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Effective and Viable Mind-Body Stress Reduction in the Workplace: A Randomized Controlled Trial

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Highly stressed employees are subject to greater health risks, increased cost, and productivity losses than those with normal stress levels. To address this issue in an evidence-based manner, worksite stress management programs must be able to engage individuals as well as capture data on stress, health indices, work productivity, and health care costs. In this randomized controlled pilot, our primary objective was to evaluate the viability and proof of concept for two mind-body workplace stress reduction programs (one therapeutic yoga-based and the other mindfulness-based), in order to set the stage for larger cost-effectiveness trials. A second objective was to evaluate 2 delivery venues of the mindfulness-based intervention (online vs. in-person). Intention-to-treat principles and 2 (pre and post) $\times$ 3 (group) repeated-measures analysis of covariance procedures examined group differences over time on perceived stress and secondary measures to clarify which variables to include in future studies: sleep quality, mood, pain levels, work productivity, mindfulness, blood pressure, breathing rate, and heart rate variability (a measure of autonomic balance). Two hundred and thirty-nine employee volunteers were randomized into a therapeutic yoga worksite stress reduction program, 1 of 2 mindfulness-based programs, or a control group that participated only in assessment. Compared with the control group, the mind-body interventions showed significantly greater improvements on perceived stress, sleep quality, and the heart rhythm coherence ratio of heart rate variability. The two delivery venues for the mindfulness program produced basically equivalent results. Both the mindfulness-based and therapeutic yoga programs may provide viable and effective interventions to target high stress levels, sleep quality, and autonomic balance in employees.

Keywords: yoga, mindfulness, online, workplace stress reduction, sleep

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Highly stressed individuals are at greater risk for multiple health conditions including cardiovascular disease (Hemingway & Marmot, 1999; Kivimäki, LeinoArjas, Luukkonen, Riihimäki, Vahtera, & Kirjonen, 2002), cancer (Antoni et al., 2006), diabetes (Hu, Meigs, Li, Rifai, & Manson, 2004), depression and anxiety (Garcia-Bueno, Caso, & Leza, 2008), fatigue (Van Houdenhove, Van Den Eede, & Luten, 2009), obesity (Black, 2003), and musculoskeletal pain (Finestone, Alfeeli, & Fisher, 2008). In fact, psychological stress and the associated chronic inflammatory response have been implicated in virtually all chronic conditions (Chrousos & Gold, 1992; McEwan, 1998; Black, 2006; Cohen, Janicki-Deverts, & Miller, 2007). Further, highly stressed employees incur productivity losses and health care costs above those with normal levels of stress (e.g., Baime, Wolever, Pace, Morris, & Bobinet, 2011; Goetzel et al., 1998). To successfully address this issue for *employees*, worksite stress management programs must be accessible, engaging, and convenient in terms of scheduling, time requirements, and on-site locations, as well as have management support. To successfully address this issue for *employers*, the programs must be economically sustainable and demonstrate effectiveness by capturing data on relevant indices of stress, health, productivity, and/or costs. In this pilot study, we evaluated the viability and proof of concept for two mind-body workplace stress reduction programs, setting the stage for larger, cost-effectiveness trials.

Mental stress adversely impacts physical and mental health. In addition to the health effects cited above, psychological stress is also widely recognized as a major contributor to poor morale, absenteeism, high staff turnover, and reduced productivity at work (Limm, Gundel, Heinmuller, Marten-Mittag, Nater, Siegrist, et al., 2011; Michie & Williams, 2003; Noblet & LaMontagne, 2006). High stress also has been shown to significantly impair memory and the ability to learn (Lupien et al., 2005). Furthermore, stressed, chronically ill employees are expensive, both in terms of health care costs and decreased productivity (Baime, Wolever, Pace, et al., 2011; Goetzel et al., 2004; Thygeson, 2010). The International Labor Organization has "estimated that 30% of all work-related disorders are due to stress, and that the loss caused by such stress-induced disorders amounted to EUR 9.2 billion in the EU, EUR 1.1–1.2 billion in the U.K., and USD 6.6 billion in U.S.A." (Mino, Babazono, Tsuda, & Yasuda, 2006). In large scale studies, employees with high stress have significantly higher annualized medical expenditures (odds ratio = 1.528) compared with those with lower stress, and their medical expenses are estimated at 45–46% above those for lower stress employees (Goetzel et al., 1998).

Across the past decade, the clinical literature has reported psychosocial and health benefits from mind-body interventions. Randomized controlled trials (RCTs) demonstrate the effectiveness of mindfulness meditation training to enhance coping skills, promote feelings of well-being, and affect favorable changes in physiology such as better immune functioning (Davidson et al., 2003; Greeson, 2009; Gross et al., 2010; Jung et al., 2010). Similar findings have been demonstrated in observational trials in diverse populations ranging from community samples (Evans, Ferrando, Carr, & Haglin; Fang et al., 2010) to organ-transplant recipients (Gross et al., 2010), with results of the latter being sustained 1 year post-mindfulness training (Gross et al., 2010). RCTs of yoga have begun to demonstrate improvement in well-being (Oken et al., 2006; Kjellgren, Bood, Axelsson, Norlander, & Saatcioglu, 2007), anxiety reduction (Smith, Hancock, Blake-Mortimer, & Eckert, 2007; Javnbakht, Kenari, & Ghasemi, 2009), as well as improved physical measures such as chronic low back pain (Sherman, Cherkin, Erro, Miglioretti, & Deyo, 2005), lowered fatigue, and improved energy, balance, and flexibility (Oken et al., 2006). There may also be a role for yoga in managing cardiovascular disease risk (Bijlani, Vempati, Yadav, Ray, Gupta, Sharma, et al., 2005) through modulation of the hypothalamic-pituitary-adrenal axis (Innes, Vincent, & Taylor, 2007). The most recent systematic Cochrane review on the effectiveness of yoga identified five RCTs for treatment of depression (Pilkington, Kirkwood, Hagen Rampes, & Richardson, 2005) and identified eight RCTs for the treatment of anxiety and anxiety disorders (Kirkwood, Rampes, Tuffrey, Richardson, & Pilkington, 2005). Although methodological inadequacies as of yet prevent the conclusion that yoga is effective in reducing depression or treating anxiety, all 13 studies reported encouraging positive results.

As evidence of mind-body stress reduction interventions has emerged in the clinical literature, the impact of such programs is simultaneously emerging in the field of worksite wellness. Four recent RCTs on workplace stress reduction programs that utilized mind-body techniques have demonstrated improvements in self-reported mood (McCraty, Atkinson, & Tomasino, 2003; Mino et al., 2006; Hartfiel et al., 2010), well-being (McCraty et al., 2003; Hartfiel et al., 2010), and psychological distress (McCraty et al., 2003; Limm et al., 2011). In addition, physiological improvements have been noted in systolic blood pressure 3 months postintervention (McCraty et al., 2003) and in sympathetic activation 1 year later (Limm et al., 2011). All of these studies were RCTs, lending some methodological credence to their findings, yet three of the four had small sample sizes (*N*s = 38, 48, and 58). The fourth (Limm et al., 2011) provided a time-intensive intervention that may not be feasible for all workplaces given limited resources for worksite implementation.

Research Questions

We propose to expand the current literature by using a larger RCT to evaluate the effectiveness of two mind-body workplace stress reduction programs designed to be highly accessible to employees: a mindfulness-based stress management intervention and a therapeutic yoga-based stress reduction program. Each 12-week intervention lasted 1 hr per week and was provided at the workplace, either in-person or online. We were primarily interested in assessing the effectiveness and outcomes of each of the programs on stress, and obtained pilot data on stress-related health indices, workplace productivity, and costs. Analyses of the two worksite programs were conducted for two primary a priori contrasts. We asked the following research question for each: "Compared to the control group, does this program help participants lower stress levels? In addition, does each program impact health indices and productivity in a positive way?" Because different interventions may be appropriate for different workplace settings, this design allowed us to efficiently evaluate the benefits of two distinct programs relative to a control group. We were less interested in comparing the two mind-body programs with each other, because worksites may have specific situations which lend themselves better to one or another of these programs. Similarly, employers may wish to offer both programs to employees. Nonetheless, our design did allow us to also compare the two mind-body programs with each other. We have included these comparisons for readers' interest. A second objective of the study was to discern whether offering the mindfulness program through an online venue would be at least as effective as offering it in-person. Given our previous experience with live, online classes wherein the interaction level was exceptionally high, we expected that the online program would perform at least as well as an in-person program. In addition, an extensive review and meta-analysis of Internet-based psychotherapeutic interventions has demonstrated no difference in effectiveness when compared with face-to-face interventions, and in some circumstances, the Internet-based work was described by clients as superior (Barak, Hen, Boniel-Nissim, & Shapira, 2008).

Method

Study Participants

The participant group consisted of 239 employees of a national insurance carrier who volunteered to participate in a RCT of mind-body interventions designed to reduce stress. Participants were representative of the company as a whole: 23.4% male with an average age of 42.9 years and most (72.4%) holding a college, graduate, or professional degree. Most were non-Hispanic (93.7%), and the majority identified their race as White (78.2%), followed by Asian (7.9%), then Black or African American (6.3%). Ninety-seven percent of the participants were working full time (96.7%) and the median annual household income was between $100,000 and $150,000. See Table 1 for detailed sociodemographics.

Recruitment emails announced the study to all company employees at each study site and directed interested employees to a dedicated internal website which offered more detailed information on the study along with preliminary screening documents. Employees were admitted to the study if they scored a 16 or higher on the 10-item Perceived Stress Scale (PSS: Cohen, Kamarck, & Mermelstein, 1983) and met other inclusion criteria. Participants were excluded if they indicated any of the following: (a) an arrhythmia requiring medication or a pacemaker; (b) pregnancy; (c) heavy tobacco or nicotine use defined as smoking one or more cigarette packs per day, or chewing tobacco five or more times per day, or use of one stick of 2 mg nicotine gum every 1–2 hr, or smoking six of more cigars daily; (d) medications that would affect heart rate (including antiarrhythmia drugs, beta blockers, calcium channel blockers, stimulants, and illicit drugs); and (e) any major medical condition (e.g., chronic obstructive pulmonary disease, chronic heart failure, angina, traumatic brain injury, and type 1 diabetes) or psychological disorder (i.e., posttraumatic stress disorder, major depression, bipolar disorder, psychosis, severe anxiety, panic disorders). They were also excluded if they reported significant current or previous yoga or meditation experience defined as routine practice at least several times per week or participation in an extended meditation or yoga retreat of more than 2 days in the past 5 years. Upon program completion, all participants received $75 as well as a $75 gift card to a massage therapy studio.

Study Interventions

Stress reduction interventions for the study included the *Viniyoga Stress Reduction Program* and two versions of *Mindfulness at Work*.

Viniyoga Stress Reduction Program. The therapeutic yoga arm was a 12-week (12-hr) program developed by the American Viniyoga Institute (AVI) that progressively introduced tools for managing stress including asanas (physical postures of yoga), breathing techniques, guided relaxation, mental techniques, and education about starting a home practice. Taught by AVI-trained teachers, the Viniyoga classes were offered at two worksites: one in Hartford, CT and one in Walnut Creek, CA. Instructional handouts were provided to educate participants on a home practice and shorter "yoga breaks" for home and at work. In addition, half of the participants (two of four classes) received a DVD to support home practice. Because preliminary analysis showed no difference between the groups with and without the DVD, these groups were combined for further analyses.

The choice of Viniyoga for an intervention rests in the theoretical understanding of its potential impact on stress. Three key features differentiate Viniyoga from other yoga traditions: primacy of the breath, the importance of asana sequencing, and adaptation of the practice to the practitioners and/or their goal(s). Through conscious modulation, the breath can have a significant influence on physiology, particularly the balance between sympathetic and parasympathetic tone in the autonomic nervous system (Sherman et al., 2005; Innes et al., 2007). Varying the respiratory rate, depth, and ratio of inhalation to exhalation can refine this effect. Similarly, the choice and sequence of poses can be used to modulate this balance and efficiently impact physical structures affected by stress. The postures within the practice sequence can be adapted to accommodate the body habitus or any individual structural limitations of the participants. Previous work suggests that application of the principles of Viniyoga may extend the known health advantages of other forms of yoga and increase the potential to manage stress levels (Wheeler & Wilkin, 2007).

Mindfulness at Work. Mindfulness at Work is a 12-week (14-hr) stress management program based upon the principles and practices of mindfulness meditation. Although the introspective practice of mindfulness has been known for over 2500 years, scientific interest in this inherent quality of human consciousness has just gained traction in the past few decades (Black, 2011). Mindfulness has been described as the "nonjudgmental observation of the ongoing stream of internal and external stimuli as they arise" (Baer, 2003), or as the "practice of paying attention in a particular way, on purpose, in the present moment and nonjudgmentally" (Kabat-Zinn, 1994). Participants in mindfulness programs learn to focus attention on feelings, thoughts, and sensations "exactly as they occur without elaboration, censorship, judgment or interpretation" (Wilbur, Engler & Brown, 1984). Being mindful thus allows participants to more deeply understand how their own thoughts, emotions, sensations, and behavioral urges arise and impact health and quality of life. Through specific mindfulness practices, participants explore their own experience and learn for themselves what to attend to and what to let subside. Various intervention programs utilize explicitly developed mindfulness meditation practices to impact distinct targets. For example, the Mindfulness-Based Stress Reduction program is a 27-hr interven-

Table 1
Participant Demographics and Measures at Baseline (N = 239)

Demographics	Control (n = 53) %	Mindfulness (n = 96) %	Yoga (n = 90) %	χ^2
Gender				1.15
Male	18.9	22.9	26.7	
Female	81.1	77.1	73.3	
Ethnicity				2.86
Not Hispanic/Latino	90.6	96.9	92.2	
Hispanic/Latino	9.4	3.1	7.8	
Race				14.02
White	71.7	85.4	74.4	
Black	3.8	4.2	10.0	
Asian	13.2	5.2	7.8	
Other	11.3	5.2	7.7	
Annual household income				6.78
20–50 K	13.2	7.3	3.3	
>50–100 K	39.6	33.3	35.6	
>100–150 K	30.2	34.4	33.3	
>150 K	17.0	25.0	27.8	
Education				10.08
High school	7.5	3.1	2.2	
Beyond high school, no college degree	34.0	21.9	20.0	
College degree	47.2	53.1	50.0	
Graduate/professional	11.3	21.9	27.8	
Employment status				1.35
Part time	5.7	2.1	3.3	
Full time	94.3	97.9	96.7	
Marital status				9.22
Never married	11.3	13.5	18.9	
Married/living as married	65.0	66.7	70.0	
Separated or divorced	22.7	18.7	11.1	
Widowed	0.0	1.0		

Measures	Control M (SD)	Mindfulness M (SD)	Yoga M (SD)	F	η^2
Age	42.7 (9.7)	44.3 (9.4)	41.6 (10.1)	1.83	.02
PSS	23.6 (3.7)	24.7 (3.5)	24.9 (4.0)	2.12	.02
PSQI	7.6 (3.3)	8.0 (3.4)	7.7 (3.3)	.44	.004
CAMS-R	29.8 (5.2)	29.9 (5.9)	29.7 (5.7)	.01	.000
CES-D	18.2 (9.2)	19.8 (9.5)	18.4 (8.6)	.74	.01
WLQ productivity loss	5.7 (4.6)	5.5 (4.3)	4.9 (3.6)	.69	.01
Current pain	1.5 (1.8)	1.8 (2.2)	2.2 (2.4)	1.83	.02
Average pain	2.2 (2.1)	2.5 (2.2)	2.6 (2.1)	.67	.01
Worst pain	3.6 (3.3)	4.1 (3.0)	4.5 (3.0)	1.56	.01
Systolic BP	118.0 (18.5)	114.8 (14.5)	113.3 (12.7)	1.64	.01
Diastolic BP	75.0 (11.6)	76.1 (9.4)	75.5 (9.7)	.21	.002
Breathing rate	15.7 (2.8)	15.4 (3.5)	15.9 (3.7)	.39	.003
HRV coherence ratio	–.27 (.49)	–.32 (.49)	–.29 (.50)	.17	.001
RR interval	842.0 (146.5)	835.4 (172.7)	856.3 (132.6)	.45	.004

Note. There were no significant baseline differences between groups in participant demographics or measures at $p < .05$.

tion used in clinical settings that targets stress, chronic pain, and a number of psychological symptoms (Kabat-Zinn, 1990; Ludwig and Kabat-Zinn, 2008; Baer, 2006; Didonna, 2009), while Mindfulness-Based Relapse Prevention (Bowen, Chawla, & Marlatt, 2011) is a 16-hr program often used in mental health programs and targets addictive behaviors. The Mindfulness at Work program teaches mindfulness practices that explicitly target work-related stress, work-life balance, and self-care. These practices are relatively brief (5–15 min) and are specifically designed to be used at work. The program itself is also designed to be delivered at worksites and consists of 12 weekly hour-long classes, and a 2-hr mindfulness practice intensive at week 10.

The two Mindfulness at Work programs in this study were identical to each other in content, except that one was provided in-person in a conventional classroom, while the second was provided through an online virtual classroom that allowed for real-time bidirectional communication. Both the in-person classroom and online classroom versions were taught by the same experienced mindfulness meditation teacher. Participants in both Mindfulness at Work arms were given handouts for home and office use, and were encouraged to complete home practice assignments.

A mindfulness-based intervention was offered because of its documented benefits in decreasing subjectively reported stress and its increasing use as a stress management intervention at worksites. Theoretically, mindfulness may reduce stress by allowing individuals to significantly shift their experience by learning to pay attention in the present moment, with a curious and accepting attitude (Kabat-Zinn, 1990; Siegel, Germer, & Olendzki, 2009). By training the mind to notice a stream of sensory and perceptual events, one begins to realize how intention and behavior are formed (Siegel et al., 2009). The careful and repeated practice of this nonjudgmental observation gradually allows individuals to realize that events are actually unfolding processes that can be quite fluid. In other words, even apparently negative events, thoughts, sensations, emotions, and behaviors come to be seen as changeable. While this process is not necessarily conscious even in those learning it, the process does allow individuals to experience the world in a significantly different, and less stressful, way. As noted in the introduction, numerous studies have documented that mindfulness-based interventions result in significant improvements in mood and positive affect, vigor, and quality of life as well as concurrent decreases in perceived stress, fatigue, depression, anxiety, and anger. Survey measures of mindfulness correlate strongly with the documented psychological benefits (Nyklíček & Kuijpers, 2008). In addition, cognitive performance is improved with mindfulness training. Attentional control and focus, working memory, emotion regulation, and other cognitive capabilities improve with even relatively brief periods of mindfulness training. (Chiesa, Calati, & Serretti, 2011; Jha, Stanley, Kiyonaga, Wong, & Gelfand, 2010). These further benefits could have particular relevance to a worksite setting because of their potential impact on productivity. Finally, a growing body of research has documented that mindfulness training results in changes in brain function and structure that may provide insight into the biological basis of the documented psychological and cognitive benefits (Newberg, Wintering, Waldman, Amen, Khalsa, & Alavi, 2010; Hölzel, Carmody, Evans, Hoge, Dusek, Morgan, et al., 2010).

Control Condition. The Control Group ($n = 53$) received the same assessments, but did not receive any stress management intervention. Instead, controls were given a list of resources available to all employees of the national insurance carrier. The list included discounted fitness programs, employee assistance programs, behavioral health services for depression, chair massage sessions, and wellness coaching opportunities.

Randomization

As shown in Figure 1, 683 potential participants completed screening documents, and 239 interested and eligible participants enrolled: 63 in California (CA) and 176 in Connecticut (CT). To ensure an adequate class size of at least 20, the CA participants were randomized into one of three conditions rather than four: yoga ($n = 20$), mindfulness (online; $n = 22$), and controls ($n = 21$). To ensure equivalent distribution across all conditions, the CT participants were randomized into one of four conditions: yoga ($n = 70$ divided into three classes), mindfulness ($n = 30$ online and $n = 44$ in-person divided into two classes), and controls ($n = 32$). Total enrollment (and number of completers) in each condition was: yoga, $n = 90$ (76 completers); mindfulness, $n = 96$ (82 completers), divided between 52 online (50 completers) and 44 in-person (32 completers); and control $n = 53$ (47 completers).

Measures

Outcome measures. Baseline measurements were taken within 2 weeks prior to randomization. The screening PSS was also used as the baseline measure. Posttest data were collected within 2 weeks of the final class (or concurrent period for wait-list controls). The measures described below were collected at both time points.

Primary outcome. The primary outcome was the PSS total score (Cohen, Kamarck, & Mermelstein, 1983), a well-known 10-item questionnaire used to evaluate responders' perceptions about their level of stress while taking into account their ability to cope with stress over the last month.

Secondary outcomes.

Sleep quality. The Pittsburgh Sleep Quality Index (PSQI; Buysse, Reynolds III, Monk, Berman, & Kupfer, 1989) total score was used to measure sleep quality during the previous month. Sleep quality is a complex phenomenon that involves several dimensions including subjective sleep quality, sleep latency, sleep duration, habitual sleep efficiency, sleep disturbances, use of sleep medications, and daytime dysfunction.

Mood and pain. The Center for Epidemiological Studies Depression Scale (CES-D; Radloff, 1977) (20-item version) was used to measure affective changes; it is one of the most common screening tests that measures depressive feelings and behaviors, and reflects the past week. Current, average, and worst pain were collected on three numerical rating scales wherein participants selected a number between 0 (lowest degree, *no pain*) to 10 (highest degree, *worst imaginable*) to indicate their experience over the past week.

Productivity. The 25-item Work Limitations Questionnaire (WLQ; Lerner, Amick, Rogers, Malspeis, Bungay, & Cynn, 2001) was used to calculate the WLQ index as a measure of health-related decrements in ability to perform job roles among employed individuals. Research has demonstrated its validity and reliability in several populations.

Mindfulness. The 12-item Cognitive and Affective Mindfulness Scale–Revised (CAMS-R; Feldman, Hayes, Kumar, Greeson, & Laurenceau, 2007) was used to measure individual differences in mindfulness and adequately sample the four domains of mindfulness (attention, present-focus, awareness, and acceptance/nonjudgment). All scales demonstrated acceptable levels of internal consistency in our sample, with Cronbach's alpha levels (α) ranging from 0.74 to 0.89.

Biological measures: Blood pressure (BP), breathing rate, and heart rate variability. Biological measures were collected as follows within 14 days prior to the program's start dates. Participants were seated, with an Omicron blood pressure cuff on their left arm supported at the midatrial level and the elbow bent approximately 100°. Participants were asked to sit quietly and to refrain from talking, moving, falling asleep, or engaging in any specific activity for 5 min. Blood pressures were then taken by a nurse or doctor, followed by a 60-s breathing rate count. An emWave sensor was placed on the right earlobe, and heart rate variability (HRV) recordings were gathered by noninvasive measurement of the pulse, as previously described (Bradley, McCraty, Atkinson, & Tomasino, 2010). In brief, calculations used the interbeat interval data to generate a number of standard indices of HRV and a measurement of heart rhythm coherence—the key

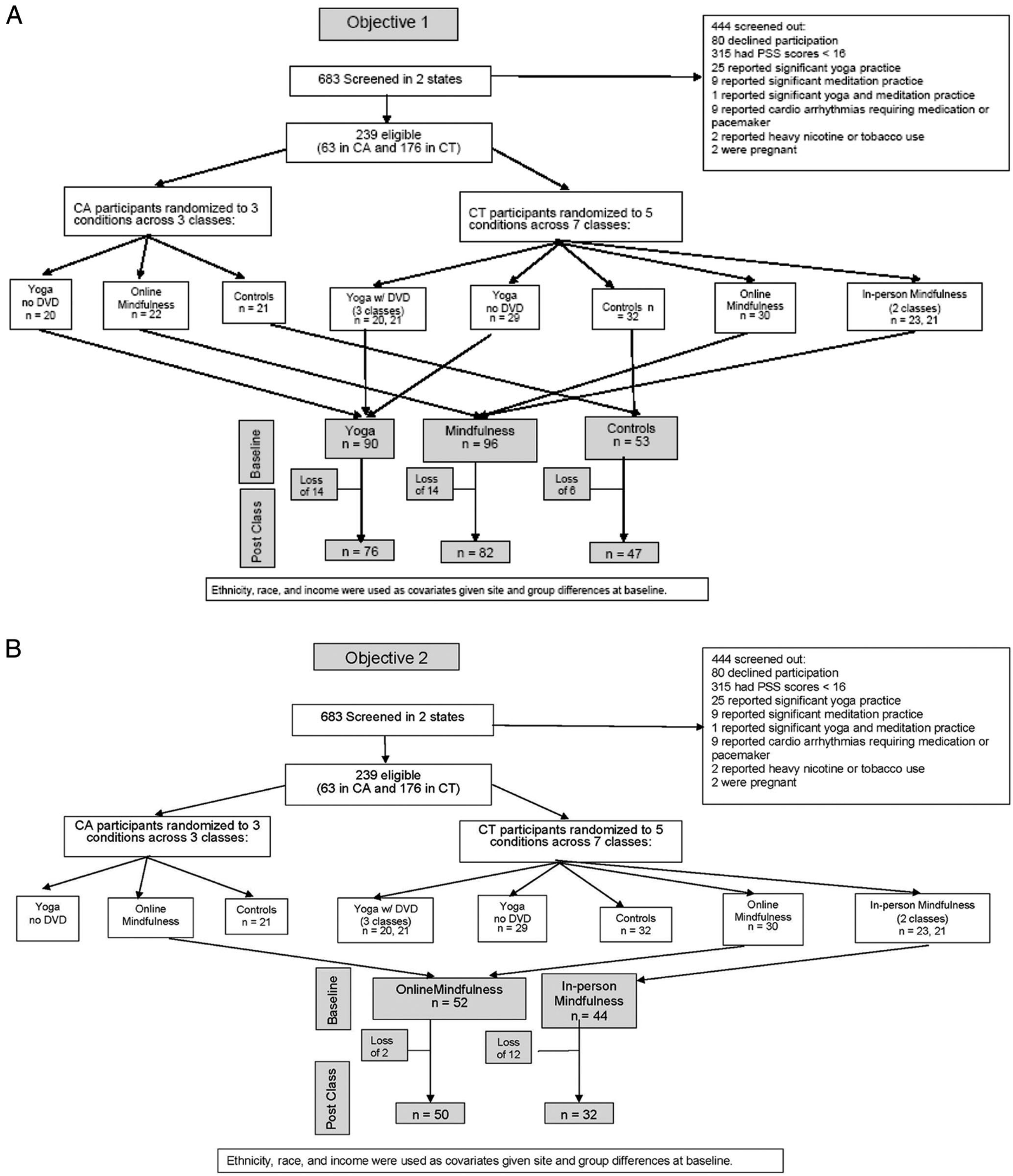

Figure 1. Participant flow.

marker of the psychophysiological coherence state. Pulse was continuously recorded at a sample rate of 250 Hz throughout a 10-min *resting baseline* period both pre- and postintervention. In addition, during the postintervention period, continuous pulse was recorded during a 4-min *stress preparation* period during which time they were instructed to quietly prepare themselves mentally and emotionally for an upcoming important or challenging event. Participants in the control group were instructed to prepare themselves for this performance task by doing "whatever you typically would do when faced with a stressful situation." Participants in the intervention groups were instructed to do a particular practice taught during the class. The measures reported here include only the RR interval (time between heart beats) and heart rhythm coherence; each reflects the difference between the resting baseline preintervention and the stress preparation period postintervention.

Analysis Plan

Our primary objective was to test two a priori contrasts. The first tested the Mindfulness at Work intervention against the controls; and the second evaluated the Viniyoga Stress Reduction Program intervention against the controls. For academic interest, we also provide comparisons between the two active interventions. We first evaluated sociodemographics and key study variables at baseline between sites. Baseline site differences were accounted for in all analyses by retaining relevant covariates when sites were combined. Using intention-to-treat (ITT) principles and a 2 (pre and post) $\times$ 3 (group) repeated-measures analysis of covariance (ANCOVA), we examined an omnibus F test for our primary variable (perceived stress). Secondarily, sleep quality, depression, and work productivity were evaluated in this same manner to clarify which variables to include in subsequent studies. When multiple secondary measures assessed the same domain, repeated-measures multivariate analyses of covariance (MANCOVAs) were used as the omnibus F test. Hence, MANCOVAs examined the secondary variables associated with pain (current pain, average pain, worst pain), blood pressure (systolic and diastolic), and HRV (breathing rate, RR interval, heart rhythm coherence ratio). Significant multivariate interaction effects were then examined at the univariate level as above. Last Observation Carried Forward (LOCF) was used to handle missing data throughout (Twisk & DeVente, 2002); ITT and per protocol analyses were then compared to confirm findings.

For the second objective, separate analyses targeted a priori hypotheses regarding the online Mindfulness at Work intervention. We used independent t tests to ensure equivalent baselines for the online and in-person mindfulness intervention. Outcome variables were then assessed using 2 (pre to post) $\times$ 2 (online vs. in-person) ANCOVA procedures and again controlling for race, ethnicity, and income. As for the first study objective, LOCF was used to handle missing data (Twisk & DeVente, 2002) for the second study, and ITT and per protocol analyses were compared to confirm findings.

Results

Baseline Analyses and Covariate Selection

Covariates were selected in two ways. First, we tested for significant sociodemographic and baseline study variable differences between the study sites (CA vs. CT) using independent t tests for continuous variables and chi-square analyses for categorical variables. Despite multiple comparisons, we set the alpha at 0.05 for baseline comparisons to protect from type II error. The CA and CT groups differed in race, $\chi^2(5) = 11.90$, $p < .05$, ethnicity, $\chi^2(1) = 3.76$, $p < .05$, and income, $\chi^2(3) = 10.43$, $p < .05$. Second, we tested for differences between the online mindfulness and in-person mindfulness groups at baseline. The two groups differed in income, $\chi^2(3) = 10.23$, $p < .01$, and systolic blood pressure $t(94) = 2.82$, $p < .01$. As a result, the CA and CT sites were combined, and the online mindfulness and in-person mindfulness groups were merged together, to form one control group and one mindfulness group, but we retained income, ethnicity, and race as covariates in all analyses. The systolic BP baseline difference became irrelevant given that the omnibus MANCOVA for BP did not find any group differences over time (see below). Finally, to ensure equivalent baseline status, we conducted a series of chi-square analyses and analysis of variance procedures to test for significant differences in baseline sociodemographic and key study variables between the three conditions: mindfulness, yoga, and control groups. As shown in Table 1, no baseline differences emerged among the three groups for any sociodemographic or key study variables, confirming a successful randomization.

Group × Time Interactions

We conducted a series of omnibus repeated-measures ANCOVAs and MANCOVAs to examine group differences in our dependent variables over time. As shown in Table 2, the repeated-measures ANCOVAs demonstrated a significant Group $\times$ Time interaction between the control, mindfulness, and yoga groups for perceived stress, $F(2, 233) = 8.89$, $p < .001$, $\eta^2 = .07$, and sleep quality, $F(2, 233) = 3.03$, $p < .05$, $\eta^2 = .03$, but not for depressive symptoms, or the work productivity index. Additionally, a marginally significant Group $\times$ Time interaction emerged among the three groups for the CAMS-R, $F(2, 233) = 2.51$, $p = .08$, $\eta^2 = .02$.

To test our a priori hypotheses, we used repeated-measures ANCOVAs to examine group differences for outcomes where the omnibus F test was significant. Results showed that compared with the control group, the mindfulness group had greater decreases in perceived stress, $F(1, 144) = 21.31$, $p < .001$, $\eta^2 = .13$, and greater decreases in sleep difficulty, $F(1, 144) = 5.17$, $p < .05$, $\eta^2 = .04$. Additionally, compared with the control group, the yoga group also had greater decreases in perceived stress, $F(1, 137) = 8.79$, $p < .01$, $\eta^2 = .06$, and greater decreases in sleep difficulty, $F(1, 137) = 5.94$, $p < .05$, $\eta^2 = .04$. No significant differences emerged between the mindfulness and yoga intervention in either perceived stress, $F(1, 180) = .56$, *ns*, $\eta^2 = .003$, or sleep difficulty, $F(1, 180) = .17$, *ns*, $\eta^2 = .001$. Because the omnibus F test was marginally significant for the CAMS-R, we also examined group differences between mindfulness, yoga, and controls in change across time for the CAMS-R mindfulness measure. Compared with the control group, the mindfulness group showed greater increases on CAMS-R mindfulness scores, $F(1, 144) = 5.75$, $p < .05$, $\eta^2 = .04$. No significant differences emerged between the control group and the yoga group, $F(1, 137) = 2.79$,

Table 2
Objective 1: Omnibus F Tests for Group × Time Differences Among Control, Mindfulness, and Yoga Groups

	Control (n = 53)	Mindfulness (n = 96)	Yoga (n = 90)		
Outcome Measures	%	%	%	F	η^2
PSS				8.89***	.07
Pre	23.52 (.52)	24.72 (.38)	24.93 (.40)		
Post	19.34 (.86)	15.86 (.64)	16.74 (.66)		
PSQI				3.03*	.03
Pre	7.38 (.46)	8.07 (.34)	7.69 (.35)		
Post	6.02 (.44)	5.72 (.33)	5.22 (.34)		
CAMS-R				2.51+	.02
Pre	30.01 (.79)	29.77 (.58)	29.69 (.60)		
Post	32.37 (.90)	34.21 (.66)	33.93 (.68)		
CES-D				1.34	.01
Pre	17.57 (1.2)	20.10 (.91)	18.45 (.94)		
Post	12.37 (1.2)	12.81 (.89)	12.87 (.92)		
WLQ productivity loss				2.07	.02
Pre	5.59 (.57)	5.54 (.42)	4.87 (.44)		
Post	4.29 (.57)	3.60 (.42)	3.91 (.43)		
Current pain				3.56*	.03
Pre	1.44 (.30)	1.82 (.22)	2.24 (.23)		
Post	1.38 (.24)	1.21 (.18)	1.24 (.18)		
Average pain				1.61	.01
Pre	2.13 (.30)	2.52 (.22)	2.64 (.23)		
Post	1.85 (.26)	2.00 (.19)	1.84 (.20)		
Worst pain				.89	.01
Pre	3.53 (.43)	4.06 (.32)	4.53 (.33)		
Post	3.05 (.42)	3.53 (.30)	3.55 (.31)		
Systolic BP				.02	.00
Pre	117.76 (2.1)	115.04 (1.5)	113.20 (1.6)		
Post	117.13 (2.1)	114.13 (1.5)	112.40 (1.6)		
Diastolic BP				.67	.03
Pre	75.00 (1.4)	76.15 (1.0)	75.48 (1.1)		
Post	76.03 (1.5)	74.93 (1.1)	73.55 (1.1)		
Breathing rate				3.02*	.03
Pre	15.56 (.47)	15.51 (.35)	15.90 (.36)		
Post	15.50 (.47)	14.41 (.35)	14.43 (.36)		
HRV Coherence ratio				15.86***	.12
Pre	−.25 (.07)	−.33 (.05)	−.30 (.05)		
Post	−.12 (.05)	.02 (.04)	.33 (.04)		
RR interval				2.42	.02
Pre	852.94 (20.8)	831.07 (15.4)	854.40 (15.8)		
Post	852.32 (16.9)	864.36 (12.5)	851.54 (12.9)		

+ $p < .10$. * $p < .05$. *** $p < .001$.

ns, $\eta^2 = .02$, or between the mindfulness and yoga groups, $F(1, 180) = .09$, *ns*, $\eta^2 = .000$, on CAMS-R scores.

We conducted a series of repeated-measures MANCOVAs to examine group differences over time when multiple secondary measures assessed the same domain: pain (worst pain, average pain, current pain), blood pressure (systolic and diastolic), and HRV (breathing rate, RR interval, heart rhythm coherence ratio). A significant multivariate interaction emerged for Group × Time in explaining HRV, Wilks's $\lambda = .85$, $F(6, 462) = 6.70$, $p < .001$, $\eta^2 = .08$. Specifically, as shown in Table 2, follow-up tests at the univariate level demonstrated significant Group × Time interactions in explaining both breathing rate, $F(2, 233) = 3.02$, $p < .05$, $\eta^2 = .03$, and heart rhythm coherence ratio, $F(2, 233) = 15.86$, $p < .001$, $\eta^2 = .12$. Repeated-measures ANCOVAs confirmed our a priori hypothesis that when asked to quietly prepare themselves for an upcoming important or challenging event at the postintervention measurement, the mindfulness group, in comparison with the controls, showed marginally greater decreases in their breathing rate, $F(1, 144) = 3.49$, $p = .06$, $\eta^2 = .02$, and greater increases in heart rhythm coherence from preintervention baseline, $F(1, 144) = 4.25$, $p < .05$, $\eta^2 = .03$. Similarly, compared with the control group, the yoga group showed marginally greater decreases in their breathing rate, $F(1, 137) = 3.47$, $p = .07$, $\eta^2 = .03$, and greater increases in heart rhythm coherence from preintervention baseline, $F(1, 137) = 29.77$, $p < .001$, $\eta^2 = .18$. No significant Group × Time multivariate interaction effects emerged for the pain measures or for blood pressure. It bears mention, however, that univariate exploratory analyses revealed group differences in current pain levels, $F(2, 233) = 7.16$, $p < .05$, $\eta^2 = .03$. Specifically, compared with the control group, the yoga group reported less current pain, $F(1, 137) = 6.51$, $p < .01$, $\eta^2 = .05$, but no differences emerged between the mindfulness and control groups, $F(1, 144) = 2.68$, *ns*, $\eta^2 = .02$, or between the mindfulness and yoga groups, $F(1, 180) = 1.60$, *ns*, $\eta^2 = .01$.

To test the equivalence of the online mindfulness group, we used a 2 (time) × 2 (group) repeated-measures ANCOVA, covarying out ethnicity, race, and income level, because income was distinct between the two groups at baseline and all three covariates were distinct across sites. As shown in Table 3, a significant Group × Time interaction emerged in explaining the heart rhythm coherence ratio, $F(1, 91) = 3.91$, $p < .05$, $\eta^2 = .04$. Compared with the in-person mindfulness group, the online mindfulness group showed greater increases in coherence from preintervention baseline to postintervention stress preparation.

Attrition and per protocol analyses. Of the 239 participants who provided baseline data for the mindfulness study, 205 (85.8%) completed the study and provided follow-up data (82 in the mindfulness intervention group, 76 in the yoga group, and 47 in the control group). Chi-square analyses revealed that attrition levels did not differ between the three groups, $\chi^2(2) = .51$ $p = .78$, because 11.3% of the participants in the control group, 14.6% of the participants in the mindfulness group, and 15.6% of the participants in the yoga group did not complete the study. Attriters did not differ from participants who completed the study in any sociodemographic or baseline variables.

Within the mindfulness group, higher levels of attrition occurred in the in-person mindfulness group (27.3%) compared with the online mindfulness group (3.8%), $\chi^2(1) = 10.50$ $p < .001$. Attriters in the online versus in-person mindfulness groups had a slightly higher baseline breathing rate than participants who completed the study, $t(94) = 2.17$, $p < .05$, and the previously significant finding for the heart rhythm coherence ratio became only marginally significant for the completers, $F(1, 77) = 3.59$, $p = .06$, $\eta^2 = .05$. Attriters did not differ from participants who completed the study in any other baseline or outcome study variables.

Table 3
ANCOVAs to Address Objective 2: Does Online Mindfulness at Work Perform as Well as In-Person Mindfulness at Work? (n = 96)

Outcome Measures	Online (n = 52) M (SE)	In-Person (n = 44) M (SE)	F	η^2
PSS			1.81	.02
Pre	24.52 (.48)	24.85 (.53)		
Post	14.91 (.79)	16.94 (.86)		
PSQI			3.00	.03
Pre	7.89 (.47)	8.10 (.51)		
Post	5.07 (.46)	6.29 (.50)		
CAMS-R			.34	.004
Pre	30.24 (.84)	29.40 (.91)		
Post	34.96 (.91)	33.43 (.99)		
CES-D			2.11	.02
Pre	19.59 (1.3)	20.01 (1.4)		
Post	11.14 (1.2)	14.23 (1.3)		
WLQ productivity loss			.60	.01
Pre	5.52 (.61)	5.43 (.66)		
Post	3.32 (.50)	3.72 (.55)		
Current pain			.64	.01
Pre	2.01 (.31)	1.63 (.33)		
Post	1.25 (.25)	1.19 (.27)		
Average pain			1.20	.01
Pre	2.60 (.30)	2.41 (.33)		
Post	1.91 (.29)	2.11 (.31)		
Worst Pain			.32	.004
Pre	3.78 (.43)	4.41 (.46)		
Post	3.39 (.43)	3.69 (.47)		
Systolic BP			.10	.001
Pre	118.39 (2.0)	110.54 (2.1)		
Post	117.69 (2.0)	109.23 (2.2)		
Diastolic BP			2.84	.03
Pre	76.53 (1.3)	75.58 (1.4)		
Post	76.49 (1.4)	72.86 (1.5)		
Breathing rate			.01	.000
Pre	14.79 (.48)	16.23 (.53)		
Post	13.77 (.47)	15.16 (.51)		
HRV Coherence ratio			3.91*	.04
Pre	–.39 (.07)	–.24 (.07)		
Post	.03 (.05)	–.003 (.05)		
RR interval			.26	.003
Pre	833.19 (23.1)	837.90 (25.1)		
Post	871.31 (17.7)	861.37 (19.2)		

* $p < .05$.

To evaluate the possible influence of differential attrition, all major analyses were repeated with completers only. These per protocol analyses largely confirmed all ITT findings, and revealed only one additional result. Specifically, the univariate Group × Time interaction for the CAMS-R mindfulness measure went from being marginally significant, $F(2, 233) = 2.51$, $p = .08$, $\eta^2 = .02$, to significant, $F(2, 199) = 3.06$, $p < .05$, $\eta^2 = .03$. As with the entire sample, the mindfulness group showed greater increases in CAMS-R mindfulness scores, $F(1, 124) = 6.40$, $p < .01$, $\eta^2 = .05$. Additionally, in the per protocol analyses, the yoga group showed increases in mindfulness compared with the control group, $F(1, 117) = 4.09$, $p < .05$, $\eta^2 = .03$, but no differences emerged between the mindfulness and yoga groups, $F(1, 152) = .03$, *ns*, $\eta^2 = .000$.

Discussion

Compared with controls, there were statistically significant reductions in perceived stress and sleep difficulties for participants of each mind-body intervention. In addition, both the mindfulness and yoga interventions demonstrated marginal improvements in breathing rate, and significant improvements in heart rhythm coherence, a measure of autonomic balance. Directionally favorable improvements in mood (measured by CES-D) and work productivity (measured by WLQ index) were not statistically significant. No Group × Time interactions were observed for blood pressure, or other exploratory measures of HRV for either intervention. The heart rhythm coherence ratio in the online mindfulness group improved more than that of the in-person group, although this may have been due to the attrition differences observed between the mindfulness venues. Although attendance at online mindfulness classes was lower, there was considerably better engagement (a notable lack of study attrition) in the online mindfulness group. This may be due to the fact that those who missed online classes could access a video to observe the missed class; there was no such option for in-person classes. Unfortunately, we did not systematically assess reasons for attrition; further studies are needed to clarify the reasons for this differential attrition.

Our findings are consistent with those of other mind-body worksite stress management programs in showing promise as health promotion interventions. They parallel the outcomes of McCraty et al. (2003) who reported reductions in stress symptoms, as well as the findings of Hartfiel et al. (2010) who documented improvements in mood, resilience, and psychological well-being. Our strong findings of improved heart rhythm coherence are also consistent with those of Limm et al., (2011), who demonstrated decreased stress reactivity and sympathetic nervous system activation. Like Limm et al. (2011), we did not observe decreases in depressive symptoms, although other stress reduction programs that targeted depression have reported such improvements (Hartfiel et al., 2010; Mino et al., 2006). For example, Mino et al. (2006) used a cognitive–behavioral therapy approach as a stress management intervention, which was apparently better suited to address depressive symptoms. In addition, their study was conducted in Japan with an entirely male sample; gender and cultural factors may play a role in their findings.

Productivity was measured by the WLQ. From the ITT analyses, outcomes observed on the WLQ suggest that the reductions in stress levels and improvement in sleep quality were not associated with significant improvements in self-reported work productivity in our sample. There could be two reasons for this. First, given that the study was not powered to detect differences in productivity, our sample size might not have been large enough to statistically capture improvements. Second, our sample was highly stressed, but did not have significant, current health issues because individuals with major medical or psychological issues were deemed ineligible for the study. Our baseline WLQ indices were below those observed in studies of employees with chronic health conditions (e.g., Reilly, Bracco, Ricci, Santoro, & Stevenes, 2004; Walker, Michaud, & Wolfe, 2005). Thus improvements in work productivity observed in this study would likely come from improvements in cognitive function rather than physical health per se. Unfortunately, we did not measure attention, concentration, or other indicators of cognitive function. Future studies should include such indicators, as well as other measures of productivity not subject to self-report bias. Decreases in perceived stress were found across all groups, including the controls. At the beginning of the recruitment period, corporate restructuring and subsequent job eliminations were occurring that may have elevated pre-PSS scores. Given that the programs were offered at the height of this reorganization, the outcomes likely reflect some regression to the mean. While the HRV measures were included to explore the potential impact of the programs on autonomic function, the findings for heart rhythm coherence were so strong that they merit discussion themselves. It is consistent with mindfulness and yoga theory that individuals would improve their autonomic tone. In fact, while it has yet to be demonstrated empirically, a major tenet of these practices is that they train individuals to be less reactive in terms of sympathetic reactivity as well as more psychologically and physiologically adaptable (McCraty, Atkinson, Tomasino, & Bradley, 2006; Thayer, Hansen, Saus-Rose, & Johnsen, 2009). While only serving as pilot data here, heart rhythm coherence certainly warrants further study.

This study demonstrates not only the effectiveness, but also the viability of integrating mind-body stress management programs into the workplace using interventions of relatively short duration (12–14 hr). First, we ensured easy access by developing a 12-week, 1-hr intervention offered weekly around lunchtime. Scheduling the intervention in this way minimized time constraint barriers for employees. Second, we streamlined ease of physical access to the mindfulness intervention by offering classes on-site or in a virtual classroom accessible via the employee's computer, which appeared to positively influence engagement. Third, the flexibility of these interventions offered in-person, online, and in-group settings, enables provision of the interventions across workplace settings with variable schedules, technology-bases, and geographical limitations. In particular, the online classes through the virtual space may allow viability of similar interventions across a large number of worksites. An additional important contribution of this study is the demonstration of targeted segmentation, which may be an important intervention consideration in terms of clinical utility (Flaxman & Bond, 2010), as well as cost-effectiveness. By targeting highly stressed employees, and focusing on the overall accessibility and practicality of the program, we developed an intervention that can be deployed easily within corporate settings (rather than being a one-time offering) compared with mind-body programs that historically were developed for consumer, academic, or community-based application.

Several limitations to this study merit mention. First, while the results may generalize to similar corporate audiences, the study population is not representative of the nation as a whole. Second, our measure of autonomic balance was captured while exploring the impact on multiple variables. Despite using omnibus tests and conservative alpha levels to control for type I error and limit the chance of inaccurately accepting the physiological benefits observed, we did use seven different measures of HRV. The findings thus need to be replicated. In addition, we captured blood pressure, breathing rate, and the HRV measures using two single assessment periods of physiological states (pre- and postintervention). As such, we did not capture the diurnal variations in reactivity and do not know the relative generalizability of the more coherent state we observed postintervention.

Future research with adequately powered samples must examine the impact of such interventions on health care costs (e.g., insurance claims), long-term productivity, biometrics, and assess the mechanism of action for such mind-body interventions. One possible mechanism may be that mind-body interventions improve health outcomes by modulating the stress response and subsequently preventing or lessening the inflammatory response (McEwan, 1998), thus ameliorating vulnerability to stress-related disease (e.g., Kiecolt-Glaser, Christian, Preston, Houts, Malarkey, Emery, et al., 2010; Innes et al., 2007). Because the inflammatory response is implicated in virtually all major chronic conditions currently burdening our health care system and employers, finding effective ways to modulate the stress response is of crucial importance to health promotion and disease prevention, in terms of both financial and human costs.

This was a large, worksite-based RCT of two easily accessible mind-body interventions that provided significant improvements in stress levels, sleep parameters, and autonomic balance. Emerging evidence also suggests that mind-body programs may demonstrate cost savings through decreased medical utilization (measured by office visits to community health centers; Roth & Stanley, 2002), medical insurance claims (Walton, Schneider, Salerno, & Nidich, 2005), and increased productivity (McCraty, Atkinson, Lipsenthal, & Arquelles, 2009). Of note, the total approved medical claims for the preceding 12 months from the employee group screened for this investigation demonstrated a significant positive correlation between their PSS scores and these medical costs ($p = .017$) such that each one-point PSS increase was associated with an annual increase of $96.36 in costs (Baime, Wolever, Pace, et al., 2011). It is clear that programs that teach techniques for managing stress can improve health and reduce risk. Emerging data also suggests that effective stress management programs may impact health care utilization and likely cost, and improve worker productivity (Goetzel & Pronk, 2010; Pelletier, Herman, Metz, & Nelson, 2010; Soler et al., 2010). It is therefore imperative to find ways to address clinically significant stress in the workplace that are practical, effective, and easily implemented.

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