Psychoneuroendocrinology (2013) 38, 2883—2889

Available online at www.sciencedirect.com

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Indirect effect of financial strain on daily cortisol output through daily negative to positive affect index in the Coronary Artery Risk Development in Young Adults Study

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Received 21 August 2012; received in revised form 11 July 2013; accepted 23 July 2013

KEYWORDS
Financial strain;
Cortisol;
Positive affect;
Negative affect

Summary Daily affect is important to health and has been linked to cortisol. The combination of high negative affect and low positive affect may have a bigger impact on increasing HPA axis activity than either positive or negative affect alone. Financial strain may both dampen positive affect as well as increase negative affect, and thus provides an excellent context for understanding the associations between daily affect and cortisol. Using random effects mixed modeling with maximum likelihood estimation, we examined the relationship between self-reported financial strain and estimated mean daily cortisol level (latent cortisol variable), based on six salivary cortisol assessments throughout the day, and whether this relationship was mediated by greater daily negative to positive affect index measured concurrently in a sample of 776 Coronary Artery Risk Development in Young Adults (CARDIA) Study participants. The analysis revealed that while no total direct effect existed for financial strain on cortisol, there was a significant indirect effect of high negative affect to low positive affect, linking financial strain to elevated cortisol. In this sample, the effects of financial strain on cortisol through either positive affect or negative affect alone were not significant. A combined affect index may be a more sensitive and powerful measure than either negative or positive affect alone, tapping the burden of chronic financial strain, and its effects on biology.

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0306-4530/$ — see front matter
http://dx.doi.org/10.1016/j.psyneuen.2013.07.016

Stress-induced stimulation of the hypothalamic—pituitary—adrenal (HPA) axis is an adaptive neurobiological process with a range of protective body-wide effects. Yet, elevated or prolonged release of glucocorticoids, seen in those economically disadvantaged, can cause physiological 'weathering' typical of diseases of aging (McEwen, 2007). For example, ambulatory and lab-induced elevations in cortisol levels have been significantly linked to various features of and risk factors for cardiovascular disease (Cagnacci et al., 2011; Hamer et al., 2010; Matthews et al., 2006). Financial disadvantage is firmly established as a significant contributor to the development and progression of a wide range of chronic diseases and mortality (Adler and Rehkopf, 2008).

Affective states are acutely associated with ambulatory cortisol, the essential human glucocorticoid released from the adrenal gland. In studies that have examined both negative and positive affect during the day and their relationship to cortisol in the same study, greater negative affect covaries with increased cortisol in some studies, and in others, greater positive affect with lower cortisol (Adam et al., 2006; Brummett et al., 2009; Nater et al., 2010). Inconsistent findings may result from the fact that while negative and positive affective states are negatively correlated, they can co-occur (Larsen et al., 2001), and that a combined affect index, i.e. the balance between participants' ratings of negative and positive affective states, may drive cortisol levels. The current study investigates this possibility, that an affect index integrating information from two opposing affective states is associated with cortisol measured at several time points across a day for each individual.

We examined these associations within the context of financial strain. Of growing interest is the role that financial strain plays in disease pathogenesis (Georgiades et al., 2009; Puterman et al., 2012; Rios and Zautra, 2011; Steptoe et al., 2005; Szanton et al., 2008, 2010). Financial strain has been previously related to elevated cortisol over the course of a day (Grossi et al., 2001), providing an important context within which to examine how financial strain may indirectly impact daily cortisol through daily affect — and in particular a negative to positive affect index.

1. Method

1.1. Procedure

During 1985—1986, CARDIA recruited 5115 participants, aged 18—30 years, at four sites, balanced for race, sex, age, and education, and assessments were conducted at study entry and eight follow-up years up to 25 years. The current study reports data from a sub-study at the year-15 follow up at the Chicago, Illinois, and Oakland, California, sites (Cohen et al., 2006). Site institutional review committee approval and informed consent were obtained. Participants from the Chicago ($N = 615$) and Oakland ($N = 721$) sites who lived within 50 miles of the site were invited to participate in the sub-study following their main study visit. Of those eligible, 836 (62.6%) consented, of which 806 returned salivary cortisol samples and the time each sample was collected. Twenty-five participants who woke up after 11 AM (between 11:15 AM and 11:00 PM) were excluded. The present analysis includes the remaining 776 participants. Sub-study participants had lower education and income and higher body mass index (BMI; kg/m^2) and diastolic and systolic blood pressure than those who did not participate in the sub-study.

1.2. Measures

1.2.1. Cortisol

At the end of year 15 clinic visit, participants received materials and instructions for ambulatory cortisol collection. Samples were collected six times on one weekday: at awakening, 45 min, 2.5 h, 8 h, and 12 h after awakening, and at bedtime. Participants were told not to eat, brush their teeth, or drink liquids for at least 15 min before samples. Alarm watches (preset to usual wakeup time) reminded participants to collect samples. Nine samples with levels below the minimum detectable level (0.7 nmol/L) were assigned values of 0.5 nmol/L. Intra- and interassay variabilities were less than 12%. Cortisol values were natural log transformed. One hundred and fifty-nine of 4697 cortisol samples were excluded due to sample collection outside the appropriate windows. For more information on sample collection, storage, assay and exclusion criteria, see Cohen et al. (2006).

1.2.2. Financial strain

In response to, ''How hard is it for you (and your family) to pay for the very basics like food, medical care, and heating?'' participants selected 1 = very hard, 2 = hard, 3 = somewhat hard, or 4 = not very hard. Financial strain was recoded: very hard and hard as high strain (<!- no-mfc ->'1'<!- /no-mfc ->), and somewhat and not very hard as low (<!- no-mfc ->'0'<!- /no-mfc ->) (Puterman et al., 2012).

1.2.3. Negative to positive affect index

At each cortisol sampling, Participants recorded the extent to which they were currently (1) 'happy, excited, content' and (2) 'worried, anxious, fearful' on a 4-point Likert scale (0—3). For each time point, *negative to positive affect index* was calculated by subtracting positive from negative affect. The intraclass correlation for the six reports of affect index made on a single day was .48, indicating that approximately half of the total variation is attributable to differences between participants in their average level of affect index, and half to fluctuations over the day.

1.3. Statistical approach

Descriptive statistics and *t*-test and chi-square test comparisons between those high and low in financial strain were examined. Mixed effects models (with the intercept, time since waking, and grand-centered affect treated as random effects [with unstructured covariance matrix], other variables treated as fixed effects) with maximum likelihood estimation were used to test the (1) associations between financial strain and the person-specific intercepts, i.e. estimated average daytime cortisol (path $X \rightarrow Y$, or '*c*', in typical mediation models) and (2) the indirect effect of financial strain on estimated average cortisol through negative to positive affect index (paths '*a*' and '*b*' in typical mediation, $X \rightarrow M$, and $M \rightarrow Y$, respectively). We also examined whether either positive or negative affect independently mediates the financial strain-cortisol relationship. To test indirect