Psychoneuroendocrinology 87 (2018) 63–73

Contents lists available at ScienceDirect

Psychoneuroendocrinology

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

Acceptance lowers stress reactivity: Dismantling mindfulness training in a randomized controlled trial

Emily K. Lindsay[a,*], Shinzen Young[b], Joshua M. Smyth[c], Kirk Warren Brown[d], J. David Creswell[a]

[a] Carnegie Mellon University, United States
[b] University of Vermont, United States
[c] Pennsylvania State University, United States
[d] Virginia Commonwealth University, United States

ARTICLE INFO

Keywords:
Mindfulness
Acceptance
Attention
Stress reactivity
Mechanisms
Stress biology

ABSTRACT

Objective: Mindfulness interventions, which train practitioners to *monitor* their present-moment experience with a lens of *acceptance*, are known to buffer stress reactivity. Little is known about the active mechanisms driving these effects. We theorize that acceptance is a critical emotion regulation mechanism underlying mindfulness stress reduction effects.

Method: In this three-arm parallel trial, mindfulness components were dismantled into three structurally equivalent 15-lesson smartphone-based interventions: (1) training in both monitoring and acceptance (Monitor + Accept), (2) training in monitoring only (Monitor Only), or (3) active control training (Coping control). 153 stressed adults (mean age = 32 years; 67% female; 53% white, 21.5% black, 21.5% Asian, 4% other race) were randomly assigned to complete one of three interventions. After the intervention, cortisol, blood pressure, and subjective stress reactivity were assessed using a modified Trier Social Stress Test.

Results: As predicted, Monitor + Accept training reduced cortisol and systolic blood pressure reactivity compared to Monitor Only and control trainings. Participants in all three conditions reported moderate levels of subjective stress.

Conclusions: This study provides the first experimental evidence that brief smartphone mindfulness training can impact stress biology, and that acceptance training drives these effects. We discuss implications for basic and applied research in contemplative science, emotion regulation, stress and coping, health, and clinical interventions.

1. Introduction

Mindfulness meditation training has emerged as a leading stress reduction approach in recent years (Creswell and Lindsay, 2014). For example, eight-week mindfulness interventions have been shown to reduce physiological and subjective reactivity to acute stress challenge tasks (Britton et al., 2012; Hoge et al., 2013; Nyklíček et al., 2013). Still, little is known about the active mechanisms of mindfulness interventions that drive these stress reduction effects. Mindfulness training commonly involves using attention to *monitor* present-moment experience while fostering *acceptance* of one's current state (Bishop et al., 2004). One possibility is that *acceptance* – defined as an orientation of noninterference and openness toward momentary sensory experience (i.e., thoughts, emotions, body sensations, sights, and sounds) – is a critical emotion regulation mechanism (Hölzel et al., 2011) underlying mindfulness training stress reduction effects (Lindsay and Creswell, 2017). In contrast to avoiding, altering, or focusing narrowly on salient negative stimuli, acceptance is an attitude of receptivity and equanimity toward all momentary experiences that allows even stressful stimuli to arise and pass without reactivity. Self-reported acceptance skills are associated with lower physiological and neural stress reactivity (Paul et al., 2013; Shallcross et al., 2013), and emotional acceptance is an effective strategy for regulating negative affect (Kohl et al., 2012) that may dampen physiological reactivity to emotional stimuli (Dan-Glauser and Gross, 2015). To evaluate the importance of acceptance training as a stress reduction mechanism in mindfulness interventions, we report the results of the first three-arm randomized controlled dismantling trial that compares a full mindfulness training program (Monitor + Accept) to a mindfulness training program without acceptance instructions (Monitor Only) and an active placebo controlled program (Coping control).

Although there are now multiple evidence-based in-person

* Corresponding author at: Carnegie Mellon University, Department of Psychology, 342C Baker Hall, 5000 Forbes Avenue, Pittsburgh, PA 15213, United States.
E-mail address: elindsay@andrew.cmu.edu (E.K. Lindsay).

http://dx.doi.org/10.1016/j.psyneuen.2017.09.015
Received 1 May 2017; Received in revised form 13 September 2017; Accepted 14 September 2017

mindfulness training interventions demonstrating stress buffering effects (e.g., Mindfulness-Based Stress Reduction (MBSR); Creswell and Lindsay, 2014), a range of 'remote' (e.g., online; smartphone-based) mindfulness interventions are now widely used (Creswell, 2017; Wahbeh et al., 2014). These remote interventions are more accessible, inexpensive, and scalable compared to in-person interventions. Several studies have demonstrated benefits of two- to three-week remote mindfulness interventions for increasing compassion (Lim et al., 2015) and reducing general stress perceptions (Cavanagh et al., 2013; Glück and Maercker, 2011), but no studies have tested whether brief remote mindfulness training reduces acute physiological stress reactivity. The present study employed a 15-lesson smartphone intervention to test its efficacy for reducing stress reactivity (Monitor + Accept vs. Coping control) and to clarify the underlying components of mindfulness training that drive these effects (Monitor + Accept vs. Monitor Only). By offering a high degree of experimental control (e.g., one instructor teaches all treatment programs, content is standardized, social contact and discussion is controlled), this smartphone intervention approach allowed for an experimental dismantling of the components unique to mindfulness training.

This study tests the primary hypothesis that acceptance training is a necessary component for mindfulness intervention stress reduction effects. Stressed adults were randomly assigned to receive one of three structurally equivalent programs: (1) Monitor + Accept (MA), standard mindfulness training with instruction in both monitoring and acceptance techniques, (2) Monitor Only (MO), instructing monitoring techniques only, or (3) Coping control, providing guidance in free reflection, analytic thinking, and problem solving.[1] After the two-week at-home intervention period and a pre-stress booster session, stress reactivity was assessed using a modified Trier Social Stress Test (mTSST; Kirschbaum et al., 1993); exaggerated cortisol and blood pressure responses to acute laboratory stressors are important markers of long term health outcomes (e.g., Cohen et al., 2002; Matthews et al., 2004). This pre-registered trial was designed to test the prediction that Monitor + Accept mindfulness training would reduce cortisol, blood pressure, and subjective stress reactivity compared to Monitor Only and control trainings.

2. Methods

2.1. Participants

Enrolled participants were 153 stressed adults (mean age = 32 - years, SD = 14; see Table 1A for baseline characteristics) recruited from the Pittsburgh community via participant registries, community advertisements, and mass emails to local organizations for a study testing smartphone training programs for managing stress. Primary study analyses are reported on data available from 144 participants who completed study assessments; N = 4 participants discontinued before the post-intervention assessment, and N = 5 discontinued participation during the mTSST (see Fig. 1 for CONSORT flow chart). No participants withdrew due to adverse effects.

The study design and hypotheses described here are pre-registered with Clinical Trials identifier NCT02433431, and this report describes the stress reactivity outcome data (secondary trial outcomes). Eligible participants were English-speaking smartphone owners (Android or iPhone) between the ages of 18–70 years[2] who scored > 5 on the 4-item Perceived Stress Scale (reflecting higher-than-average perceived stress; Cohen et al., 1983; Cohen and Williamson, 1988; Warttig et al., 2013). To minimize the interference of medical conditions and behaviors on primary stress and biological outcomes (and to ensure the safety of participants and research staff), participant exclusion criteria included: chronic mental or physical disease; hospitalization for mental or physical illness in the past 3 months; medication use that interferes with HPA axis or immune system functioning; current antibiotic, antiviral, or antimicrobial treatment; use of oral contraceptives; and travel to countries on CDC travel alert list in the past 6 months (for potential bloodborne pathogen exposure). Finally, in order to test the effects of developing mindfulness skills in a novice population, those with a regular systematic mind-body practice (greater than 2 times per week) were excluded. Written informed consent was obtained from all participants, and all study procedures were approved by the Carnegie Mellon University IRB. Study data was collected between February 2015 and April 2016. Trial recruitment was stopped when the goal of enrolling 150 participants was reached.

Previous 8-week mindfulness intervention studies have demonstrated a medium effect size for stress reactivity outcomes (Cohen's $d = 0.63$; Nyklíček et al., 2013) and pilot 2-week online mindfulness training interventions show small-medium effects on general stress perceptions ($d = 0.37$–0.46; Cavanagh et al., 2013; Glück and Maercker, 2011). Thus, estimating an effect size of $d = 0.52$, G*Power calculated a total of N = 147 participants needed to detect omnibus differences between three study conditions at 80% power using an ANOVA (Faul et al., 2007). The stress reactivity data reported here were not analyzed until the complete dataset was collected.

2.2. Procedure

Briefly, as part of the larger three-arm parallel trial, interested participants were pre-screened for eligibility by telephone, then further screened at an in-person baseline assessment (which began between 2:00pm and 6:00pm). Subject IDs were assigned sequentially, and the study PI used a random number generator to pre-assign one of three condition codes to each ID in blocks of 8, 16, or 24 using a 3-3-2 randomization sequence (so that for every 8 participants enrolled, 3 were assigned to MA, 3 to MO, and 2 to control). Trained study staff enrolled eligible participants and instructed participants to download their assigned intervention by code (all participants were blind to study condition, and study staff were blind to condition in 76% of baseline sessions[3]). Enrolled participants provided a dried blood spot (DBS) sample, completed a questionnaire and task battery, and were oriented to the at-home study assessments and intervention. During three weeks of at-home study activities, participants completed three consecutive days of pre-intervention experience sampling, a 14-day intervention period (see Materials), and three consecutive days of post-intervention experience sampling. Participants received study reminder texts and phone calls throughout the at-home period, and were able to call or text our study hotline to ask questions or resolve technical issues. DBS and experience sampling outcomes will be reported in other manuscripts.

The mTSST stress reactivity findings described in this report were assessed at post-intervention. Participants returned for this assessment between 2:00pm and 6:00pm to control for diurnal variation in cortisol (mean = 3:51pm; no differences between conditions: $F(2,145) = 0.30$, $p > 0.250$). The appointment was an average of 4.66 days (SD = 1.88) after the at-home intervention (range: 3-12 days, with 86% of appointments occurring within 5 days; see Table 2). In 89% of post-intervention sessions, experimenters were blind to study condition.

Participants first provided a DBS sample and then were seated, fitted with a blood pressure cuff, and administered a post-intervention questionnaire and task battery (not reported here). During this time, the

[1] Mindfulness is conceptualized in relation to present moment experience, and as we later discuss, because this study was designed to test whether acceptance modifies one's relationship to momentary experience (Lindsay and Creswell, 2017) in ways that reduce stress reactivity, we did not develop an Acceptance Only comparison program.

[2] While initial plans involved enrolling an older sample, due to recruitment difficulties, the eligible age range was expanded after enrolling four participants.

[3] Study managers who contacted participants during the intervention period were not blind to condition code. Study managers also served as experimenters in cases when blind research assistants were unavailable (e.g., during semester breaks). All mTSST evaluators were blind to condition.