Brain, Behavior, and Immunity 61 (2017) 21–26

Contents lists available at ScienceDirect

Brain, Behavior, and Immunity

journal homepage: www.elsevier.com/locate/ybrbi

Short Communication

Inflammation and positive affect: Examining the stress-buffering hypothesis with data from the National Longitudinal Study of Adolescent to Adult Health

Cara L. Blevins [a], Sara J. Sagui [a], Jeanette M. Bennett [a,b,*]

[a] Health Psychology Graduate Program, The University of North Carolina at Charlotte, USA
[b] Department of Psychology, The University of North Carolina at Charlotte, USA

ARTICLE INFO

Article history:
Received 16 February 2016
Received in revised form 14 July 2016
Accepted 17 July 2016
Available online 18 July 2016

Keywords:
Positive affect
Perceived psychological stress
Inflammation
Stress protective
Young adulthood

ABSTRACT

The present study examined the influence of positive affect (PA) on levels of inflammation within the context of Pressman and Cohen's (2005) stress-buffering model, which suggests that PA confers protective health benefits through its ability to mitigate the pathogenic influence of stress. We hypothesized that greater PA would buffer against the influence of perceived psychological stress (PPS) on systemic inflammation, operationalized as C-reactive protein (CRP, mg/L). Specifically, we predicted that PA would moderate the relationship between PPS and CRP. Cross-sectional data were drawn from Wave IV (2008–2009) of the National Longitudinal Study of Adolescent to Adult Health (Add Health). Participants (n = 3093) ranged in age from 25 to 34 years old (M = 29.0 ± 1.79). Using a moderated hierarchical regression analysis, PPS and PA significantly interacted to predict levels of CRP (p < 0.05). Examination of the simple slopes revealed a disordinal interaction between PPS and PA, such that higher PA was protective against elevated CRP levels, but only when individuals also reported greater levels of PPS. Thus, the data partially support the stress-buffering model of PA and extend existing evidence regarding the complexity by which PPS and PA influence health. Findings also provide caution of future assumptions that relationships among PA, PPS, and physical health markers, such as CRP, are always positive (*e.g.*, PA) or negative (*e.g.*, PPS) in nature.

1. Introduction

Acute inflammatory responses are essential components of recovery from infection or injury. Chronic elevations in proinflammatory biomarkers, such as levels of C-reactive protein (CRP; *e.g.*, >1 mg/L), are associated with a range of chronic illnesses including cardiovascular disease (CVD), type-II diabetes, and metabolic syndrome (Ansell et al., 2003; Dockray and Steptoe, 2010; Kiecolt-Glaser et al., 2003; McDade et al., 2006; Ridker, 2003). Systemic inflammation can be influenced by a variety of innate factors including biological (*e.g.*, age, sex, medication use) and psychosocial (*e.g.*, race, perceived stress, socioeconomic status) characteristics (Bennett et al., 2013; O'Connor et al., 2009).

The experience of perceived psychological stress (PPS; Cohen et al., 2007; Lazarus and Folkman, 1984) has been associated with impaired immune function and a greater propensity to illness and infection (Kiecolt-Glaser et al., 2003; McDade et al., 2006; Robles et al., 2009). PPS has been shown to upregulate CRP production and enhance expression of proinflammatory cytokines including interleukin-6 (IL-6), interleukin-1 beta (IL-1β), and tumor necrosis factor-alpha (TNF-α; Ershler and Keller, 2000; Kiecolt-Glaser et al., 2003; McDade et al., 2006). Burgeoning research suggests that intrinsic positive psychosocial processes, such as positive affect, may protect or buffer against stress and inflammation, conveying salutary benefits (Chida and Steptoe, 2008; Meyer et al., 2014; Pressman and Cohen, 2005; Steptoe et al., 2005).

Positive affect (PA) refers to the experience of feelings or moods that reflect pleasurable engagement with the environment, such as happiness, interest, and enthusiasm (Watson et al., 1988). PA can be experienced at both the state and trait levels. State PA is typically assessed as one's report of how s/he has felt over a short period of time (*i.e.*, day or moment), while trait PA represents a report of how one "typically" feels or the average of multiple measures of state PA (Polk et al., 2005; Pressman and Cohen, 2005). The strongest associations between PA and health have been noted at the trait level (Pressman and Cohen, 2005; Robles et al., 2009), and

* Corresponding author at: Department of Psychology, UNC Charlotte, 9201 University City Blvd., Charlotte, NC 28223, USA.
E-mail address: jeanette.bennett@uncc.edu (J.M. Bennett).

http://dx.doi.org/10.1016/j.bbi.2016.07.149
0889-1591/

prospective studies have associated trait PA with decreased morbidity and all-cause mortality (Chida and Steptoe, 2008; Kubzansky et al., 2001), as well as with attenuated inflammatory response to acute psychological stressors (Robles et al., 2009; Steptoe et al., 2008).

To describe the specific mechanisms by which PA influences health, Pressman and Cohen (2005) proposed a theoretical framework consisting of two general models. The *direct effects model* suggests that PA broadly influences physiological systems and behavior, regardless of its effect on perceptions of and responses to stress. Alternately, the *stress-buffering model* suggests that PA may protect or "buffer" against the negative influence of stress on health and behaviors.

A wide range of studies have supported assumptions that PA conveys health protective benefits; however, little work has utilized the Pressman and Cohen (2005) stress-buffering framework to examine specific mechanisms by which PA protects against stress' detrimental effects on physical health. Therefore, the present study sought to examine the influence of PA on systemic inflammation within Pressman and Cohen's (2005) stress-buffering framework. Specifically, this study hypothesized that PA would moderate the relationship between PPS and CRP.

2. Methods

2.1. Participants

Publically available cross-sectional data from Wave IV of the National Longitudinal Study of Adolescent to Adult Health (Add Health; Harris et al., 2009) were used to examine our hypothesis and included individuals who participated in finger stick dried blood spot (DBS) collection ($N = 4543$). CRP values ranged from 0.08 mg/L to 95.2 mg/L. Individuals with CRP levels $\geqslant 6.25$ mg/L ($n = 1034$; see Data Analysis section for explanation) and abnormal sleep values ($n = 149$) were removed from the analyses. Listwise deletion was used to account for missing data, yielding a final sample of $n = 3354$ for the unadjusted model and $n = 3093$ for the adjusted model.

Among the 3093 participants, average BMI was 27.76 ± 6.13 kg/m^2, mean age was 29 ± 1.79 years, and average CRP levels were 1.92 ± 1.61 mg/L. In addition, 50.7% were female, 36.7% reported smoking at least 1 cigarette in the past 30 days, and 67.4% stated they sleep between 7 and 9 h on a regular basis. Approximately 70.6% of individuals identified as White; 19.4% identified as Black; and 10% identified as Asian, Native American, Other or Hispanic, All Races. Overall, 13.2% of respondents endorsed no physical activity over the past seven days, 31% endorsed more than one physical activity per day, and 67% reported being active on three or less days over the past seven, including participation in individual or team sports (*e.g.*, baseball or golf) or organized exercise (*e.g.*, aerobics or weight lifting). In regards to education and income, approximately 14.6% of participants completed high school or an equivalent degree, 33.9% completed some college, and 35% finished a bachelor's degree or higher; approximately 44.6% reported an annual household income of $49,999 or less, and 16.3% endorsed an income over $100 K. Please see Supplemental Table 1 for additional information summarizing participant characteristics.

2.2. Measures

Positive affect (PA) was assessed with a single-item taken from *Section 14: Social Psychology and Mental Health*. Respondents indicated on a four-point Likert scale (0 = *never or rarely* to 3 = *most of the time or all of the time*) the degree to which they felt happy during the past seven days. Prior research suggests that a single-item happiness measure can accurately predict mortality or longevity (Kawamoto and Doi, 2002; Steptoe and Wardle, 2011). Further, measures utilizing the 'past week' time frame have previously been used to assess stable reflections of affect (*e.g.*, Ostir et al. (2000)). Higher scores on this measure indicated greater PA.

Perceived psychological stress (PPS) was assessed using Cohen and colleagues's (1983) four-item Perceived Stress Scale that examines stressful life appraisals. Responses were noted on a five-point Likert scale (0 = *never* to 4 = *very often*) and reflected the frequency with which feelings and thoughts have occurred throughout the past month in relation to stressful situations. This questionnaire was included only in Wave IV thereby precluding analyses with this measure in earlier waves. Internal consistency reliability in this sample was acceptable ($\alpha = 0.73$).

Negative affect (NA) has previously been related to PPS and inflammatory processes (Raison et al., 2006; Taylor et al., 2006) and was therefore included as a critical covariate in our analyses. To mirror the assessment of PA, NA was taken from a single-item asking respondents the degree to which they felt sad during the past seven days on a four-point Likert scale (0 = *never or rarely* to 3 = *most of the time or all of the time*). This is supported by previous work suggesting that a single-item of sadness drawn from the Center for Epidemiological Studies – Depression (CES-D) scale can accurately predict mortality among cognitively intact adults (St. John and Montgomery, 2009). Higher scores on this measure indicated greater NA. Information detailing the calculation of all other study covariates (*i.e.*, age, body mass index [BMI], socioeconomic status [SES], tobacco use, exercise, sleep, and anti-inflammatory medications) can be found in the Supplemental Materials.

2.3. Immunological assay

Dried blood spots (DBS) were collected via finger stick immediately following the completion of study questionnaires and stored −70 C freezer until assayed at the University of Washington, Department of Laboratory Medicine (see Whitsel et al. (2012), for full assay protocol). A high-sensitivity sandwich enzyme linked immunosorbent assay (ELISA) method was used to quantify CRP (mg/L); the limit of detection was 0.035 mg/L, and intra- and inter-assay coefficients were 8.1% and 11%, respectively. For a small sub-sample ($n = 87$), plasma samples were also collected; DBS and plasma levels were highly correlated ($r = 0.98$; Whitsel et al., 2012).

2.4. Data analysis

Two hierarchical moderated regression models (unadjusted and adjusted) were used to test the hypothesis via SPSS (Version 23). Continuous covariates were transformed to z-scores and categorical covariates were weighted effect coded (Hayes and Matthes, 2009). Serum CRP levels can be as high as 1.6 times that of DBS levels (Brindle et al., 2010); therefore, to be conservative, reported analyses and data reported in the main and Supplemental Materials only include participants with CRP values <6.25 mg/L (*i.e.*, estimated to have <10 mg/L in the blood as values greater than 10 mg/L can be indicative of acute infection; see Pearson et al. (2003) and McDade et al. (2006) for review). In addition, CRP data were natural log transformed before analysis to achieve a residual distribution that was approximately normal.

An interaction term was computed as the product of the z-scored PPS and PA variables. The adjusted model controlled for age, sex, race, BMI, SES, NA, anti-inflammatory medication use, and relevant health-behaviors including current tobacco use, current levels of exercise, and sleep duration (Janicki-Deverts et al., 2010; McDade et al., 2006; O'Connor et al., 2009).