedded over time. Longitudinal studies spanning adolescence and early adulthood will be important for determining how these physiological profiles evolve and whether they predict later cardiovascular and mental health outcomes. Lastly, the current results support the "black exceptionalism" idea that NHBs are the racial group for whom assimilation into the American mainstream is most distinctively difficult (Leslie and Sears, 2022). This contrasts with the "peoples of color" hypothesis that argues that all minority groups "of color" are particularly likely to be excluded from assimilation, compared with the trajectories of "White" minorities of European ancestry (Chan, 1991; Leslie and Sears, 2022). Thus, the current results may be some of the first to highlight the physiological consequences of "black exceptionalism" and suggest that expressive suppression may be one mechanism by which discrimination and unfair treatment "get under the skin" and lead to various racial disparities in health and well-being.

CRediT authorship contribution statement

Luca Carnevali: Writing – original draft, Formal analysis. **Darcianne K. Watanabe:** Writing – review & editing, Funding acquisition, Data curation. **Margherita Barbetti:** Writing – review & editing, Visualization, Formal analysis. **Alexandra T. Tyra:** Writing – review & editing, Investigation, Data curation. **DeWayne P. Williams:** Writing – review & editing. **Annie T. Ginty:** Writing – review & editing, Resources, Investigation, Data curation. **Julian F. Thayer:** Writing – review & editing, Funding acquisition, Conceptualization.

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Declaration of competing interest

The authors declare the following financial interests/personal relationships which may be considered as potential competing interests: Given his role as Associate Editor of International Journal of Psychophysiology, Luca Carnevali had no involvement in the peer review of this article and had no access to information regarding its peer review. Full responsibility for the editorial process for this article was delegated to another journal editor. If there are other authors, they declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Appendix A. Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.ijpsycho.2026.113386.

Data availability

Data will be made available on request.

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