Effective and viable mind-body stress reduction in the workplace: Two randomized, controlled trials

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Abstract

Highly stressed employees are subject to greater health risks, increased cost and productivity losses than those with normal stress levels. To address this issue, work-site stress management programs must be able to engage individuals as well as capture data on stress, health indices, work productivity, and healthcare costs. In this randomized controlled pilot, our primary objective was to evaluate the viability and proof of concept for two innovative mind-body workplace stress reduction programs, setting the stage for larger cost-effectiveness trials. A second objective was to evaluate two delivery venues of the mindfulness intervention (online versus in-person). Intention-to-treat principles and 2 (pre and post) X 2 (group) Repeated Measures ANCOVA 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 thirty-nine (239) employee volunteers were randomized into a therapeutic Viniyoga worksite stress reduction program, one of two Mindfulness at Work™ programs, or a control condition that participated only in assessment. Compared to 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 were basically equivalent. Both the Mindfulness at Work™ and therapeutic Viniyoga programs provide a viable and effective intervention to target high stress levels, sleep quality and autonomic balance in employees.

Keywords: yoga, Viniyoga, mindfulness, online, workplace stress reduction, stress, sleep, heart rate coherence

Effective and viable mind-body stress reduction in the workplace:

Two randomized, controlled trials

Highly stressed individuals are at greater risk for multiple health conditions including coronary heart disease (Hemingway et al. 1999), cancer (Antoni et al. 2006), diabetes (Hu et al. 2004), depression and anxiety (Garcia-Bueno et al. 2008), fatigue (Van Houdenhove et al. 2009), obesity (Black 2003) and musculoskeletal pain (Finestone et al. 2008). In fact, psychological stress and the associated chronic inflammatory response have been implicated in virtually all chronic conditions (Chrousos and Gold 1992; McEwan 1998; Black 2006; Cohen et al. 2007). Further, highly stressed employees incur productivity losses and healthcare costs above those with normal levels of stress (e.g., Baime, 2011; Goetzel, et al 1998). To successfully address this issue for employees, work-site stress management programs must be accessible, engaging and convenient in terms of scheduling, time requirements, on-site locations and 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 innovative 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 et al., 2010; 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, Morris & Bobinet, 2011; Goetzel et al., 2004; Thygeson 2010). The International Labor Organization (ILO) 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 UK, and USD 6.6 billion in USA" (Mino et al 2006). In large scale studies, employees with high stress have significantly higher annualized medical expenditures (odds ratio = 1.528) compared to 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 et al., 2010; Fang et al., 2010) to organ-transplant recipients (Gross et al.,2010), with results of the latter being sustained one year post-mindfulness training (Gross et al.,2010). RCTs of yoga have begun to demonstrate improvement in well-being (Oken et al., 2006; Kjellgren, A, et al 2007) anxiety reduction (Smith, C. et al 2007; Javnbakht, et al 2009) as well as improved physical measures such as chronic low back pain (Sherman, K.J. et al 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 through modulation of the hypothalamic-pituitary-adrenal axis (Innes et al., 2007). The most recent systematic Cochrane review on the effectiveness of yoga identified five RCTs for treatment of depression (Pilkington, et al. 2005) and identified eight RCTs for the treatment of anxiety and anxiety disorders (Kirkwood et al 2005). All thirteen studies reported encouraging positive results, although methodological inadequacies as of yet prevent the conclusion that yoga is effective in reducing depression or treating anxiety.

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 work-site wellness. Four recent RCTs on workplace stress reduction programs that utilized mind-body techniques have demonstrated improvements in self-reported mood (McCraty et al, 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., 2010). In addition, physiological improvements have been noted in systolic blood pressure three months post-intervention (McCraty et al., 2003) and in sympathetic activation one year later (Limm et al., 2010). All of these studies were RCTs, lending some methodological credence to their findings, yet three of the four had small sample sizes (Ns = 38, 48 and 58). The fourth (Limm et al., 2010) 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 evaluating the effectiveness of two mind-body workplace stress reduction programs designed to be highly accessible to employees: a mindfulness-based stress management intervention called “Mindfulness at Work™ ” and a therapeutic yoga-based program, “Viniyoga Stress Reduction Program.” Each 12 week intervention lasted one hour 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. Separate studies of the two work-site programs were conducted for two a priori hypotheses, comparing each intervention to the same control group. We asked a similar research question for each: “Does this program help participants lower stress levels? In addition, does each program impact health indices and productivity in a positive way?” Since 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 not interested in comparing the two mind-body programs to each other, as 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.. 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.

Methodology

Study Participants

The participant group consisted of 239 employees of a national insurance carrier who volunteered to participate in a randomized controlled trial 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: 1) an arrhythmia requiring medication or a pacemaker; 2) pregnancy; 3) 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 hours, or smoking six of more cigars daily; 4) medications that would affect heart rate (including anti-arrhythmia drugs, beta blockers, calcium channel blockers, stimulants, and illicit drugs); and 5) 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. post-traumatic 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 *Viniyoga Stress Reduction Program* and two versions of *Mindfulness at Work*™ .

Viniyoga Stress Reduction Program. The therapeutic Viniyoga arm was a 12-week (12 hour) Viniyoga-based program developed by Gary Kraftsow, MA, E-RYT (500), the Founder and Director of the American Viniyoga Institute (AVI) and Viniyoga Wellness Programs. The program progressively introduced tools for managing stress including asana (physical postures of yoga), breathing techniques, guided relaxation, and mental techniques, and education about starting a home practice. The Viniyoga classes were taught by AVI-trained teachers at the two worksites in Hartford, CT and Walnut Creek, CA. Instructional handouts were provided educating 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.Since 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 practitioner(s) 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 impacted by stress. The postures within the practice sequence can be adapted to accommodate the body habitus or any individual structural limitations of the participants. It appears 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 et al. 2007)

Mindfulness at Work™ . The two *Mindfulness at Work*™ programs 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 bi-directional communication. Mindfulness at Work™ is a 12-week (14-hour) mindfulness-based stress management program based on the original work of Jon Kabat-Zinn, who created Mindfulness-Based Stress Reduction (MBSR), an eight-week, 27-hour stress reduction intervention that has been validated in numerous clinical and professional settings [Kabat-Zinn 1990; Ludwig and Kabat-Zinn 2008; Baer, R. A. (Ed.) 2006, Didonna, F (Ed.) 2009]. The Mindfulness at Work™ program, designed by Elisha Goldstein, PhD and refined by Michael Baime, MD, adapted MBSR principles to more explicitly address worksite stress and be delivered at the worksite. It consisted of 12 weekly hour-long classes, and a two-hour mindfulness practice intensive at week 10. The mindfulness techniques were based on those presented in MBSR, but shortened and modified to make them easier to perform at a worksite. Both the classroom and online versions were taught by the same experienced mindfulness meditation teacher. Participants in both *Mindfulness at Work*™ arms were asked to complete home practice assignments and were given handouts for home and office use.

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 perceptual and sensory events, one begins to realize how intention and behavior is formed (Siegel, Germer & Olendzki, 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 and 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 many 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. (Hölzel, Ott, Gard, Hempel, Weygandt Morgen, et al.,2008).

Control Condition. A single Control Group (n=53) was used for comparison with each of the intervention groups. The Control Group received the same assessments, but did not receive any stress management intervention. Instead, they 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 Table 2, 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: Viniyoga Stress Reduction Program (n = 20), Mindfulness at Work™ (online; n = 22), and Controls (n = 21). To ensure equivalent distribution across all conditions, the CT participants were randomized into one of four conditions: Viniyoga Stress Reduction Program (n = 70 divided into three classes), Mindfulness at Work™ (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: Viniyoga n = 90 (76 completers), Mindfulness at Work™ n = 96 (82 completers), divided between 52 online (X completers) and 44 in-person (X 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. Post-test data were collected within 2 weeks of the final class (or concurrent period for wait-list controls). At both time points, the measures described below were collected: numerical rating scales for current and average pain; Cognitive Awareness Mindfulness

Scale (CAMS-R: Feldman 2007); blood pressure, breathing rate and a number of exploratory Health Rate Variability (HRV) indices (listed in table below); and the Work Limitations Questionnaire index (WLQ: Lerner 2001).

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: Stress-related Heatlh Indicies.

Sleep Quality. The Pittsburgh Sleep Quality Index (PSQI: Buysse et al. 1989a) 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), one of the most common screening tests that measures depressive feelings and behaviors within the past week, was used to measure affective changes. Only total score is reported. 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.

Biological Measures: BP and HRV. Biological measures were collected as follows within 14 days of the program's start dates. Participants were seated, with an Omicron blood pressure cuff on their left arm supported at the mid-atrial level and the elbow bent approximately 100 degrees. Participants were asked to sit quietly and to refrain from talking, moving, falling asleep, or engaging in any specific activity for 5 minutes. Blood pressures were then taken by an RN or MD, followed by a 60 second breathing rate count.

An emWave sensor was placed on the right earlobe, and HRV recordings were gathered by noninvasive measurement of the pulse, as previously described (Bradley, McCraty, Atkinson, & Tomasino, 2010). In brief, using the inter-beat interval data, a number of standard indices of HRV and a measurement of heart rhythm coherence—the key marker of the psychophysiological coherence state—were derived including: RR interval (heart rate), standard deviation of RR intervals, root mean square of successive differences (RMSSD), high frequency power, low frequency power, total power, and coherence ratio. Pulse was continuously recorded at a sample rate of 250 Hz throughout a ten minute *resting baseline* period both pre- and post-intervention. In addition, during the post-intervention period, continuous pulse was recorded during a four-minute *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.

Mindfulness. The 12-item CAMS-R was used to measure individual differences in mindfulness and adequately sample the four domains of mindfulness (attention, present-focus, awareness, and acceptance/non-judgment). All scales demonstrated acceptable levels of internal consistency in our sample, with Cronbach's alpha levels (α) ranging from 0.74 to 0.89.

Secondary Outcome: Productivity. The recently-developed 25-item WLQ 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.

Analysis Plan

Two separate studies were conducted. The first tested the Mindfulness at Work™ intervention against the controls; and the second evaluated the Viniyoga Stress Reduction Program intervention against the same controls. For each study, we first evaluated sociodemographics and key study variables at baseline between sites. Baseline site differences were accounted for in the primary analyses by retaining relevant covariates when sites were combined. Using intention-to-treat principles and a 2 (pre and post) by 2 (group) Repeated Measures ANCOVA, we examined group differences from pre-treatment to post-treatment on participants' perceived stress, stress-related health indices and work productivity. The primary variable was the PSS, with multiple secondary variables evaluated to clarify which variables to include in subsequent studies. An omnibus F test was used to simultaneously test the multiple variables associated with HRV. Last Observation Carried Forward (LOCF) was used to handle missing data (Twisk & DeVente, 2002). Because multiple analyses were conducted on secondary variables, we employed family-wise Bonferroni Corrections to control for Type I error in the omnibus test. Hence, only those that reached $p < .01$ level of significance were considered to show significant interactions or main effects.

For the second objective, separate analyses targeted a priori hypotheses regarding the online Mindfulness at Work™ intervention. We expected that the online Mindfulness at Work™ program would perform at least as well as the in-person program in terms of stress and secondary measures. These expectations were formed from previous experience with live, online classes wherein the interaction level was exceptionally high. In addition, an extensive review and meta-analysis of Internet-based psychotherapeutic interventions has demonstrated no difference in effectiveness when compared to face-to-face interventions, and in some circumstances, the Internet-based work was described by clients as superior (Barak, Hen, Boniel-Nissim & Shapira, 2008).

Results

Study One: Mindfulness at Work™ versus Controls

Baseline Analyses and Covariate Selection.

Covariates were selected in two ways. First, we tested for significant sociodemographic and baseline study variable differences in the study sites [California (CA) versus Connecticut (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 control groups differed in race [χ^2 (5) = 11.90, p < .05], ethnicity [χ^2 (1) = 3.76, p < .05], and income [χ^2 (3) = 10.43, p < .05]. The CA and CT mindfulness groups did not differ from one another in any sociodemographic variable. Secondly, we tested for differences between the online mindfulness and in-person mindfulness groups at baseline. The two groups differed in income [χ^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. We addressed the SBP baseline difference between the in-person and online mindfulness classes as described below. Finally, to ensure equivalent baseline status, we conducted a series of chi-square analyses and independent *t* tests to test for significant differences in baseline sociodemographic and key study variables between the control and mindfulness group. As shown in Table 1, no differences emerged between the control and mindfulness group for any sociodemographic or key study variables.

Group x Time Interactions (n = 149)

As shown in Table 2, a significant group x time interaction emerged between the control and mindfulness groups for perceived stress [F = (1, 144) = 21.31, p < .001, η^2 = .13], sleep quality [F (1, 144) = 5.17, p < .05, η^2 = .04], and mindfulness [F(1,144) = 5.75, p < .05, η^2 = .04], but not for depressive symptoms, pain measures, or the work productivity index. Compared to the control group, the mindfulness group showed greater decreases in perceived stress (from *M* = 23.51 to *M* = 19.43 for control and from *M* = 24.73 to *M* = 15.81 for mindfulness), greater decreases in sleep difficulty (from *M* = 7.32 to *M* = 6.03 for control and from *M* = 8.07 to *M* = 5.68 for mindfulness) and greater increases in mindfulness (from *M* = 29.9 to *M* = 32.2 for control and from *M* = 29.8 to *M* = 34.3 for mindfulness). Further, a significant group x time interaction emerged in explaining the heart rhythm coherence ratio [F = (1, 144) = 4.25, $p < .05$, η^2 = .03]. When asked to quietly prepare themselves for an upcoming important or challenging event at the post-intervention measurement, the mindfulness group, in comparison to the controls, showed greater increases in heart rhythm coherence from pre-intervention baseline (from *M* = -.26 to *M* = -.12 for control and from *M* = -.32 to *M* = .01 for mindfulness). No significant group x time interactions emerged between the control and mindfulness groups for any of the other physiological variables.

To test the equivalence of the online mindfulness group, we used a 2 (time) X 2 (group) repeated measures ANCOVA, covarying out ethnicity, race, and income level, as 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 x time interaction emerged in explaining the heart rhythm coherence ratio [F = (1, 91) = 3.91, $p < .05$, η^2 = .04]. Compared to the in-person mindfulness group, the online mindfulness group showed greater increases in coherence from pre-intervention baseline to post-intervention stress preparation (from *M* = -.24 to *M* = -.003 for in-person mindfulness and from *M* = -.39 to *M* = .03 for online mindfulness).

Attrition and Per Protocol Analyses

Of the 149 participants who provided baseline data for the MAW study (including the 53 Controls used in both trials), 129 (88.4%) completed the study and provided follow-up data (82 in the intervention group and 47 in the control group). Chi-square analyses revealed that attrition levels did not differ between the control and mindfulness groups [χ^2 (1) = ,31 p =.58], as 11.3% of the participants in the control group and 14.6% of the participants in the mindfulness 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, 82 of the 96 (85.4%) participants who provided baseline date completed the study and provided follow-up data. Higher levels of attrition occurred in the in-person mindfulness group (27.3%) compared to the online mindfulness group (3.8%) [χ^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 [$t(94) = 2.17$, $p < .05$], but attriters did not differ from participants who completed the study in any other baseline study variables or sociodemographic variables. To evaluate the possible influence of differential attrition, all major analyses were repeated with completers only. These per protocol analyses confirmed all ITT findings, and revealed no additional results.

Study 2: Viniyoga Stress Reduction Program versus Controls

Baseline Analyses and Covariate Selection.

As in the first study, covariates for our analyses examining group differences between the control and therapeutic Viniyoga groups were selected by examining site differences as well as baseline differences between the control and Viniyoga groups. Because the CA and CT sites differed in race, ethnicity, and income, we continued to use these covariates in our analyses. Next, to ensure equivalent baseline status, we conducted a series of chi-square analyses and independent *t* tests to test for significant differences in baseline sociodemographic and key study variables between the control and Viniyoga groups. As shown in Table 1, the control and Viniyoga group differed in education level [χ^2 (3) = 9.05, $p < .05$]. Therefore, education was retained as an additional covariate in our analyses comparing the control and Viniyoga groups.

Group x Time Interactions (n = 143)

As shown in Table 4, a significant group x time interaction emerged between the control and Viniyoga groups for perceived stress [$F = (1, 137) = 8.79$, $p < .01$, $\eta^2 = .06$], sleep quality [$F (1, 137) = 5.94$, $p < .05$, $\eta^2 = .04$], and current pain [$F = (1, 137) = 6.51$, $p < .01$, $\eta^2 = .05$], but not for depressive symptoms, average or worst pain measures, mindfulness, or the work productivity index. Compared to the control group, the Viniyoga group showed greater decreases in perceived stress (from *M* = 23.47 to *M* = 19.08 for control and from *M* = 25.01 to *M* = 16.91 for Viniyoga), greater decreases in sleep difficulty (from *M* = 7.24 to *M* = 5.92 for control and from *M* = 7.86 to *M* = 5.37 for Viniyoga), and improvement in current pain rating (decreased from *M* = 1.36 to *M* = 1.24 for Viniyoga while current pain increased in the control group from *M* = 1.41 to *M* = 2.24). Further, a significant group x time interaction emerged in explaining the heart rhythm coherence ratio [$F = (1, 137) = 29.77$, $p < .001$, $\eta^2 = .18$]. Compared to the control group, the Viniyoga group showed greater increases in heart rhythm coherence from pre-intervention baseline to post-intervention stress preparation (from *M* = -.23 to *M* = -.11 for control and from *M* = -.32 to *M* = .32 for yoga). Although significant only at the 0.05 level, rather than the Bonferroni-corrected family-wise error rate of 0.025, a group x time interaction did emerge in explaining diastolic blood pressure [$F = (1, 137) = 4.29$, $p < .05$, $\eta 2 = .03$]. While the control group's diastolic blood pressure increased from pre to post-intervention (from M = 74.58 to M = 75.84), the Viniyoga group's diastolic blood pressure decreased (from M = 75.79 to M = 73.77). No significant group x time interactions emerged between the control and Viniyoga groups for any of the other physiological variables.

Attrition and Per Protocol Analyses

Of the 143 participants who provided baseline data for the Viniyoga study (including the 53 Controls used in both trials), 123 (84.2%) completed the study and provided follow-up data (76 in the intervention group and 47 in the control group). Chi-square analyses revealed no differential levels of attrition: 11.3% of the Controls and 15.6% of the Viniyoga participants did not complete the study.

Compared to participants who completed the study, attriters reported slightly higher scores on the CAMS-R [t (141) = 2.30, $p < .05$], but attriters did not differ from participants who completed the study in any other study or sociodemographic variables. To evaluate the possible influence of differential attrition, all major analyses were repeated with completers only. These per protocol analyses confirmed all ITT findings, and revealed no additional results.

Discussion

Compared to controls, there were statistically significant reductions in perceived stress and sleep difficulties for participants of either mind-body intervention. In addition, both the mindfulness and Viniyoga interventions demonstrated significant improvements in Heart Rhythm Coherence, a measure of autonomic balance. The mindfulness group also outperformed controls in ratings of mindfulness; and the Viniyoga group outperformed controls in ratings of current pain. Directionally favorable improvements in mood (measured by CES-D) and work productivity (measured by WLQ index) were not statistically significant. Diastolic blood pressure improved in the Viniyoga condition alone, compared to controls, although it did not meet our stringent alpha levels. No group x time interactions were observed in systolic blood pressure, breathing rate or other exploratory measures of Heart Rate Variability 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 at Work™ classes was lower, there was considerably better engagement (a notable lack of study attrition) in the online Mindfulness at Work™ 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.

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 and blood pressure, 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, (2010) who demonstrated decreased stress reactivity and sympathetic nervous system activation. Like Limm et al. (2010), 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 Work Limitations Questionnaire (WLQ), which includes the following axes: time management, physical demands, output demands, interpersonal demands and productivity loss. From the ITT analyses, outcomes observed on the WLQ suggest that the reductions in stress levels and improvement in sleep quality did not result in significant improvements in work productivity (see Table 1). 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 as those 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 et al, 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.

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 Heart Rate Variability 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, particularly for the Viniyoga condition. 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 et al., 2006; Thayer et al., 2009). While only serving as pilot data here, heart rhythm coherence certainly warrants further study.

This study demonstrates the effectiveness as well as viability of integrating mind-body stress management programs into the workplace using interventions of relatively short duration (12-14 hours). First, we ensured easy access by developing a 12-week, one-hour intervention offered once a week 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. With increased demand for cost-effectiveness of workplace health interventions, it is novel to identify and target the highly stressed segment of an employee population using a convenient and validated 10 item questionnaire, the PSS. 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 to 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 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 post intervention). 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 post-intervention.

Future research with adequately-powered samples must examine the impact of such interventions on healthcare costs (e.g., insurance claims), long-term productivity, biometrics and the mechanism of action of 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., Keicolt-Glaser et al., 2010; Innes et al., 2007). Since 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 randomized controlled trial 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 et al., 2005), and increased productivity (McCraty et al., 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 Perceived Stress Scale (PSS) scores and these medical costs ($p=0.017$) 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, reduce risk, impact healthcare utilization and likely cost, and improve worker productivity (Goetzel & Pronk, 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.

Table 1. Participant Characteristics at Baseline

	Control (n = 53) Percent	**Mindfulness (n = 96) Percent**	**Yoga (n = 90) Percent**	**Control vs. Mindfulness χ2**	**Control vs. Yoga χ2**
Gender				.33	1.12
Male	18.9	22.9	26.7		
Female	81.1	77.1	73.3		
Ethnicity				2.68	.12
Not Hispanic/Latino	90.6	96.9	92.2		
Hispanic/Latino	9.4	3.1	7.8		
Race				6.76	5.60
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				2.83	6.54
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				5.66	9.05*
High School (HS)	7.5	3.1	2.2		
Beyond HS, 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	.44
Part Time	5.7	2.1	3.3		
Full Time	94.3	97.9	96.7		
Marital Status				2.80	5.59
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	0.0		
	M (SD)	**M (SD)**	**M (SD)**	**t-value**	**t-value**
Age	42.74 (9.7)	44.29 (9.4)	41.57 (10.1)	-.95	.68
PSS	23.62 (3.7)	24.67 (3.5)	24.92 (4.0)	-1.71	-1.92
PSQI	7.47 (3.3)	7.99 (3.4)	7.72 (3.3)	-.91	-.45
CAMS-R	29.81 (5.2)	29.85 (5.9)	29.72 (5.7)	-.04	.09
CES-D	18.17 (9.2)	19.78 (9.5)	18.43 (8.6)	-1.01	-.17
WLQ Productivity Loss	5.65 (4.6)	5.47 (4.3)	4.90 (3.6)	.24	1.07
Systolic BP	118.0 (18.5)	114.8 (14.5)	113.3 (12.7)	1.16	1.78
Diastolic BP	75.0 (11.6)	76.1 (9.4)	75.5 (9.7)	-.62	-.29
Breathing Rate	15.7 (2.8)	15.4 (3.5)	15.9 (3.7)	.44	-.34
Coherence Ratio	-0.27 (.49)	-0.32 (.49)	-0.29 (.50)	.58	.26
RR Interval	842.0 (146.5)	835.4 (172.7)	856.3 (132.6)	.24	-.60

*p < .05. **p < .01. ***p < .001

Table 3. Study 1a: Group x Time Interactions from RM ANCOVAs for Controls versus Mindfulness at Work™ (n = 149

	Control (*n* = 53) *M* (SE)	**Mindfulness at Work (*n* = 96)** *M* (SE)	F	eta^2
PSS			21.31***	.13
Pre	23.51 (.50)	24.73 (.37)		
Post	19.43 (.82)	15.81 (.60)		
PSQI			5.17*	.04
Pre	7.32 (.46)	8.07 (.34)		
Post	6.03 (.46)	5.68 (.34)		
CAMS-R			5.75*	.04
Pre	29.92 (.80)	29.79 (.59)		
Post	32.19 (.90)	34.28 (.67)		
CES-D			2.12	.02
Pre	17.66 (1.3)	20.06 (.95)		
Post	12.58 (1.2)	12.77 (.91)		
WLQ Productivity Loss			1.69	.01
Pre	5.57 (.61)	5.52 (.45)		
Post	4.33 (.55)	3.58 (.41)		
Current Pain			2.68	.02
Pre	1.48 (.29)	1.84 (.21)		
Post	1.41 (.25)	1.23 (.19)		
Average Pain			.82	.01
Pre	2.12 (.30)	2.55 (.22)		
Post	1.85 (.28)	2.03 (.21)		
Systolic BP			.01	.001
Pre	117.38 (2.2)	115.12 (1.6)		
Post	116.89 (2.2)	114.16 (1.6)		
Diastolic BP			1.88	.01
Pre	74.79 (1.4)	76.21 (1.1)		
Post	75.62 (1.4)	75.09 (1.1)		
Breathing Rate			3.49	.02
Pre	15.63 (.46)	15.48 (.34)		
Post	15.56 (.47)	14.39 (.35)		
Coherence Ratio			4.25*	.03
Pre	-.26 (.07)	-.32 (.05)		
Post	-.12 (.05)	.01 (.03)		
RR Interval			2.85	.02
Pre	854.81 (21.9)	828.25 (16.2)		
Post	853.37 (18.0)	864.98 (13.3)		

Table 4. Study 1b. Group x Time Interactions from RM ANCOVAs for Online versus In-Person Mindfulness (n = 96).

	Online (*n* = 52)	**In-Person (*n* = 44)**		
	***M* (SE)**	***M* (SE)**	**F**	**eta^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			.63	.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)		
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)		
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)		

Table 5. Study 2: Group x Time Interactions from RM ANCOVAs for Control versus Yoga (n = 143).

	Control (*n* = 53) *M* (SE)	Yoga (*n* = 90) *M* (SE)	F	eta²
PSS			8.79**	.06
Pre	23.47 (.56)	25.01 (.42)		
Post	19.08 (.92)	16.91 (.70)		
PSQI			5.94*	.04
Pre	7.24 (.45)	7.86 (.34)		
Post	5.92 (.43)	5.37 (.33)		
CAMS-R			2.79	.02
Pre	30.05 (.79)	29.58 (.60)		
Post	32.56 (.90)	33.76 (.68)		
CES-D			.15	.001
Pre	17.34 (1.2)	18.91 (.91)		
Post	12.25 (1.2)	13.22 (.93)		
WLQ Productivity Loss			.76	.01
Pre	5.60 (.57)	4.94 (.43)		
Post	4.19 (.62)	4.06 (.47)		
Current Pain			6.51**	.05
Pre	1.41 (.31)	1.36 (.25)		
Post	2.24 (.24)	1.24 (.19)		
Average Pain			2.92	.02
Pre	2.12 (.30)	2.65 (.23)		
Post	1.83 (.25)	1.84 (.19)		
Systolic BP			.01	.00
Pre	117.72 (2.1)	113.48 (1.6)		
Post	117.14 (2.1)	112.73 (1.6)		
Diastolic BP			4.29*	.03
Pre	74.56 (1.5)	75.79 (1.1)		
Post	75.84 (1.5)	73.77 (1.2)		
Breathing Rate			3.47	.03
Pre	15.75 (.47)	15.86 (.35)		
Post	15.50 (.48)	14.44 (.37)		
Coherence Ratio			29.77***	.18
Pre	-.23(.07)	-.32 (.05)		
Post	-.11 (.05)	.32 (.04)		
RR Interval			.20	.001
Pre	846.32 (19.2)	853.75 (14.6)		
Post	850.59 (16.9)	849.42 (12.8)		

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