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Skin-Deep Resilience in Black Youth: Striving and Sleep Reactivity to Daily Stress

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Objective: Referred to as “skin-deep resilience,” previous studies have found that striving—characterized by high levels of self-control and perseverance—is linked with better psychological health, but worse physical health, particularly among youth of color who have low socioeconomic status. However, the underlying mechanisms are unclear. This study investigated the role of sleep reactivity (poorer sleep following daily stress) in skin-deep resilience by examining the associations among striving, sleep reactivity, psychological health, and a subclinical marker of cardiovascular disease. ***Method:*** Participants were 315 Black youth with low socioeconomic status, who completed self-reported measures of striving (self-control and grit) and psychological health (well-being and internalizing symptoms). Using an 8-day diary and actigraphy approach, sleep reactivity was operationalized as changes in sleep duration, efficiency, and awakenings on days youth reported more stress. Subclinical cardiovascular disease was assessed by measuring peripheral endothelium-dependent vasodilation, determined by measuring brachial artery flow-mediated dilation. ***Results:*** High strivers exhibited good psychological health (well-being: $\beta = .46$; internalizing symptoms: $\beta = -.31$) but had sleep systems that were more responsive to daily stress (i.e., striving was associated with shorter, $\beta = .17$, less efficient, $\beta = .13$, and less continuous, $\beta = .11$, sleep on days with more stress); in turn, sleep reactivity to daily stress was associated with poorer flow-mediated dilation (efficiency $\beta = -.17$, awakenings $\beta = -.13$). ***Conclusion:*** These findings highlight the sleep system’s reactivity to daily stressors as a potential mechanism underlying skin-deep resilience.

Public Significance Statement

Referred to as “skin-deep resilience,” striving—characterized by high levels of self-control and perseverance—has been linked with better psychological health, but worse physical health, particularly among youth of color who have low socioeconomic status. This study found that Black youth with low socioeconomic status who were high strivers exhibited sleep reactivity—shorter or poorer sleep on stressful days. In turn, such sleep reactivity was associated with poorer endothelial function, a biomarker that has been linked to future cardiovascular disease.

Keywords: skin-deep resilience, race, sleep, daily stress, cardiovascular health

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Upward mobility in one's socioeconomic status (SES) is typically associated with beneficial life outcomes, such as greater wealth and more satisfaction with life (e.g., Kendig et al., 2016). However, several lines of research suggest that such achievements in "climbing the ladder" can sometimes come with a trade-off in physical health, particularly among people of color. For example, among Black and Latino/a adolescents with low SES, completing a 4-year college degree was associated with better mental health in young adulthood, such as fewer depressive and anxiety symptoms; at the same time, however, these young adults exhibited increased risk for metabolic syndrome (Gaydosh et al., 2018). Similarly, among Black youth who grew up in low SES neighborhoods, attending college was associated with better mental health, but higher levels of allostatic load (an indicator of increased cardiometabolic risk based on adiposity, blood pressure, and hormone levels), compared to those who have low SES but did not attend college (Chen et al., 2015). Consistent with this pattern where people of color are not benefiting from upward mobility, other researchers have also documented patterns of diminished gains, such that relative to their White counterparts, Black people do not reap the same level of health benefits from postulated protective factors, such as having larger social networks, higher levels of self-efficacy, or higher levels of sense of control (Assari, 2018; Assari et al., 2018). Together, these findings suggest a phenomenon referred to as "skin-deep resilience." Here, resilience is defined as the experience of positive outcomes, or faring better than would have been expected, in the face of adversity (Troy et al., 2023). As such, youth of color with low SES who achieved upward mobility appear to be resilient outwardly by various external metrics, or above the skin (e.g., earning higher incomes and exhibiting better mental health); however, beneath the skin, or biologically, they appear to experience diminished returns of their successes, as their bodies accrue cardiovascular disease risks more rapidly (Chen et al., 2022).

This phenomenon has prompted the question of why upward mobility would increase risk for cardiovascular disease among youth of color. While there are existing conceptual models that focus on the health of minority groups, such as the biopsychosocial model of racism (Clark et al., 1999), they largely focus on social and environmental factors underlying health disparities, rather than why upward socioeconomic mobility may accrue physical health costs among people of color. One explanation proposed by the skin-deep resilience theory (Chen et al., 2022) is that achieving upward mobility requires a high level of sustained striving, characterized by exerting heightened levels of self-control, working strenuously toward challenges, and maintaining perseverance despite setbacks (Duckworth et al., 2007; James et al., 1987). Many youth of color from households with low SES have to sustain this high level of striving in the educational domain while simultaneously managing demands from their home environment, such as performing obligations like caring for siblings or assisting parents with their jobs, which are more common in households with lower SES (Burton, 2007). Oftentimes as well, these youth have to strive for success in environments that do not have sufficient resources to support their efforts (Bottiani et al., 2016) while enduring contextual stressors that are often related to racism (Clark et al., 1999), like discrimination and victimization (e.g., Galán et al., 2021; Seaton & Iida, 2019). Together, these contextual demands and stressors are thought to repeatedly activate stress-responsive systems (Clark et al., 1999; McEwen, 1998). In typical responses to an acute stressor, physiological activation is sustained for an appropriate period and then turned off when no longer needed. However, because striving involves persevering over time through difficulties and sustaining continual strenuous efforts toward challenges, the effort involved in persistently high striving may prevent stress-responsive systems from learning to habituate to the impacts of daily life stressors, and such a lack of adaptation to repeated stressors is thought to over time accrue to disease risks (McEwen, 1998). Together, these theoretical perspectives and preliminary evidence point to striving as a potential factor underlying the adverse health costs of upward mobility among youth of color.

This explanation is consistent with John Henryism (JH) theory, which posits that coping with such a highly effortful style in difficult conditions like low SES may result in chronically activated bodily systems, leading to increased risk for hypertension (James, 1994). Indeed, among Black adults with low SES, reporting a high level of effortful coping and determination to succeed (JH coping) exhibited increased blood pressure, relative to those with similarly low SES but reported low JH coping (James et al., 1987, 1992). Preliminary evidence has also emerged among younger populations: Black and Latino/a youth with lower SES reported greater risk for metabolic syndrome when they reported higher (vs. lower) JH coping (Ehrlich et al., 2024). Furthermore, the current explanation is also consistent with the notion that, relative to emotion-focused coping strategies (e.g., reappraisal; Troy et al., 2017), problem-focused coping strategies, like striving, in the context of uncontrollable stressors, may produce adverse outcomes as failures to change intractable circumstances culminate (Lazarus & Folkman, 1984). Indeed, adolescents who had difficulties disengaging from pursuing unattainable goals exhibited increased low-grade inflammation over the course of 1 year (Miller & Wrosch, 2007). As Black adolescents with low SES are exposed to myriad stressors with low controllability, often related to systemic racism and structural inequalities (e.g., discrimination, segregation, and lack of institutional support; Clark et al., 1999), striving in this context may not be fruitful, exacerbating frustrations and stress that can lead to poorer health outcomes (Lazarus & Folkman, 1984; Troy et al., 2017). However, distinct from skin-deep resilience theory, conceptualizing striving as JH coping or a problem-focused coping strategy does not address how or why striving may lead to the tradeoff pattern of better psychological health, but poorer physical health described here.

Sleep is a stress-responsive system that has not been examined in the context of skin-deep resilience, despite being theorized as an important pathway connecting striving to cardiometabolic risk (Chen et al., 2022). Previous research has demonstrated reliable links between daily stress and sleep in adolescents: youth of color exposed to daily discrimination (El-Sheikh et al., 2022; Fuller-Rowell et al., 2017; Yip et al., 2020) and interpersonal conflicts (Schacter et al., 2022) exhibited shorter sleep duration, more sleep awakenings and disturbances, and poorer sleep quality. However, conceptual models have highlighted that the extent to which sleep is affected following stress exposure varies from person to person, an individual difference referred to as sleep reactivity (Drake et al., 2011). Specifically, some individuals exhibit higher sleep reactivity, characterized by shorter and poorer sleep following daily stressors, whereas others experience low sleep reactivity, characterized by no changes in sleep following daily stressors (Messman et al., 2023; Yoo et al., 2023).

Here, we propose that continual strenuous striving in low SES contexts may sensitize the sleep system to be more reactive to daily stress. High striving while managing the myriad contextual stressors mentioned above may put youth in a state of heightened vigilance and physiological arousal (Muraven & Baumeister, 2000), which in turn has been linked to greater stress-related sleep disturbances (Fernández-Mendoza et al., 2010; Palagini et al., 2016). Furthermore, when exposed to daily stressors, high strivers may put aside their emotions to focus on other tasks, but such coping strategies have been linked to greater sleep disturbances (Hoyt et al., 2009). Consistent with these postulations and skin-deep resilience patterns, greater daily stress was associated with poorer sleep (more disturbance and earlier next-day awakenings) only among students with low, but not high, SES (Peltz et al., 2021) and students with high, but not low, conscientiousness, a construct closely related to striving (Quaedflieg et al., 2023). As such, we hypothesized that high strivers may display greater sleep reactivity to daily stress, conceptualized as shorter, less efficient sleep, and more awakenings on days when daily stress levels are higher (Yoo et al., 2023). Because sleep reactivity is theorized to be a precursor to future sleep problems, such as insomnia and circadian disorders (Kalmbach, Anderson, & Drake, 2018; Kalmbach, Cuamatzi-Castelan, et al., 2018), we expect the association between striving and sleep reactivity to manifest earlier than the association between striving and habitual sleep problems. Therefore, given that the current investigation targets youth, our primary focus is on sleep reactivity rather than habitual sleep problems.

In turn, sleep reactivity may have ramifications for cardiovascular disease. In general, poorer sleep—such as shorter sleep and poorer sleep quality—has been linked to higher levels of inflammation, increased risk for metabolic syndrome, and higher blood pressure among youth (Countryman et al., 2013; El-Sheikh et al., 2022). More closely related to sleep reactivity, day-to-day fluctuations in sleep have also been linked to obesity and elevated blood pressure in adolescents, above and beyond habitual level of sleep problems (Morales-Ghinaglia & Fernandez-Mendoza, 2023). However, to the best of our knowledge, no studies have examined whether individual differences in the sleep system's reactivity to stress are also associated with cardiovascular disease. Here, we focused on a marker of subclinical cardiovascular disease: endothelium-dependent vasodilation assessed via brachial artery flow-mediated dilation (FMD). We opted for this assessment because endothelial dysfunction is considered an early pathogenic process in atherosclerosis development (Davignon & Ganz, 2004) that is detectable in childhood and adolescence (Hopkins et al., 2015; Järvisalo et al., 2002). Studies have shown that youth with lower FMD exhibited greater cardiometabolic risk, such as higher level of low-density lipoprotein cholesterol (e.g., Järvisalo et al., 2002). In adult studies, FMD preceded the emergence of traditional cardiovascular risk markers (e.g., Halcox et al., 2009) and predicted coronary artery disease and future cardiovascular events (e.g., myocardial infarction and stroke), above and beyond traditional cardiovascular markers (Inaba et al., 2010; Yeboah et al., 2007). Finally, FMD is also sensitive to both stress (Rodriguez-Miguelez et al., 2022) and sleep problems (e.g., Fernandez-Mendoza et al., 2021) among youth. Therefore, we tested whether sleep reactivity to daily stress would be linked to FMD.

The current investigation analyzed a sample of 315 Black youth from low SES households to examine, for the first time, the role of sleep in skin-deep resilience. Utilizing an 8-day actigraphy and daily diary design, we considered the associations among striving, sleep reactivity, psychological health, and FMD. Striving was measured using self-reported questionnaires. Sleep reactivity to daily stress was measured across the 8 days of diary and actigraphy assessments. Psychological well-being, satisfaction with life, and depressive and anxiety symptoms were measured by self-report. Consistent with the skin-deep resilience theory (Chen et al., 2022), we hypothesized that (a) striving would be associated with greater well-being and fewer mood symptoms; (b) striving would also be associated with greater sleep reactivity to daily stress; and (c) in turn, sleep reactivity would be associated with lower FMD. Finally, following previous literature (e.g., Kouros & El-Sheikh, 2015; Yip et al., 2020), we additionally examined habitual sleep problems (average level of sleep problems), and expected findings with sleep reactivity to be above and beyond habitual sleep problems.

Method

Participants and Procedure

Participants were 400 Black youth aged 14–19 (64% female at birth) recruited from the greater Chicago area through advertisements, presentations at schools, outreach to community organizations, and through a direct mail campaign. The sample size was determined based on a power analysis conducted to achieve the aims of the broader study. One caregiver was invited to participate together with each youth. This study focused on Black youth from low-income households, as defined by youth who identified as Black, were between ages 14 and 19, and whose family income was reported by caregivers to be below 2 times the federal poverty threshold for their household size. Other eligibility criteria included being English speaking, having no current major chronic illnesses that necessitated taking regular medication, having no mental health disorder serious enough to warrant hospitalization in the past year, and having no pervasive developmental disorder that would make the youth unable to complete the study protocol. Participants who were currently pregnant or acutely ill were offered the option of rescheduling.

Eligible youth and their caregiver were invited to a laboratory visit, during which the youth completed psychosocial questionnaires and health assessments while the caregiver completed interviews assessing family socioeconomic background. For eight nights beginning the night of the lab visit, youth were asked to complete daily diaries, which were completed using their preferred electronic devices (74% phone and 26% computer/tablet) at the end of each day, right before bedtime. During the 8-day study period, youth also wore an actigraphy watch that assessed daily sleep.

Participants were included in the current analyses if they had completed measures of all covariates described below as well as at least one of the outcome assessments (sleep reactivity, psychological health, or FMD), resulting in an analytical N of 315, nine (2%) did not have measures for all covariates, nine (2%) did not complete/have good images for FMD, 18 (5%) did not complete the daily diaries and/or actigraphy data, 22 (6%) did not have at least 3 days of diary or actigraphy data, and 27 (7%) did not have at least 3 days of paired diary and actigraphy data. Youth not included in the current analyses did not differ from included youth on age, parental education, striving, sleep reactivity, psychological health, and FMD (p's $> .147$). However, the youth not included in the current analyses were more likely to be female and had reached a higher pubertal stage. Youth provided either written assent or consent (depending on age), and caregivers provided written consent to participate in all study procedures, which were approved by the Northwestern University Institutional Review Board. Data can be available upon request with Institutional Review Board approval and a data use agreement.

Measures

Striving

Striving was assessed during the laboratory visit using two self-reported questionnaires: the Self-Control Inventory (Humphrey, 1982) and the Grit Scale (Duckworth et al., 2007). The Self-Control Inventory includes 15 items that assessed the habitual tendency to stay focused on goals, plan ahead, and not be distracted from goals (e.g., "How often do you stick to what you are doing, even during long, unpleasant tasks, until you are finished") rated on a 0 = *never* to 4 = *almost always* scale ($M = 2.69$, $SD = 0.44$, $\alpha = .76$). The Perseverance of Effort subscale of the Grit Scale includes six items that assessed the habitual tendency to work strenuously toward challenges and maintain effort despite failure (e.g., "I have overcome setbacks to conquer an important challenge") rated on a 1 = *not at all like me* to 5 = *very much like me* scale ($M = 3.96$, $SD = 0.65$, $\alpha = .75$). As the two scales correlated highly ($r = .52$), we averaged their standardized aggregate scores to create a composite such that higher scores indicated higher striving.

Daily Stress

Over an 8-day period, daily stress was assessed each night using an online survey sent to youths' phones. Youth completed four items that gauged subjective experiences of stress that day (e.g., "I had more things to do today than I could handle") rated on a 0 = *not at all* to 4 = *completely* scale (Pearlin et al., 1990). The intraclass correlation (ICC) was .56 (about 56% of total variability attributed to between-individual differences and 44% to within-individual differences).

Actigraphy-Based Sleep Measures

Youths' sleep was assessed objectively using the Actigraph wGT3X-BT (Actigraph, Florida, United States). Youth were instructed to wear the actigraphy watch on their nondominant wrist for eight consecutive days (seven nights), removing it only for showering or swimming. Motion was monitored in 1-min epochs to determine whether the youth were awake or asleep. Self-reported sleep and wake times were included in the daily online survey sent to youths' phones and were used to corroborate the coding of actigraphy sleep data by a team of trained coders. The ActiLife Software (V6.13.4, Actigraph) used the Sadeh algorithm, which has established validity among youth (Sadeh, 2011; van Kooten et al., 2021), to calculate sleep parameters. Sleep duration was defined as the number of minutes between bedtime and wake time scored as asleep (ICC = .22); sleep efficiency was defined as the percentage of epochs scored as asleep between bedtime and wake time (ICC = .50); wake after sleep onset (WASO) was defined as the number of minutes youth spent awake after having fallen asleep (ICC = .39). ICCs indicate the proportion of total variability attributable to between- versus within-individual variation. Thus, the expected lower ICCs suggest substantial variability attributable to within-individual daily variations (78% for duration, 50% for efficiency, and 61% for WASO), allowing the estimation of within-individual stress–sleep association described below.

Psychological Health

To gauge psychological health, we assessed both internalizing symptoms and well-being during the laboratory visit. Internalizing symptoms were assessed using the Generalized Anxiety Disorder-7 Screening Tool (Spitzer et al., 2006) and the Center of Epidemiological Studies Depression Scale (Radloff, 1977). The Generalized Anxiety Disorder-7 Screening Tool includes seven items that assessed anxiety symptoms experienced over the last 2 weeks (e.g., feeling nervous, anxious, or on edge) rated on a 0 = *not at all* to 3 = *nearly every day* scale ($M = 1.21$, $SD = 0.88$, $\alpha = .91$). The Center of Epidemiological Studies Depression Scale includes 20 items that assessed depressive symptoms over the past week (e.g., "I was bothered by things that don't usually bother me") rated on a 0 = *rarely or none of the time* to 3 = *most or almost all the time* scale ($M = 1.15$, $SD = 0.59$, $\alpha = .79$). As the two scales correlated highly ($r = .74$), we averaged their standardized aggregate scores to create a composite such that higher scores indicated more internalizing symptoms.

Well-being was assessed using the scale of Psychological Well-Being (Ryff & Keyes, 1995) and the Satisfaction With Life scale (Diener et al., 1985). The Psychological Well-Being includes nine items assessing environmental mastery, purpose in life, and self-acceptance (e.g., "I have a sense of direction and purpose in life") rated on a 1 = *strongly disagree* to 6 = *strongly agree* scale ($M = 4.28$, $SD = 0.70$, $\alpha = .72$). The Satisfaction With Life includes five items assessing satisfaction with life (e.g., "In most ways my life is close to my ideal") rated on a 1 = *strongly disagree* to 7 = *strongly agree* scale ($M = 4.44$, $SD = 1.32$, $\alpha = .86$). As the two scales correlated highly ($r = .50$), we averaged their standardized mean scores such that higher scores indicated greater well-being.

Subclinical Cardiovascular Disease Marker

Brachial artery FMD was assessed during the laboratory visit using noninvasive high-resolution ultrasound measurements (UNEXEF38G, Nagoya, Japan) that estimated the change in brachial artery diameter in response to reactive hyperemia. This system has been used successfully in other studies of youth (Takeuchi et al., 2015) and has established validity and reliability (Broxterman et al., 2019). Participants were assessed during morning hours following an overnight fast. A standard blood pressure cuff was placed on the youth's right forearm, two inches below the antecubital fossa. Images of the brachial artery were obtained at baseline using an ultrasound probe with a 10-MHz frequency. Participants rested for 2 min prior to cuff occlusion. The blood pressure cuff was inflated to 50 mm Hg above the participant's systolic blood pressure to occlude arterial flow for 5 min. Following this, the cuff was deflated (allowing blood flow to increase substantially, referred to as reactive hyperemia). Postocclusion images were obtained continuously for 2 min following cuff deflation. The maximum brachial artery diameter during this 2-min reactive hyperemia period was recorded. Images were digitized and analyzed using the system's automated analytic software (UNEX PCA Analysis). FMD was expressed as the percentage change from preocclusion baseline diameter to maximum diameter postocclusion. Lower FMD values indicate reduced vasodilatory responses, reflecting worse endothelium-dependent vasodilation.

Covariates

Covariates include age, sex at birth, pubertal status, and caregiver education. Youth reported age and sex at birth. They also completed a questionnaire to assess pubertal status (Physical Development Scale; Petersen et al., 1988). As a measure of SES, a primary caregiver reported their highest degree of education attained, 1 = *some high school or less* ($n = 25$, 6%); 2 = *high school diploma or equivalency* ($n = 89$, 23%); 3 = *some college* ($n = 130$, 33%); 4 = *associate's degree* ($n = 59$, 15%); 5 = *bachelor's degree* ($n = 55$, 14%); 6 = *master's degree* ($n = 33$, 8%); or 7 = *doctoral degree* ($n = 4$, 1%).

Analytical Approach

Prior to analyses, outliers (3 *SD*s from the mean) were inspected and winsorized to the next highest or lowest values. This applied to five variables: sleep duration reactivity ($n = 4$, 1%), efficiency reactivity ($n = 6$, 2%), WASO reactivity ($n = 4$, 1%), FMD ($n = 3$, 1%), and striving ($n = 1$, 0.3%). To capture sleep reactivity to daily stress, we conducted multilevel models where days were nested within individuals, which accounted for dependencies among the daily observations. These models estimated the coefficients reflecting the link between person-centered stress and sleep duration, efficiency, or WASO (Yoo et al., 2023). Substantial variability was observed in these coefficients, suggesting that the extent to which sleep changes as a function of stress varied from youth to youth (Figure S1 in the online supplemental materials). We extracted these coefficients for each youth and recoded them such that more positive coefficients indicated that on days youth experienced more stress than their usual, they experienced more sleep problems (i.e., shorter duration, lower efficiency, and increased WASO). Sleep reactivity slopes were extracted only if the youth had at least 3 days of diary and actigraphy data. Furthermore, to ensure findings were robust to the analytical approach, analyses involving sleep reactivity were repeated using Dynamic Structural Equation Modeling using Bayesian estimation (see the online supplemental materials).

Primary analyses first examined how striving related to psychological health and sleep reactivity. Specifically, a series of regressions was conducted separately predicting psychological health and sleep reactivity from covariates and striving. Average sleep parameters were additionally entered as covariates in analyses involving sleep reactivity. Second, a series of regressions was used to estimate how sleep reactivity related to FMD. In these analyses, both sleep reactivity and average sleep were entered simultaneously to examine their independent associations with FMD. For ease of interpretation, percent changes in outcome were estimated by natural log transforming the outcomes and then exponentiating the regression coefficient associated with sleep reactivity.

We then conducted two sets of exploratory analyses. First, to examine the specificity of the expected association between sleep reactivity and FMD, we tested whether sleep reactivity was associated with psychological health. Note that because striving was expected to be positively associated with sleep reactivity and psychological health, we did not expect greater sleep reactivity to daily stress to be related to psychological health. That is, we surmise that striving would be associated with better psychological health via a pathway unrelated to poorer sleep reactivity to daily stress. Second, we examined whether there were indirect effects from striving to sleep reactivity to FMD and direct associations from striving to FMD. Indirect effects and their 95% confidence intervals (CIs) were estimated by percentiles in the distribution of 50,000 bootstrapped samples using PROCESS macros (Hayes, 2022).

Finally, to examine whether results were robust to methodological approaches, sensitivity analyses were conducted rerunning analyses only among youth with at least 5 days of matching diary and actigraphy data and using sleep reactivity slopes that controlled for day effects (using dummy codes of day number with Day 0 as the referent) and weekday versus weekend effects. Moreover, we also examined whether the associations among striving, sleep reactivity, and FMD remained when controlling for physical activity, body mass index, and community violence (a neighborhood-level stressor; see the online supplemental materials for measurement), as these variables have known correlations with daily stress, sleep, and FMD (citations in the online supplemental materials).

Results

Table S1 in the online supplemental materials presents descriptive statistics. Diary completion rates were acceptable; 80% filled out at least 7 days of diaries, 14% filled out 4–6 days of diaries, and 5% filled out at least 3 days. Actigraphy compliance was good; 78% wore the watch at night for at least 7 days, 17% for between 4 and 6 days, and 5% for at least 3 days.

> *Hypothesis 1:* Striving will be associated with better psychological health.

Accounting for age, sex, pubertal status, and caregiver education, youth with higher levels of striving exhibited greater well-being ($b = 0.47$, $SE = 0.05$, $p < .001$) and fewer internalizing symptoms ($b = -0.34$, $SE = 0.05$, $p < .001$): every *SD* increase in striving was associated 0.46 *SD* increase in well-being and 0.31 *SD* decrease in internalizing symptoms (Table 1).

> *Hypothesis 2:* Striving will be associated with greater sleep reactivity to daily stress.

Accounting for age, sex at birth, pubertal status, and caregiver education, youth with higher levels of striving had more sleep problems in response to daily stress (greater sleep reactivity), as summarized in Table 1. Specifically, on days they experienced more (vs. less) stress, high strivers had shorter duration of sleep ($b = 0.57$, $SE = 0.19$, $p = .003$), less efficient sleep ($b = 0.01$, $SE = 0.003$, $p = .027$), and more awakenings ($b = 0.02$, $SE = 0.01$, $p = .045$). These translate to about 0.17 *SD* increase in the stress–duration linkage, 0.13 *SD* increase in stress–efficiency linkage, and 0.11 *SD* increase in the stress–awakenings linkage per *SD* of striving. When additionally controlling for the corresponding averaged sleep parameters, striving remained significantly associated with sleep reactivity in terms of duration ($b = 0.33$, $SE = 0.14$, $p = .021$), efficiency ($b = 0.01$, $SE = 0.003$, $p = .033$), and awakenings ($b = 0.02$, $SE = 0.01$, $p = .048$).

> *Hypothesis 3:* Greater sleep reactivity will be associated with worse FMD.

Table 1
Main Effects of Striving on Psychological Health and Sleep Reactivity to Daily Stress (Smallest Analysis N = 315)

Variable	Psychological health		Sleep reactivity to daily stress		
	Well-being	Internalizing symptoms	Duration	Efficiency	Awakening
Striving	β = .46, *b* = 0.47 (0.05), *p* < .001*	β = −.31, *b* = −0.34 (0.05), *p* < .001*	β = .17, *b* = 0.57 (0.19), *p* = .003*	β = .13, *b* = 0.01 (<0.01), *p* = .027*	β = .11, *b* = 0.02 (0.01), *p* = .045*
Age	β = −.16, *b* = −0.09 (0.03), *p* = .002*	β = .19, *b* = 0.11 (0.03), *p* < .001*	β = −.07, *b* = −0.12 (0.11), *p* = .286	β = −.07, *b* = 0.00 (<0.01), *p* = .226	β = −.08, *b* = −0.01 (0.01), *p* = .201
Female at birth	β = −.03, *b* = −0.05 (0.10), *p* = .624	β = .05, *b* = 0.11 (0.11), *p* = .351	β = .16, *b* = 0.97 (0.43), *p* = .025*	β = −.01, *b* = 0.00 (0.01), *p* = .944	β = −.1, *b* = −0.03 (0.02), *p* = .162
Caregiver education	β = −.01, *b* = −0.01 (0.03), *p* = .758	β = −.07, *b* = −0.05 (0.03), *p* = .132	β = .04, *b* = 0.08 (0.12), *p* = .493	β = .08, *b* = 0.00 (<0.01), *p* = .154	β = −.01, *b* = 0.00 (0.01), *p* = .887
Pubertal status	β = −.03, *b* = −0.04 (0.07), *p* = .58	β = .06, *b* = 0.08 (0.08), *p* = .298	β = .01, *b* = 0.04 (0.3), *p* = .89	β = .12, *b* = 0.01 (0.01), *p* = .121	β = .15, *b* = 0.03 (0.01), *p* = .049*

Note. Standardized βs, unstandardized *b*s, standard error in parentheses, and *p* values are presented. Sleep reactivity was coded such that higher values indicated shorter duration, lower efficiency, and more awakenings in response to higher daily stress.
* *p* < .05.

Greater sleep reactivity to daily stress in terms of efficiency and awakenings was associated with worse FMD (Table 2): every 1 *SD* decrease in sleep efficiency in response to higher daily stress was associated with 1% (or 0.17 *SD*) decrease in FMD ($b = -9.31$, $SE = 3.54$, $p = .009$); and every 1 *SD* increase in awakening minutes in response to higher daily stress was associated with 1% (or 0.13 *SD*) decrease in FMD ($b = 2.26$, $SE = 1.07$, $p = .036$). Importantly, these associations were independent of the average level of efficiency and awakenings. Sleep reactivity in terms of duration was not associated with FMD ($b = -0.01$, $SE = 0.07$, $p = .886$).

Exploratory Analyses

First, we examined whether sleep reactivity was associated with psychological health. Adjusting for covariates, sleep reactivity to daily stress was not associated with psychological well-being (duration: $b = 0.04$, $SE = 0.024$, $p = .060$; efficiency: $b = 0.25$, $SE = 1.27$, $p = .842$; and awakenings: $b = -0.08$, $SE = 0.38$, $p = .831$) nor internalizing symptoms (duration: $b = 0.001$, $SE = 0.025$, $p = .971$; efficiency: $b = -2.54$, $SE = 1.31$, $p = .053$; and awakenings: $b = -0.70$, $SE = 0.396$, $p = .077$), suggesting that sleep reactivity was uniquely associated with poorer FMD.

We also tested whether sleep reactivity served as a pathway connecting striving to FMD. A significant indirect effect was observed ($b = -0.05$, $SE = 0.04$, 95% CI [−0.1347, −0.001]), such that striving was associated with worse sleep reactivity in terms of efficiency ($\beta = .13$, $b = 0.01$, $SE = 0.003$, $p = .027$), which in turn was associated with lower FMD ($\beta = -.17$, $b = -9.31$, $SE = 3.54$, $p = .009$).[1] We did not observe significant indirect effects for sleep reactivity in terms of duration and awakenings, as depicted in Figure S2 in the online supplemental materials.

We then explored whether striving had direct associations with FMD. We did not find evidence that striving was associated with FMD ($b = -0.04$, $SE = 0.15$, $p = .785$). However, because previous research has documented that striving–health associations are most prominent in the lowest SES groups even within lower income samples (Brody et al., 2013, 2020), we tested for a striving by parental education interaction, and found this to be significant ($\beta = .27$, $b = 0.22$, $SE = 0.10$, $p = .038$). Among youth whose parents have a high school education or less, higher striving was associated with lower FMD ($\beta = -.19$, $b = -0.56$, $SE = 0.29$, $p = .055$), but among youth whose parents have a bachelor's degree or higher, striving was not associated with FMD ($\beta = .11$, $b = 0.33$, $SE = 0.24$, $p = .16$), as depicted in Figure S3 in the online supplemental materials.

Sensitivity Analyses

We first examined whether results were robust to methodological approaches; we reconducted primary analyses using sleep reactivity slopes only if at least 5 days of matching diary and actigraphy data were available (Tables S3 and S4 in the online supplemental materials). In addition, we reconducted analyses using sleep reactivity slopes that controlled for day effects (using dummy codes of day number with Day 0 as the referent) and weekday versus weekend effects (Tables S5 and S6 in the online supplemental materials). Moreover, we examined whether results were robust to additional covariates – physical activity, body mass index, and community violence (Tables S7 and S8 in the online supplemental materials). The pattern of results did not differ in all three sets of sensitivity analyses—striving remained significantly associated with poorer sleep reactivity; in turn, sleep reactivity in terms of efficiency and WASO remained significantly associated with poorer FMD. The only exception was that striving was no longer associated with sleep reactivity in terms of WASO when controlling for additional covariates ($p = .055$).

Discussion

Among Black youth with low SES, those with higher levels of striving exhibited good psychological health (greater well-being and fewer internalizing symptoms) but had poorer sleep on days with daily stress. Specifically, high strivers had shorter, less efficient, and less continuous sleep on days when stress was higher. In turn, poorer sleep efficiency and continuity in response to daily stress were associated with lower FMD (indicating a poorer increased risk for cardiovascular disease). Together, the current patterns of results were consistent with the skin-deep resilience hypothesis,

[1] As a total effect (striving → FMD) was not observed, we did not make any inferences about whether the indirect effect was a "full" or "partial" indirect effect nor compute the proportion of variances of total effect accounted for by sleep reactivity (Hayes, 2013).

Table 2
Main Effects of Sleep Reactivity on Endothelial Function (Smallest Analysis N = 315)

Variable	Flow-mediated dilation Standardized β, unstandardized *b* (*SE*), and *p* value		
Sleep reactivity—duration	$\beta = -.01$, $b = -0.01$ (0.07), $p = .886$		
Average sleep duration	$\beta = .05$, $b = 0.00$ (<0.01), $p = .528$		
Sleep reactivity—efficiency		$\beta = -.17$, $b = -9.31$ (3.54), $p = .009$*	
Average sleep efficiency		$\beta = .08$, $b = 0.03$ (0.02), $p = .198$	
Sleep reactivity—awakenings			$\beta = -.13$, $b = -2.26$ (1.07), $p = .036$*
Average sleep awakenings			$\beta = -.01$, $b = 0.00$ (0.01), $p = .813$
Age	$\beta = -.03$, $b = -0.04$ (0.10), $p = .678$	$\beta = -.03$, $b = -0.05$ (0.10), $p = .602$	$\beta = -.04$, $b = -0.06$ (0.10), $p = .539$
Female at birth	$\beta = .11$, $b = 0.58$ (0.39), $p = .137$	$\beta = .11$, $b = 0.57$ (0.38), $p = .136$	$\beta = .11$, $b = 0.55$ (0.38), $p = .156$
Caregiver education	$\beta = .05$, $b = 0.09$ (0.10), $p = .362$	$\beta = .06$, $b = 0.11$ (0.10), $p = .278$	$\beta = .05$, $b = 0.09$ (0.10), $p = .390$
Pubertal status	$\beta = -.01$, $b = -0.03$ (0.26), $p = .902$	$\beta = .01$, $b = 0.04$ (0.26), $p = .879$	$\beta = .01$, $b = 0.05$ (0.26), $p = .860$

Note. Sleep reactivity was coded such that higher values indicated shorter duration, lower efficiency, and more awakenings in response to days with higher stress.
* $p < .05$.

which posits that striving promotes resilience overtly in terms of psychological health, but that this resilience can take a physiological toll on sleep and FMD.

With respect to the sleep findings, we posit that persistently high levels of self-control and strenuous effort may sensitize the sleep system, such that nighttime sleep becomes more strongly tied to daytime stress. Consistently, previous research has found that more daily stress was associated with earlier awakenings the next morning among college students high (vs. low) in the personality trait of conscientiousness, which overlaps with the striving construct (Quaedflieg et al., 2023). Furthermore, in a sample of African Americans, goal-striving stress was associated with decreases in sleep duration across 8 years. Notably, this link was only apparent among high school and college graduates, but not among those with less than a high school education or those who attended but did not graduate from college (Cain-Shields et al., 2021). Together, these findings suggest that among Black youth with low SES, striving may help youth achieve educational goals like graduating high school and college, but this may come at a cost for sleep reactivity. In addition, because striving involves persevering through difficulties, when confronted with heightened demands, high strivers may be less likely to engage in self-care restorative health behaviors like sleep (Chen et al., 2022). Building on previous research, the current findings shed light on how the sleep system may be yet another system implicated in skin-deep resilience, and one that may operate via persistent striving (Chen et al., 2022).

Sleep reactivity, in turn, was associated with worse FMD, a subclinical marker of early cardiovascular disease. This finding is consistent with experimental studies which found that shorter sleep led to lower FMD (Hall et al., 2017) and prospective studies that linked habitually shorter sleep to lower FMD decades later (Hall et al., 2017). We extend these findings by documenting associations of FMD with how the sleep system responds to daily stressors and demonstrating that these associations held above and beyond habitual sleep problems. To this end, recent theories highlighted autonomic dysregulation as an explanation for these associations (Hall et al., 2017). Specifically, wakefulness is associated with increased sympathetic nervous system activities, which in turn may increase hormones (e.g., Angiotensin-II) known to decrease nitric oxide production, a key vasodilator secreted by the endothelium to facilitate dilation (Harris et al., 2010; Navar, 2014; Shatanawi et al., 2011). As such, sleep problems in response to daily stress may reduce nitric oxide bioavailability via autonomic dysregulation and, in turn, contribute to reduced FMD.

Both associations between striving and sleep reactivity as well as between sleep reactivity and FMD were above and beyond habitual sleep outcomes. From a developmental standpoint, it is possible that sleep reactivity represents an early indicator of alterations to the sleep system—one that can be observed in healthy adolescents and one that may precipitate habitual sleep problems over time. Consistently, conceptual models have postulated sleep reactivity as a pathogenic vulnerability factor that increases risk for future sleep disorders (Drake et al., 2011; Kalmbach, Anderson, & Drake, 2018). Indeed, in a population-based sample of adult good sleepers, sleep reactivity to stress predicted the development of insomnia symptoms and chronic insomnia disorder 2 years later (Jarrin et al., 2014). Collectively, these findings suggest sleep reactivity as a potential early warning sign among youth of color that is detectable in adolescents without chronic sleep problems and is associated with a preclinical cardiovascular risk marker. In addition, while the current study did not observe associations among habitual sleep problems, striving, and FMD, these associations may emerge over time when sleep reactivity to stress turns into more stable and chronic sleep disturbances.

Additional analyses revealed that poorer sleep efficiency reactivity served as a pathway connecting striving to FMD, but indirect effects via duration reactivity and WASO reactivity were not observed. It is important to note that given the exploratory nature of these analyses, the observed patterns are best considered preliminary and should only be interpreted if replicated. The lack of indirect effects via duration reactivity is due to the lack of association between duration reactivity and FMD. This may be because both insufficient and excessive sleep duration have been linked to stress (Short et al., 2020) and increased risk for cardiovascular disease (Krittanawong et al., 2019), including FMD (Hall et al., 2017). As such, some youth may sleep shorter, whereas others may sleep longer, in response to stress, obscuring the association between duration reactivity and FMD. With regard to WASO reactivity, both the path connecting striving to WASO reactivity and the path connecting WASO reactivity to FMD were significant. However, the indirect effect estimate (the product of the two paths' estimates) was not strong enough to be reliably significant in the current sample, despite having a comparable effect size as the indirect effect via efficiency reactivity (indirect effect via efficiency reactivity standardized $\beta = -.018$ vs. indirect effect via WASO reactivity standardized $\beta = -.013$). Thus, it may be that the lack of significant indirect effect with this WASO reactivity is due to insufficient power. Together, if replicated in future better powered samples, such as in large public data sets like Midlife in the United States which contains relevant assessments, this may suggest that striving confers risks via disruption of efficiency and continuity. However, as mentioned, these results are best considered tentative and should only be interpreted if substantiated by future research.

Moreover, this indirect effect was observed without an overall association between striving and FMD. This may be because striving is postulated to be associated with cardiovascular risk, not just via sleep reactivity, but also via other mechanisms, such as increased discrimination and decreased sense of belonging as high-striving youth advance into more prestigious but predominantly White spaces, reduced restorative behaviors like leisure activities, or increased stress-reducing but health-compromising behaviors like eating unhealthy foods (Chen et al., 2022). As such, the link between striving and FMD may only become apparent when these various mediating pathways have unfolded and become established, such that we may see evidence for a main effect of striving on FMD in future years as we continue to follow these adolescents. It may also be that this association is moderated by a third factor, obscuring the overall association between striving and FMD. Indeed, caregiver education attainment was a significant moderator such that striving was only associated with FMD among youth whose parents had lower educational attainment. This pattern is consistent with previous literature documenting that skin-deep resilience patterns tend to emerge only in the lowest SES groups (Brody et al., 2013, 2020). Because youth in the current sample have relatively low resource-based SES (low income to poverty ratio), youth who have parents with less education may experience additional prestige-based SES disadvantage. Striving may take a particular toll for these youth as they may be first in the family to advance in educational spaces, which can increase the pressure to succeed and contribute to feelings of lack of belonging (Chen et al., 2022). The interaction pattern may also suggest striving to be innocuous for FMD when caregiver education is high, indicating success in coping as adolescents can still accrue psychological health benefits. However, when caregiver education is low—indicating severely limited resources—striving may no longer be effective as efforts might be met with increased resistance due to heightened structural disadvantages, ultimately leading to a cost for FMD.

With respect to psychological outcomes, high striving was associated with lower internalizing symptoms and greater well-being. Previous research highlights that striving benefits psychological health by promoting goal achievement (Emmons, 1986) and perceived sense of control (Duckworth et al., 2016). Moreover, the act of striving—especially in the face of SES and racial disadvantages—may reflect elevated optimism about the future and perceptions of outcome efficacy. This increased positive outlook and sense of potential success can, in turn, promote the use of reappraisal and acceptance (Zou et al., 2022), thereby enhancing psychological health (Aldao et al., 2010). Future research will benefit from assessing both striving and emotion regulation to clarify their independent contributions to health. By contrast, the reactivity of the sleep system to daily stressors was not associated with psychological health. While it might at first seem puzzling why poorer sleep reactivity would not be linked to worse psychological health, it is important to note that previous empirical studies examining the link between sleep and psychological health have largely focused on habitual sleep problems (Baglioni et al., 2016). As sleep reactivity is thought to be a precursor to habitual sleep problems (Kalmbach et al., 2023; Yoo et al., 2023), it may be that sleep reactivity is relatively distal from psychological health to see associations in the current youth sample. Another reason for a lack of relationship between sleep reactivity and psychological health may be that sleep reactivity contributes to daily transient changes in well-being, which may not readily translate into more trait-like mental health. The present study found that striving is linked to better psychological health, and we postulate that these associations emerge via other pathways that are unrelated to sleep reactivity, such as the ones described above of goal achievement, external positive reinforcements, and increased perceived control.

This study invites several future directions. First, would striving similarly alter sleep reactivity to other daily psychosocial processes (besides stress), such as social interactions and affect, or positive events? Furthermore, as sleep is just one of various systems that respond to daily processes, would striving among youth of color from low SES backgrounds also be associated with responsivity of other systems to daily stress, such as more sensitive cardiovascular (e.g., higher blood pressure in response to daily events)? Second, future research will be necessary to examine the mechanisms underlying the associations among striving, sleep reactivity, and FMD. This might involve testing both psychosocial mechanisms, such as high cognitive arousal (Kalmbach, Cuamatzi-Castelan, et al., 2018), and biological mechanisms, such as autonomic dysregulation (Hall et al., 2017). Third, as mentioned above, sleep reactivity may be a useful early warning sign for unfolding skin-deep resilience. Future research will be necessary to determine how early sleep reactivity can be detected, whether it has clinical value in predicting later cardiovascular disease risk, and whether its predictive value would remain across the lifespan. Fourth, interventions that target youth who grow up under disadvantage often seek to promote self-control and grit (e.g., Bierman et al., 2021; Shechtman et al., 2013); our findings suggest that these interventions should consider the potential physical health consequences of their efforts. Indeed, the skin-deep resilience phenomenon has prompted motivations to reconceptualize resilience for practitioners, highlighting the need for more holistic approaches that account for structural oppression in the pursuit of resilience (Anderson, 2019). If replicated, the current findings suggest sleep as a modifiable mechanism that can be targeted to prevent inadvertent consequences for subclinical cardiovascular disease of striving for success. However, rather than focusing solely on modifying sleep, an individual-level factor, future intervention research should embed resources that promote sleep within structural-level interventions, such as cash transfers or policies that increase access to health care, so that tangible systemic changes are supported with individual-level resources (Chen et al., 2024).

The strengths of this study include the use of ecological methods to assess daily processes and sleep, examining outcomes in multiple domains, and recruiting a historically understudied sample of Black youth with low SES. There are limitations. First, as analyses were done cross-sectionally, we are unable to establish the directionality of our findings and cannot make inferences about causality for associations among striving, sleep reactivity, psychological health, and FMD. Yet, it is reasonable to speculate reversed directions; for example, better psychological health may increase cognitive and emotional capacities (Fredrickson & Joiner, 2002; Willroth et al., 2023), promoting optimism and outcome efficacies that in turn enable youth's efforts to strive. Future research would benefit from utilizing longitudinal designs and repeat assessments of sleep reactivity and health, modeling their trajectories over time, and examining whether striving would moderate these trajectories as well as whether changes in sleep reactivity would track with changes in health. Second, because we had too few days of diaries and actigraphy, we did not examine other temporal scenarios with regard to the link between daily stress and sleep (e.g., whether poorer sleep heightens perceived stress the next day and whether striving would predict that). Future research will benefit from increasing the number of diary and actigraphy days and leveraging that to examine whether striving impacts bidirectional relationships between daily stress and sleep, and how these associations in turn are related to cardiovascular disease risk. Third, youth from the current sample had shorter sleep and worse efficiency than the averages of non-Hispanic Black youth of similar ages based on the National Health and Nutrition Examination Survey, a nationally representative sample (Su et al., 2022). Future research is necessary to examine whether the current findings would replicate in other samples of Black youth. Fourth, this study only recruited Black youth and is the first to investigate the role of sleep in skin-deep resilience. Therefore, future research is necessary to examine whether the current findings are specific to youth of color and not White youth and whether findings will extend to other youth of color as theorized.

In conclusion, this study demonstrated that among Black youth with low SES, striving was associated with better psychological health, but worse sleep reactivity, manifested as shorter, less efficient, and less continuous sleep on days with higher versus lower stress. In turn, sleep reactivity was associated with lower FMD, a subclinical marker for cardiovascular disease. These findings contribute to the emerging literature on skin-deep resilience by identifying a potential mechanistic pathway via a sensitized sleep system.

Resumen

Objetivo: Estudios previos, conocidos como "resiliencia superficial," han descubierto que el esfuerzo, caracterizado por altos niveles de autocontrol y perseverancia, se relaciona con una mejor salud psicológica, pero con una peor salud física, especialmente entre jóvenes de color de bajo nivel socioeconómico (SES, por sus siglas en inglés). Sin embargo, los mecanismos subyacentes no están claros. Este estudio investigó el papel de la reactividad del sueño (sueño deficiente tras el estrés diario) en la resiliencia superficial, examinando las asociaciones entre el esfuerzo, la reactividad del sueño, la salud psicológica y un marcador subclínico de enfermedad cardiovascular. ***Método:*** Participaron 315 jóvenes Afrodescendientes de bajo nivel socioeconómico (SES), quienes completaron medidas auto informadas de esfuerzo (autocontrol y tenacidad) y salud psicológica (bienestar y síntomas internalizados). Mediante un diario de 8 días y un enfoque actigráfico, se operacionalizó la reactividad del sueño como cambios en la duración, la eficiencia y los despertares del sueño en los días en que los jóvenes reportaron mayor estrés. La enfermedad cardiovascular subclínica se evaluó midiendo la vasodilatación periférica dependiente del endotelio, determinada mediante la evaluación de la dilatación mediada por el flujo de la arteria braquial (FMD, por sus siglas en inglés). ***Resultados:*** Los que se esforzaron más mostraron una buena salud psicológica (bienestar: $\beta = .46$; síntomas internalizantes: $\beta = -.31$) pero tenían sistemas de sueño que respondían mejor al estrés diario (es decir, el esfuerzo se asoció con un sueño más corto [$\beta = .17$], menos eficiente [$\beta = .13$] y menos continuo [$\beta = .11$] en los días con más estrés); a su vez, la reactividad del sueño al estrés diario se asoció con un peor FMD (eficiencia $\beta = -.17$, despertares $\beta = -.13$). ***Conclusiones:*** Estos hallazgos resaltan la reactividad del sistema del sueño a los estresores diarios como un mecanismo potencial subyacente a la resiliencia superficial.

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