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Trait mindfulness predicts the presence but not the magnitude of cortisol responses to acute stress

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ABSTRACT

Background: Mindfulness, or the practice of observing present moment experiences with acceptance, is thought to improve health at least partially by limiting hypothalamic-pituitary-adrenal (HPA) axis over-responsiveness during episodes of acute stress. However, models of allostatic load suggest that HPA axis under-responsiveness can also be detrimental to health, and the relationship between mindfulness and cortisol under-responsiveness has yet to be examined. The present study therefore aimed to address this knowledge gap, and to revisit the relationship between mindfulness and acute cortisol response magnitude while excluding (or statistically controlling for) individuals displaying HPA axis under-responsiveness.

Methods: Participants (124 healthy undergraduate students) were subjected to a stressful speech task, and completed a trait mindfulness questionnaire. Salivary cortisol was collected 0, +15, +25, +40, and +55 min post-stressor onset.

Results: Greater trait mindfulness was associated with greater odds of displaying a cortisol response relative to none, but was unrelated to the magnitude of cortisol responses among those who displayed an acute response.

Conclusions: In the present sample, trait mindfulness was associated with cortisol responses, but this was driven by the fact that subjects low in mindfulness were more likely to be non-responders. Contrasting the effects of mindfulness on the presence (i.e., present vs. absent) and the degree (i.e., magnitude) of acute stress responses may therefore be warranted in future research.

1. Introduction

Mindfulness, or the practice of monitoring present moment experiences with acceptance, is thought to mitigate psychological and physiological stress reactions, thereby limiting the cumulative impact of acute stress reactions on health (Mindfulness Stress Buffering Account or MSBA; Creswell and Lindsay, 2014). Consistent with this account, some work suggests that the effects of mindfulness interventions are most pronounced in health outcomes aggravated by stress. For example, stress has been shown to speed up HIV viral replication (Cole et al., 1998), and mindfulness training was found to slow CD4+ T lymphocyte decline (i.e., a marker of HIV progression) relative to a control intervention (Creswell et al., 2009). Other experimental support for the MSBA suggests that mindfulness may improve health by modulating cortisol responses to acute stress. For example, trait mindfulness was negatively associated with cortisol reactivity (i.e., response magnitude) to a stressful speech task in undergraduate students (Brown et al., 2012), suggesting that mindful individuals may benefit from reduced hypothalamic-pituitary-adrenal (HPA) axis activation during acute stress.

Linking mindfulness to HPA axis functioning is important in establishing a stress buffering effect of mindfulness because the end-product of the HPA axis, cortisol, is a primary stress mediator which widely impacts the body (McEwen, 2002). Models of stress and health suggest that over-exposure (or under-exposure) to primary stress mediators like cortisol contributes to allostatic load (i.e., biological wear and tear; McEwen, 1998), and ultimately lead to negative health outcomes like cardiovascular disease (Black and Garbutt, 2002). A dysfunctional HPA axis may contribute to allostatic load via several pathways (McEwen, 1998). For example, poor recovery from acute stress (i.e., when cortisol levels return to baseline levels too slowly) will increase cortisol exposure and thus increase allostatic load. Similarly, an over-responsive HPA axis will yield acute cortisol secretions of excessive magnitude leading to increased cortisol exposure and allostatic load. In relation to this framework, mindfulness is thought to limit HPA axis over-responsiveness during acute stress (Creswell and Lindsay, 2014).

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In addition to over-exposure of stress mediators (e.g., exaggerated cortisol reactivity), an inadequate or blunted response to acute stress (i.e., cortisol levels do not increase as a function of stressor exposure) may also lead to illness via hyperactivity of stress mediators normally counter-regulated by cortisol (Edwards et al., 2011; McEwen, 1998). For example, cortisol suppresses the production of pro-inflammatory cytokines like tumor necrosis factor alpha (TNF-α; Chrousos, 1995), and excess production of TNF-α is associated with susceptibility to autoimmune disorders like psoriasis (Victor and Gottlieb, 2002). In sum, cortisol under-exposure may also lead to disease (McEwen, 1998), and the relationship between mindfulness and HPA axis under-responsiveness remains unexamined. Some disorders known to be exacerbated by stress and excess cytokine activity, also tend to respond positively to mindfulness interventions. For example, stress often precedes the onset and exacerbation of psoriasis (Al'Abadie et al., 1994), and psoriasis patients undergoing a mindfulness intervention tend to show more rapid lesion resolution rate relative to a passive control condition (Kabat-Zinn et al., 1998). Thus, mindfulness could derive some of its stress buffering effects by limiting cortisol under-responsiveness.

Proposing that mindfulness could act as a stress buffer by limiting cortisol over-responsiveness and under-responsiveness may seem contradictory. However, the hypothesized health benefits of mindfulness are theoretically dependent upon the degree to which mindfulness reduces cortisol reactivity *among cortisol reactors*. In other words, greater mindfulness is thought to reduce the magnitude of acute cortisol responses, but not to the extent that highly mindful individuals are no longer responding to stressful stimuli with HPA axis activation. If mindfulness reduced the magnitude of cortisol responses to the extent that mindful individuals did not mount a cortisol response, mindfulness would theoretically promote cortisol under-exposure and disease. Based on this assertion, distinguishing between the effect of mindfulness on blunted cortisol responding (i.e., the absence of cortisol reactivity versus some reactivity) from the effect of mindfulness on the magnitude of cortisol responses (among reactors) is important because promoting limited cortisol reactivity may benefit health while promoting non-reaction will not.

Related to this point, procedures commonly used to model repeated cortisol data (e.g., mixed models) assume a single underlying population, and thus aggregate responses across non-reactor and reactors alike. This is problematic because, while *on average* social-evaluative stressors reliably induce HPA axis activation (Dickerson and Kemeny, 2004), a significant proportion of individuals often do not mount an observable increase following stressor exposure to such laboratory tasks (e.g., Newman et al., 2007). For example, Kirschbaum et al. (1993) reported that 30% of individuals in their sample displayed limited cortisol increases following the Trier Social Stress Test (i.e., > 2.5 nmol/L). This observation has led some to infer the presence of subpopulations of responders, and avoid the practice of averaging responses across all participants (e.g., Miller et al., 2013). Thus, the present study also examined how the relationship between mindfulness and cortisol response magnitude changes when the effect of mindfulness on reactor status is taken into consideration.

In summary, empirical support for a mindfulness stress buffering account suggests that mindfulness limits cortisol over-exposure by reducing the magnitude of acute cortisol responses to stress. Nevertheless, the effect of mindfulness on the likelihood of mounting any cortisol response to stress (i.e., reactor status) has yet to be examined. This knowledge gap is important because distinguishing between the effect of mindfulness on reactor status and the effect of mindfulness cortisol responses magnitude has implications for the hypothesized health protective effects of mindfulness. More specifically, the extent to which mindfulness improves health via an effect on cortisol response magnitude depends on the degree to which this effect is limited to individuals who mount a cortisol response (i.e., cortisol reactors). To address this knowledge gap, the present study tested the association between trait mindfulness and the likelihood of mounting any cortisol response to acute stress relative to no response. Additionally, the present study also examined how the association between trait mindfulness and cortisol response magnitude changes when controlling for the association between mindfulness and reactor status.

2. Material and method

2.1. Participants

One hundred and twenty-four healthy undergraduate students participated in this study (56% Female, M_{age} = 20 ± 2.07). Participants were 59% Asian-American, 14% Caucasian, 10% Middle-Eastern, 10% Hispanic, and 7% other ethnicities. Participants were ineligible for the study if they reported a chronic or serious health condition, use of tobacco, medication, or if they indicated a weekday wake time past 10:00 AM. The Institutional Review Board of University of California, Irvine, approved all procedures.

2.2. Procedure

All testing sessions were conducted after 12 PM. Upon arrival in the laboratory, participants provided consent, then completed a series of questionnaires, including demographics, depressed mood, health behavior/history, followed by a rest period (45 min in total). Subsequently, all participants completed the social-evaluative stressor task (10 min of preparation and 5 min speech) which effectively induces a cortisol response on average (Dickerson and Kemeny, 2004). The stress task entailed that participants delivered a speech pertaining to a hypothetical job interview in front of two evaluators. Ten minutes post-stressor, participants completed post task questionnaires (which included trait mindfulness) and rested by reading emotionally neutral magazines (30 min in total). Finally, participants were debriefed and compensated ($20).

2.3. Measures

2.3.1. Salivary cortisol

Saliva samples were collected using a Salivette sampling device (Sarstedt, Inc., Newton, N. C.) five times during the experiment (i.e., +0, +15, +25, +40, and +55 min post-stressor onset). Research assistants explained to participants how to collect samples (i.e., participants were instructed to tilt their head back, drop the dental roll in their mouth without touching it with their hands, saturate the dental roll with saliva for up to 3 min, and replace the dental roll in the Salivette without touching it with their hands), and were present while the samples were collected. Samples were stored at −20 °C. All saliva samples were centrifuged and assayed at the University General Clinical Research Center using standard enzyme-linked immunoassay procedures (Diagnostic Systems Laboratories, Inc., Webster, TX). Samples were assayed in duplicate and averaged, with a sensitivity of < 0.012 μg/dL; inter-assay and intra-assay coefficients of variation were less than 8%.

2.3.2. Mindfulness

Trait mindfulness was assessed using the 15-item Mindful Attention Awareness Scale (Brown and Ryan, 2003). This questionnaire was completed after the stress task. Participants rated the degree to which they are attentive to/aware of present experiences on a 6-point scale (1 = almost always; 6 = almost never). The scores on each item were reverse coded and averaged to obtain a total trait mindfulness score (M = 4.02 ± 0.77, α = 0.87); greater scores indicate greater mindfulness.

2.3.3. Depressed mood

Prior work suggests that greater depression predicts blunted cortisol