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SHORT COMMUNICATION

Life satisfaction moderates the impact of socioeconomic status on diurnal cortisol slope

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Abstract The association between SES and health is well established; however, only a handful of studies have investigated the relationship between SES and daily cortisol parameters. Further, within this small literature, virtually no studies have looked at psychological factors that might mitigate this relationship. In this study, we tested whether life satisfaction — the overall subjective affective assessment of one's own life — acts as a protective factor against cortisol dysregulation driven by low-SES. Among a large sample ($N = 1325$) of individuals from the Midlife in the United States (MIDUS) survey, we found that low-SES individuals with high levels of life satisfaction had a cortisol circadian profile similar to those of high-SES individuals. In contrast, low-SES individuals reporting low life satisfaction experienced attenuated morning cortisol concentrations and a flatter (''less healthy'') diurnal cortisol slope. Although more studies are needed to investigate the constellation of psychological resources and processes through which life satisfaction exerts its effects, the current work shows that the general affective evaluation of one's own life acts as a buffer against the detrimental effect of low-SES on health-related physiological processes.

The impact of socioeconomic status (SES) on health has been scientifically investigated for decades, with low SES consistently identified as a reliable predictor of greater risk for poor health (Adler et al., 1994). A more recent challenge for researchers has been to identify the biological pathways through which chronic stress associated with low SES exerts its deleterious effect on health. The end product of the hypothalamic-pituitary adrenal (HPA) axis, cortisol, is widely viewed as one the main indicators of the individual cumulative physiological risk associated with chronic stress. Cortisol secretion follows a diurnal rhythm, with higher levels at awakening followed by an acute rise about 30 min later (i.e., Cortisol Awakening Response or CAR) and a progressive decline across the rest of the day (i.e., cortisol slope). Flattened cortisol circadian profiles have been showed to have negative implications for physical health (Kumari et al.,

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2010), including mortality (Kumari et al., 2011); therefore, it is not surprising that low-SES has been associated with flatter cortisol rhythms, with low cortisol levels at awakening and a less steep decline of cortisol throughout the day (Cohen et al., 2006; Gustafsson et al., 2010; Hajat et al., 2010; Dowd et al., 2011).

Life satisfaction, the overall subjective affective assessment of one's own life (Pavot et al., 1991), has also been identified as a reliable predictor of good health and longevity; however, only few studies have looked at which physiological processes might be affected by this aspect of psychological well-being (Cacioppo et al., 2000). For example, no empirical study has tested whether low life satisfaction is associated with diurnal cortisol parameters predictive of undesirable health outcomes (e.g., flatter diurnal cortisol slope). Further, in various studies (Koivumaa-Honkanen et al., 2000; Siahpush et al., 2008), life satisfaction seems to predict positive health outcomes above and beyond SES, suggesting that SES and life satisfaction, albeit modestly correlated, might be two distinct pathways toward better health.

Within this framework, we hypothesized that life satisfaction may act as a protective factor against the detrimental effect of low-SES on physiological processes implicated on health. In other words, being satisfied with one's life might buffer the physiological costs of low-SES. This novel hypothesis awaits empirical testing and is the central focus on the current study, wherein various parameters of diurnal cortisol were investigated.

1. Method

Data were drawn from the National Study of Daily Experiences (NSDE II; $N = 2022$), a subsample of Midlife in the United States (MIDUS) II—the second wave of data collection for MIDUS I, a large panel survey of adults between the ages of 25 and 74. The NSDE II included four days of salivary cortisol collection and eight days of daily phone interviews. For the current study, inclusion criteria required that participants did not have missing values for the variables of interest during MIDUS II, and cortisol data collection for NSDE II. The sample consisted of 1325 adults (54.6% female, 95.7% White/Caucasian; age, $M = 56.6$ years, $SD = 11.7$ years).

1.1. Measures

1.1.1. Socioeconomic status (SES)

Similarly to previous studies (Gruenewald et al., 2012), self-report data from various sources were used to derive an index of SES. Five indicators were used: education level (from 1—no school/some grade school, to 12—any type of doctorate), current financial situation (11 point Likert scale), difficulty in paying bills (1—difficult, 2—not very difficult, 3—not at all difficult), participant wage on the last calendar year (from 1—less than $0, to 42—$200,000 or more), availability of money to meet basic needs (1—not enough, 2—just enough, 3—more than enough). Scores on each of these scales, which all correlated among each other (average $r = 0.305$, range $r = 0.092$—0.675, lowest $p = 0.001$), were standardized (i.e., z-scores) and a composite was computed, with high scores indicating higher SES.

1.1.2. Life satisfaction

Life satisfaction was assed using a four-item scale in which participants were asked to report on a scale from 0 to 10 the quality of their overall life, work, health, and family[1] ($\alpha = 0.65$). For example, people were asked: ''On a scale of 0 to 10, where 0 means the worst and 10 means the best, how would you rate your life these days?''.Higher scores in the scale reflect higher levels of life satisfaction (Prenda and Lachman, 2001).

1.1.3. Salivary cortisol

Salivary cortisol was collected using Salivettes (Sarstedt, Rommelsdorft, Germany). On average, saliva collection during NSDE II occurred 20.54 months ($SD = 13.57$) after the MIDUS II questionnaire assessment. On days 2—5 of the 8-day NSDE study period, participants self-collected saliva samples at four time points each day; immediately upon waking, 30 min later to assess cortisol awakening response (CAR), before lunch, and at bedtime. Cortisol concentrations were quantified with a commercially available luminescence immunoassay (IBL, Hamburg, Germany) with intra-assay and interassay coefficients of variability less than 5%. Saliva collection compliance was assessed using nightly telephone interviews and paper-and-pencil logs included in the collection kits. Cortisol values were log-transformed to correct for positive skew in the cortisol distribution (Adam and Kumari, 2009). In order to make sure that all transformed scores were positive, a constant of 1 was added before the transformation.

1.1.4. Potential covariates

Several standard covariates in diurnal cortisol studies (Adam and Kumari, 2009) were included in the analyses. Specifically, covariates included age, gender (male = 0, female = 1), race/ethnicity (0 = white, 1 = nonwhite), smoker (0 = non smoker, 1 = smoker), average hours of sleep and average wake time across the days of salivary cortisol sampling. In secondary analyses, we also controlled for average daily negative affect (14 items rated on 5-point Likert scale, $\alpha = 0.89$; see for example, Almeida et al., 2001) and average daily positive affect (13 items rated on 5-point Likert scale, $\alpha = 0.96$; see for example, Almeida et al., 2001) as a stringent test the robustness of effects of life satisfaction on cortisol parameters.

1.2. Data analysis

Hierarchical Linear Modeling (HLM) was used for data analyses. HLM allows for the simultaneous estimation of multiple cortisol parameters (cortisol at wakeup, CAR, and slope) and the prediction of individual differences in diurnal cortisol profiles. Following prior diurnal cortisol research (Adam and Kumari, 2009), Time Since Waking, Time Since Waking-squared, and CAR (dummy coded 0 or 1) were modeled at Level-1 to provide estimates of each participant's diurnal cortisol rhythm. At Level-2 (person-level), we first tested

[1] The family satisfaction item was created by averaging scores for relationship with spouse/partner and relationship with children as indicated in the original study (Prenda and Lachman, 2001).