Health Psychology

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Online First Publication, March 25, 2013. doi: 10.1037/a0031362

CITATION
Jacobs, T. L., Shaver, P. R., Epel, E. S., Zanesco, A. P., Aichele, S. R., Bridwell, D. A., Rosenberg, E. L., King, B. G., MacLean, K. A., Sahdra, B. K., Kemeny, M. E., Ferrer, E., Wallace, B. A., & Saron, C. D. (2013, March 25). Self-Reported Mindfulness and Cortisol During a Shamatha Meditation Retreat. *Health Psychology*. Advance online publication. doi: 10.1037/a0031362

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0278-6133/13/$12.00 DOI: 10.1037/a0031362

BRIEF REPORT

Self-Reported Mindfulness and Cortisol During a Shamatha Meditation Retreat

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Objective: Cognitive perseverations that include worry and rumination over past or future events may prolong cortisol release, which in turn may contribute to predisease pathways and adversely affect physical health. Meditation training may increase self-reported mindfulness, which has been linked to reductions in cognitive perseverations. However, there are no reports that directly link self-reported mindfulness and resting cortisol output. Here, the authors investigate this link. ***Methods:*** In an observational study, we measured self-reported mindfulness and p.m. cortisol near the beginning and end of a 3-month meditation retreat ($N = 57$). ***Results:*** Mindfulness increased from pre- to post-retreat, $F(1, 56) = 36.20$, $p < .001$. Cortisol did not significantly change. However, mindfulness was inversely related to p.m. cortisol at pre-retreat, $r(53) = -.31$, $p < .05$, and post-retreat, $r(53) = -.30$,

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These data were part of The Shamatha Project, a multi-method study on the effects of meditation training on cognition, emotion regulation, and physiological function. The project was funded by Fetzer Institute Grant #2191, gifts from the Hershey Family, Tan Teo, Yoga Research and Education, Mental Insight, Baumann Foundations, Santa Barbara Institute for Consciousness Studies, Grant Couch and Louise Pearson, Caroline Zecca-Ferris, and other individual and anonymous donors, all to C. D. S. Additional fellowships to B. K. S. and K. A. M. were awarded by the Social Sciences and Humanities Research Council of Canada and National Science Foundation. We thank Shiri Lavy and Alan Kanner for preliminary work.

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$p < .05$, controlling for age and body mass index. Pre to postchange in mindfulness was associated with pre to postchange in p.m. cortisol, $\beta = -.37$, $t(49) = 2.30$, $p < .05$: Larger increases in mindfulness were associated with decreases in p.m. cortisol, whereas smaller increases (or slight decreases) in mindfulness were associated with an increase in p.m. cortisol. ***Conclusions:*** These data suggest a relation between self-reported mindfulness and resting output of the hypothalamic-pituitary-adrenal system. Future work should aim to replicate this finding in a larger cohort and determine stronger inference about causality by using experimental designs that include control-group conditions.

Keywords: cortisol, meditation, mindfulness, rumination, stress

Humans have a capacity to sustain psychological stress beyond an acute event by worrying about the future or ruminating over the past. Such perseverations may influence endocrine function. For example, naturalistic or laboratory-induced rumination and worry over nontraumatic stressors (public speaking, interpersonal transgressions, etc.) have been linked to cortisol release (e.g., Byrd-Craven, Geary, Rose, & Ponzi, 2008; Kuehner, Huffziger, & Liebsch, 2009; McCullough, Orsulak, Brandon, & Akers, 2007; Zoccola, Dickerson, & Zaldivar, 2008). This type of psychological stress, if prolonged, may mediate adverse effects on physical health and aging (Brosschot, 2010; Brosschot, Pieper, & Thayer, 2005; McEwen, 2003).

By contrast, the tendency to direct cognitive resources away from worry and rumination should be associated with a reduction in resting cortisol. Shamatha meditation involves cultivating aspects of mindfulness by directing cognitive resources toward a chosen target and away from uncontrolled, ruminative thought and cognitive perseverations (Wallace, 2006). Previously, we reported that participation in a Shamatha meditation retreat is associated with improvements on a number of cognitive and socioemotional outcome measures within a study based on a wait-list controlled design (Jacobs et al., 2011; MacLean et al., 2010; Sahdra et al., 2011). Among these measures was an improved propensity to let go of distressing thoughts and attend to different sensory domains, daily tasks, and the current contents of the mind, as assessed using a carefully constructed, self-report measure of mindfulness (Baer et al., 2008). In the present report, within the same sample of participants, we determine whether self-reported mindfulness, as well as change in mindfulness, is directly related to resting cortisol.

Method

Mindfulness, cortisol, and body mass index (BMI) were measured onsite, before and after a 3-month meditation retreat. Participants were randomly assigned to participate in the meditation retreat or to be a part of a wait-list control group. The wait-list control group then later participated in a second, identical retreat. Cortisol was measured in all active retreat participants. Practical constraints precluded cortisol measurement in the wait-list condition during the first retreat period. Data were combined across both retreats.

Participants and Meditation Training

Sixty participants were recruited through public advertisements and randomly assigned to either the first retreat ($N = 30$) or a wait-list control group ($N = 30$) using stratified (age, sex, handedness, ethnicity, and meditation experience) random assignment. Groups were matched on gender (28 men and 32 women), age ($M = 48$, range 22–69), handedness, education, nonverbal IQ (Raven's Progressive Matrices), major domains of personality (measured by the Big Five Inventory; John, Donahue, & Kentle, 1991), trait anxiety (measured by the Trait-Anxiety Inventory; Spielberger, Gorsuch, Lushene, Vagg, & Jacobs, 1983), depression (measured by the Center for Epidemiologic Studies Depression Scale; Radloff, 1977), well-being (measured by the Psychological Well-Being Scale; Ryff, 1989), and self-reported meditation practice time. This procedure is further detailed in MacLean et al. (2010). All procedures were approved by the Institutional Review Board of the University of California, Davis. Participants paid for room and board (~$5,300) but were compensated for the testing sessions in our study at $20/hr.

Meditation retreats were held at the Shambhala Mountain Center in Red Feather Lakes, CO. Practices emphasized the cultivation of attentional skills, including mindfulness of breathing, where attention is directed toward the breath; observing mental events, where attention is directed toward immediate thoughts; and observing the nature of consciousness, where attention is directed toward awareness, as the meditative object. Participants also practiced cultivating benevolent mental states, including loving-kindness, compassion, empathic joy, and equanimity (Wallace, 2006). The group met 2×/day for 1-hr sessions to engage in guided meditations and dialogue but primarily practiced solitary meditation for much of the day ($M = 6.3$ hr/day, $SD = 1.34$). These solitary meditations were practiced in 20–30 min increments. During the middle portion of the 3-month retreat, participants were encouraged to enter into silence, which lasted for ~4 weeks. Aside from group meditation sessions and mealtimes, participants were free to structure their days (including meditation sessions, exercise, and free time) as they wished, in consultation with Dr. Wallace.

Measures

Cortisol collection and assay. Saliva was collected by passive drool for 3 consecutive days at pre-retreat (2 weeks after arrival, for acclimatization) and post-retreat (10 weeks after arrival). Samples were collected in the afternoon (2 hr after lunch) and at bedtime (right before sleep), frozen at −20 °C, shipped to the laboratory of Dr. Sally Mendoza at the University of California Primate Center in Davis, and stored at −70°C until assayed. Prior to assay, samples were thawed and centrifuged at 3000 rpm for 20 min. Cortisol concentrations were estimated using commercial radioimmunoassay kits (Siemens Medical Solutions Diagnostics, Los Angeles, CA), as described by Corbett, Mendoza, Abdullah, Wegelin, and Levine

(2006). Intra- and interassay coefficients of variation were 3.03% and 3.52% (first retreat) and 3.76% and 4.42% (second retreat). Consecutive daily collections were averaged and then transformed using the natural log. We calculated p.m. cortisol as the average of afternoon and bedtime values.

BMI. Participants were weighed at pre- and post-retreat. BMI was calculated as mass (kg)/height (m^2) and used as a covariate.

Mindfulness. Participants completed the 37-item Five Factor Mindfulness Questionnaire (Baer et al., 2008) 5 days after arriving at the retreat site (pre-retreat) and 12 weeks into the retreat (post-retreat). No meditation had taken place before the initial measure. The Mindful Observing facet focuses on the extent to which cognitive resources are directed toward sensory experiences; the Mindful Acting facet focuses on the extent to which resources stray from daily tasks (e.g., brushing one's teeth); the Mindful Nonreacting facet focuses on the extent to which one can let go of distressing thoughts. The two facets not used in the present study (Mindful Describing and Mindful Nonjudging) do not reflect processes that are likely to be developed within traditional Shamatha meditation (Wallace, 2006).

Statistical Approach

Pre- and post-effects of the retreat on mindfulness and cortisol were assessed using repeated-measures analysis of variance and analysis of covariance. Correlations among study variables at each time-point were tested using Pearson's *r*. The effect of mindfulness-change on cortisol-change was tested by regressing cortisol measures at post-retreat on study variables using OLS regression. All analyses were performed with IBM SPSS (version 19). Only participants with complete data across both cortisol and mindfulness assessments were included ($N = 57$).

Results

Mindfulness

Changes in mindful acting, mindful observing, and mindful non-reacting were all intercorrelated, with coefficients ranging from $r(55) = .58$ to $r(55) = .70$, $p < .0001$. These facets were averaged for a more reliable indicator of meditation-related changes, hereafter referred to as *mindfulness*. Mindfulness increased from pre-retreat ($M = 5.16$, $SD = .77$) to post-retreat ($M = 5.76$, $SD = .72$), $F(1, 56) = 36.20$, $p < .001$, as similarly reported (Jacobs et al., 2011).

BMI

BMI (kg/m^2) decreased from pre-retreat ($M = 25.82$, $SD = 4.97$) to post-retreat ($M = 25.03$, $SD = 4.56$), $t(56) = 4.93$, $p < .0001$. There were no significant relations between BMI and mindfulness at pre-retreat, $r(55) = .01$, $p = .93$, or post-retreat, $r(55) = -.07$, $p = .58$. Although BMI was related to p.m. cortisol at pre-retreat, $r(55) = -.40$, $p < .01$, this relation was not significant at post-retreat, $r(55) = -.19$, $p = .17$.

P.M. Cortisol and Associations With Mindfulness

Even after controlling for change in BMI, $F(1, 55) = 1.91$, $p = .17$, p.m. cortisol (nmol/L) did not significantly change from pre-retreat ($M = 1.29$, $SD = .26$) to post-retreat ($M = 1.36$, $SD = .34$). However, mindfulness was inversely associated with p.m. cortisol at both pre-retreat, $r(54) = -.31$, $p < .05$, and post-retreat, $r(54) = -.30$, $p < .05$, controlling for age and BMI (see Figure 1). A regression analysis, summarized in Table 1, indicates that changes in p.m. cortisol were predicted by changes in mindfulness. This effect also remained significant when BMI was not included in the model, $\beta = -.36$, $t(51) = 2.27$, $p = .03$. Statistical diagnostics confirmed that collinearity was not a concern. This effect is depicted in Figure 1, using upper and lower quartiles of mindfulness-change: whereas larger increases in mindfulness were associated with an average pre/post decrease in p.m. cortisol, smaller increases (or slight decreases) were associated with an average increase in p.m. cortisol. When considering the directionality of these changes in p.m. cortisol, it is helpful to note that mindfulness decreased from pre-retreat ($M = 5.54$, $SD = .63$) to post-retreat ($M = 5.33$, $SD = .57$) in the lowest quartile of mindfulness-change, $t(13) = 2.64$, $p < .05$), where 10 out of 14 subjects decreased from pre- to post-retreat. In contrast, mindfulness increased from pre-retreat ($M = 4.57$, $SD = .81$) to post-retreat ($M = 6.21$, $SD = .61$) in the highest quartile of mindfulness-change, $t(13) = 10.0$, $p < .0001$), where all 14 subjects increased.

Discussion

Although the effects of mindfulness training on cortisol have been previously reported (mainly based on standardized, 8-week Mindfulness-Based Stress Reduction courses), results have been mixed (for a review, see Matousek, Dobkin, & Pruessner, 2010). Further, no studies have directly assessed self-report measures of change in mindfulness with change in cortisol output. The present data indicate an inverse relation between self-reported mindfulness and cortisol cross-sectionally and a significant relation between changes in these two variables.

The present findings are tentative for several reasons: (a) further work should replicate these data in a larger cohort; (b) the relations reported here do not demonstrate causality; (c) we do not have comparable cortisol measures for the wait-list control group during the meditation retreat period; (d) self-selection bias limits the generalizability of this group to other populations; (e) spurious variables, such as the tranquil retreat setting, may also have been associated with cortisol release and self-reported mindfulness in each participant; and (f) to allow for acclimatization, cortisol measures were taken 2 weeks after arrival to the retreat site, which meant that participants had already been meditating for up to 9 days before the initial cortisol measure was taken. Finally, there is debate regarding the meaning and measurement of mindfulness (Williams & Kabot-Zinn, 2011). Here, we used the scale developed by Baer and colleagues (2006), whose definition of mindfulness may not match all Buddhist views (e.g., Kabat-Zinn, 2011).

Future work is required to determine why p.m. cortisol increased, on average, in those with smaller increases (or slight decreases) in mindfulness. One possibility is that some individuals experience separation-related negative affect near the end

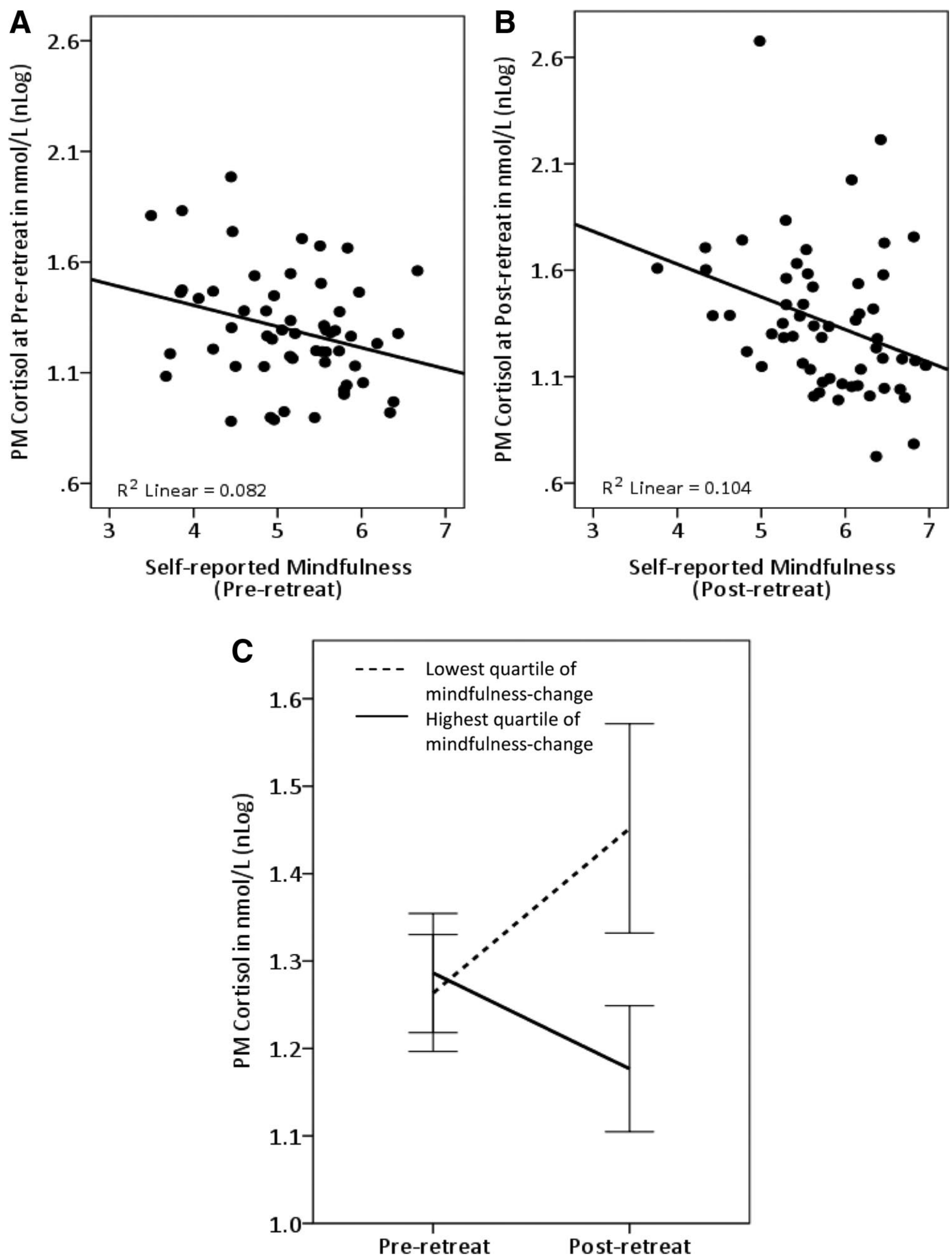

Figure 1. A and B: Inverse relation between Mindfulness and p.m. (PM) cortisol at pre- and post-retreat. The correlation at post-retreat remains significant even if the highest cortisol value is excluded, $r(55) = -.29$, $p < .05$. C: Plot depicting the effect of mindfulness-change on cortisol-change (see Table 1 for statistics), using the highest and lowest quartiles of mindfulness-change from pre- to post-retreat ($N = 14$ in each quartile). Error bars are ± 1 *SD*.

of intensive therapeutic experiences, as in psychotherapy (e.g., Charman & Grahm, 2004). Training that increases mindfulness may buffer against negative affect, as demonstrated by Jha, Stanley, Kiyonaga, Wong, & Gelfand (2010), which may affect associated regulation of neuroendocrine activity. Future work should also focus on the contributions of mediating variables. For example, self-reported mindfulness is related to greater sleep quality, more physical activity, and reduced binge eating (Roberts & Danoff-Burg, 2010). These health-related behaviors may also explain the mindfulness-cortisol relation. Another mediating factor may be rumination, which is inversely associated with mindfulness and meditation practice (e.g., Kemeny et al., 2012; Raes & Williams, 2010) and may be causally related to negative affect (for a review, see Thomsen, 2006). In turn, negative affect is associated with increased cortisol release (e.g., Polk, Cohen, Dyle, Skoner, & Kirschbaum, 2005). Here,

Table 1
Predicting Changes in p.m. Cortisol From Changes in Mindfulness (Dependent Variable is p.m. Cortisol at Post-Retreat)

	B	*SE*	β	*t*	*p*
Step 1 (R^2 = .09)					
Constant	1.38	.62		2.25	.03
Age	.00	.00	.18	1.35	.18
BMI at pre-retreat	−.01	.01	−.18	1.26	.22
Mindfulness at pre-retreat	−.01	.06	−.03	.22	.83
PM Cortisol at pre-retreat	.13	.21	.10	.63	.53
Step 2 (R^2 = .17)					
Step 1 predictors repeated					
BMI at post-retreat	.00	.05	−.06	.10	.93
Mindfulness at post-retreat	−.17	.08	−.37	2.30	.03

Note. BMI = body mass index. For *t*-test values in Step 2, *df* = 49.

we take the first step by reporting a direct relation between mindfulness and cortisol.

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Received October 24, 2011
Revision received July 23, 2012
Accepted July 27, 2012 ■