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Buffering of Physiological and Affective Reactivity By a Single Proactive 5-minute Stress Management Technique

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BUFFERING OF PHYSIOLOGICAL AND AFFECTIVE REACTIVITY BY A SINGLE PROACTIVE 5-MINUTE STRESS MANAGEMENT TECHNIQUE

by

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ABSTRACT

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by

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A plethora of recent research highlights the long-term chronic disease risks of elevated blood pressure (BP), heart rate (HR) and affective and cognitive responses to mental stressors and how traditional forms of mindfulness meditation (MM) and progressive muscle relaxation (PMR) may help offset these long-term risks. On top of that, briefer forms of MM (e.g., 3-day training sessions) have shown benefits for emotional and physical health. Further, perseverative cognitions, or the tendency to worry and rumination about stressful events, is linked with heightened CV reactivity, and may impede the success of stress management techniques. The purpose of this study was to investigate the feasibility of using a single, 5-minute session of mindfulness meditation to reduce physiological reactivity and acute psychological mood and stress responses to a stressor (compared to an alternative stress management technique and an active control condition). We conducted the following experimental protocol: 1) collected 10-minute baseline measures of BP and HR, as well as mood and perceived stress, 2) conducted a single 5-minute stress reduction technique (MM or PMR) or control, 3) ran a short version of the Trier Social Stress Test, 4) collect mood and perceived stress measures, and 5) conducted a 10-minute recovery period to allow participants' BP and HR levels to return to baseline. We hypothesized that (1) those in the stress management groups would show less BP and HR reactivity during the stress induction, as well as increased positive affect and/or decreased negative affect and reduced perceived stress after the stress induction compared to the control group and (2) this benefit would be greater for those who score low (vs. high) on trait PCs. Statistical analyses included mixed design repeated-measures ANOVA to assess the relationships of intervention type (MM vs PMR vs control) and period (mean BP or HR scores at each time point) with repeats on the period variable. There were no significant findings for MM or PMR reducing reactivity, perceived stress, or negative mood (nor increases in positive mood) to the stressor.

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MM	Mindfulness Meditation
PMR	Progressive Muscle Relaxation
CV	Cardiovascular
CVD	Cardiovascular Disease
BP	Blood Pressure
DBP	Diastolic Blood Pressure
SBP	Systolic Blood Pressure
HR	Heart Rate
HRM	Heart Rate Monitor
TSST	Trier Social Stress Test
RSQ	Response Style Questionnaire
PSWS	Penn State Worry Scale
PSS	Perceived Stress Scale
NA	Negative Affect
PA	Positive Affect

Stress management research has traditionally focused on interventions when one is already stressed which is not surprising considering a lot of stress is unpredictable (Schaeffer, Street, Singer, & Baum, 1988). However, there are many moments when we know we are about to engage in something stressful, ranging from everyday traffic delays (Schaeffer et al., 1988) and oral presentations (Merz & Wolf, 2015) to sport competitions (Laborde, Brull, Weber, Anders, 2011; McKay, Niven, Lavallee, & White, 2008) and exam stress (Melillo, Bracale, & Pecchia, 2011). People who experience these anticipatory stressors tend to show elevated psychophysiological responses to those stressors, including blood pressure (BP; Conley & Lehman, 2012), cortisol (John, Verma, & Khanna, 2011; Paridon, Timmis, Nevison, & Bristow, 2017), and heart rate variability (HRV; i.e., reduced autonomic cardiac control or flexibility in heart rate; Laborde et al., 2011; Melillo et al., 2011). For example, Conley and Lehman (2012) found significantly higher BP for college students during an on-going exam period compared to a non-exam period. Considering BP and HR reactivity to stress can predict future hypertension (Singh et al., 1998; Steptoe, Kivimäki, Lowe, Rumley, & Hamer, 2016), which is one of the most common and powerful contributors to cardiovascular disease (Kannel, 1996), developing *targeted, proactive* tools that improve BP and HR during anticipatory stress could prove extremely valuable in future health outcomes.

While there is a plethora of research showing the anticipatory stress response on predictable stressors, previous research falls short on evaluating acute, proactive techniques that could be beneficial in these moments and potentially lessen the overall burden of regular stress management practices. Further, evaluating the acute stress reduction effects of short-term stress interventions may provide valuable insight as to how these techniques work and how to implement them most efficiently. Specifically, evaluating the lowest dose necessary to reduce acute psychophysiological reactivity would be invaluable in developing tailored interventions at targeted moments to reduce stress, rather than relying on residual carryover from regular stress management practices. The present study describes the first documented evaluation of a *five-minute, single-session* of MM training as a proactive buffer of CV reactivity and self-reported mood during acute stress in comparison to an alternative singular 5-minute stress management intervention (i.e. progressive muscle relaxation) and an active, no stress management intervention (control).

It further tests if these effects are moderated by the tendency to engage in perseverative cognitions (PCs), as worry and rumination about stressful events is linked with heightened CV reactivity. These aims are critical as chronically elevated BP to related lab stressors predict future high BP and other chronic diseases (Low et al., 2009; Steptoe et al., 2016; Treiber et al., 2003) and PCs appear to exacerbate those effects (Gerin et al., 2006; Ottaviani et al., 2011). As well, effective emotion regulation is a major pathway to the optimal health benefits of MM (Creswell et al., 2014; Teper et al., 2013). This intervention would offer ideal feasibility to manage singular stress events, including actively manipulating physiological responses prior to the stressful event for effective stress management in the moment, as well as targeting specific anticipatory events to reduce reactivity before it has a chance to negatively impact the body.

History of Mindfulness Meditation and Progressive Muscle Relaxation

Of particular interest is the practice of mindfulness meditation (MM), which is common in standard clinical practices in psychology (Baer, 2003; Hughes et al., 2014; Ma & Teasdale, 2004; Segal & Walsh, 2016; Teasdale et al., 1995; Teasdale et al., 2000; Wahbeh et al., 2016). The practice of MM traces back to yoga in Hinduism in 1500 BCE, with various forms found all over the world in a variety of clinical settings (Chompoo, 2015). In general, MM occurs when one focuses their attention on the internal and external experiences in the moment (Baer, 2003;

Kabat-Zinn, 1994), in turn, optimizing stress reduction efforts (Chiesa & Serretti, 2009). MM relates to positive health outcomes over a variety of domains, including reduced symptoms of acute depression (Chiesa & Serretti, 2010; Costa & Barnhoffer, 2016; Ma & Teasdale, 2004; Segal & Walsh, 2016; Teasdale et al., 1995; Teasdale et al., 2000)) and anxiety (Hofmann et al., 2010), perseverative cognitions (PCs; i.e., chronic tendencies to worry about and reflect on future and past negative events; Brosschot et al., 2010; Nolen-Hoeksema & Morrow, 1999), clinic BP (Hughes et al., 2014), and reduced HR (Zeidan et al., 2010c), as well as reducing cortisol levels prior to sport competitions (John et al., 2011).

Another intervention that is increasingly used in stress management is progressive muscle relaxation (PMR), which originated in 1908, and was developed by a physician at Harvard University, Edmund Jacobson, in an effort to help people learn to remove or minimize muscular tension (Jacobson, 1938). Like MM, PMR is often used in clinical practices, and involves intentionally tensing and releasing various muscle groups in the body (Jacobson, 1938). PMR is effective in improving depression, state anxiety, perceived stress, heart rate, and cortisol (Broota & Dhir, 1990; Chellew, Evans, Fornes-Vives, Pérez, & Garcia-Banda, 2015; Dolbier & Rush, 2012; Neeru, Khakha, Satapathy, & Dey, 2015; Pawlow & Jones, 2002; Pawlow & Jones, 2005; Vancampfort et al., 2013). While the long-term psychological benefits of regular MM practice are important, particularly in the context of chronic stress, it is also important to understand how much training is necessary to produce positive effects, such as improved BP and HR, to better understand the mechanisms by which these stress management techniques might produce long-term benefits to health and well-being.

Efficacy of Traditional Mindfulness Meditation and Progressive Muscle Relaxation

Typical MM intervention protocols instruct participants to find a comfortable, quiet location, sit or lay in a comfortable position, and close their eyes and focus on the feeling of air moving in and out of the body as one breathes. Further, they are instructed that if and when thoughts come up in the mind, to not ignore or suppress them but simply note them, remain calm and use their breathing as an anchor. Kabat-Zinn (1985) was one of the first researchers to bring this technique into a controlled setting to evaluate its effect on health. Mindfulness is now in standardized clinical practices such as Mindfulness Based Stress Reduction (MBSR) and Mindfulness Based Cognitive Therapy (Baer, 2003; Hughes et al., 2014; Ma & Teasdale, 2004; Segal & Walsh, 2016; Teasdale et al., 1995; Teasdale et al., 2000; Wahbeh et al., 2016).

Additionally, traditional MM protocols involve time intensive group formats—a weekly 2-hour class for 8 weeks on top of daily home practice (Baer, 2003; Hughes et al., 2014; Wahbeh et al., 2016). Clearly, for optimal benefit, it is crucial to have sustained adherence to MM protocols. Yet, this long, standardized group format may be a barrier for some individuals, mainly due to time, costs, travel, and learning curve. Given the difficulty with the time-commitment that many patients experience and report when practicing MM (Bosworth et al., 2010), this daily commitment might represent a barrier to long-term adoption. A meta-analysis of 22 studies showed that even within a single study setting, attrition rates to treatment can range from 3 to 40% (Baer, 2003).

Typical PMR protocols instruct participants to attend to certain areas of the body, tensing and then relaxing the muscles in that area before moving onto the next area (Jacobsen, 1938). Progressive muscle relaxation protocols originally involved consistent daily practice, often requiring more than 40 individual sessions (Carlson & Hoyle, 1993). After decades of this procedure, researchers developed an abbreviated version involving 20-25 minutes of relaxing through 16 different muscle groups (Bernstein & Borkovec, 1973).

Brief progressive muscle relaxation interventions have received some attention by researchers, with a standard 20 to 25-minute protocol being developed in the early 1970s. Bernstein and Borkovec (1973) developed this brief protocol utilizing methods from the original progressive muscle relaxation protocol but shortening it to 20-25 minutes of relaxing through 16 different muscle groups. However, this intervention is still generally used over an 8 to 12-week period and assigns at home practice every day, twice a day for 15-20 minutes (Bernstein & Borkovec, 1973).

Similar to traditional MM protocols, PMR involves practicing over 8-12 weekly sessions. A meta-analysis evaluating the effectiveness of PMR found it to be beneficial among a myriad of disorders, including tinnitus, migraine and tension headaches, and essential hypertension, overall concluding that it is an effective intervention (Carlson & Hoyle, 1993). While current interventions involve this 8 to 12-week timeframe, discovering the benefits of a single session may provide invaluable knowledge for tailored treatment plans, targeting stressful moments, as well as having the potential to develop a biofeedback type model to show individuals its immediate benefits and improve adherence to future practice.

Benefits of Brief Mindfulness Meditation and Progressive Muscle Relaxation

Given these potentially high levels of attrition, research has also explored the potential of briefer MM protocols, finding generally positive effects on related health outcomes (Creswell et al., 2014; Kabat-Zinn et al., 1998; Rausch et al., 2006; Zeidan et al., 2010a; Zeidan et al., 2010b, Zeidan et al., 2010c). For example, a 3-day MM protocol improved skin clearing with psoriasis patients undergoing phototherapy (Kabat-Zinn et al., 1998). Additionally, Zeidan and colleagues found that a 3-day MM protocol reduced self-reported pain from electrical stimulation (2010a); a

4-session MM protocol improved fatigue, anxiety, mood, and cognitive abilities (2010b); and a 3-session MM protocol reduced negative mood and heart rate (HR; 2010c). More recently, Creswell et al. (2014) found that a 3-day MM intervention buffers self-reported psychological stress reactivity to the Trier Social Stress Test (TSST). Finally, Shearer, Hunt, Chowdhury & Nicol (2016) found among young adults who practiced mindfulness meditation (vs. dog therapy or no treatment control) for four weekly one-hour sessions, HRV was significantly higher during a cognitive challenge that immediately followed the intervention. Although a comprehensive review on these shorter protocols has yet to evaluate attrition rates, they are still relatively time intensive and could face high dropout rates as a result.

One way to promote adherence to MM protocols may be to help patients see that there are immediate effects to doing MM to build a sense of self-efficacy and perceived control. This may also improve patient confidence in attending a group session. Although some work has shown benefits from single sessions of large-group mantra meditation and progressive muscle relaxation on anxiety levels (Rausch et al., 2006), single-session group formats of MM specifically have yet to be tested nor is it clear if such single-sessions could buffer the physiological effects of stress.

The shortest duration of non-group MM shown to be beneficial thus far has been 20 minutes. Cruess et al. (2015) set out to evaluate 15 to 20-minute stress reduction techniques prior to a lab stressor as a potential buffer to physiological and psychological reactivity. They evaluated the effects of an enhanced-mindfulness intervention (e.g. leading participants through exercises in labeling thoughts and envisioning negative thoughts as waves without allowing them significant value) and a somatic-relaxation intervention (e.g. muscle relaxation through observation of the body's kinesthetic sensations) prior to the Trier Social Stress Test on salivary cortisol measures (i.e., an indicator of increased release of stress hormones in the body), finding an equally significant reduction in the stress response among these groups. However, 20 minutes is still a relatively large time commitment for a proactive tool, particularly when buffering against acute stressors. Thus, stress management efforts should strive to find an effective activity that fits more easily into natural life events and experiences to promote adherence. Further, a continuous measure of stress reactivity (e.g. continuous BP and/or HR measures to fully illustrate the reactivity prior, during, and after a stressful event) during the entirety of the experiment would be beneficial in understanding how these novel, brief stress reduction techniques affect the physiological stress response.

Recently, Fennell, Benau, & Atchley (2017) had experienced meditators and non-meditators practice a single session of MM for 20 minutes between anger induction tasks, and evaluated physiological measures (i.e., respiration rate and BP) before and after the tasks. Essentially, the procedure was as follows: baseline physiological measures, anger induction, physiological measures, return to baseline, MM, anger induction, and physiological measures. While this study revealed that a single session of MM can be a buffer to prolonged reactivity to future stressors for non-meditators, it did not examine the potential proactive benefits for short engagement in MM before any stressor or negative mood state was induced. For instance, everyday traffic delays increase CV stress responses (Schaeffer et al., 1988). Thus, rather than going through extensive MM training, one could spend 5 minutes in their vehicle doing MM before they start driving to offset the physiological reactivity linked with those stressors. The only other known comparison of this sort utilized 20 minutes of interacting with a dog as their active control (Shearer, Hunt, Chowdhury, & Nicol, 2016). Their results showed that undergraduate students had reduced anxiety via self-report measures for both the MM and active control conditions, but only the MM group showed improved HRV during a cognitive stress task.

In an effort to explore active controls for MM, techniques that have found similar results to briefer MM would be an appropriate place to start, such as PMR. Specifically, Pawlow and Jones (2005) evaluated if a single session (20-25 minutes) of PMR could reduce cortisol and heart rate among undergraduate students. They found significantly reduced cortisol levels among the PMR group from pre- to post-relaxation period, as well as significantly less perceived stress, anxiety, and heart rate. Additionally, Dolbier and Rush (2012) found that 20 minutes of PMR increased normalized high-frequency HRV and decreased the low- to high-frequency HRV ratio among high-stressed undergraduate students in a lab setting. With this abbreviated technique showing positive results at 20 minutes similar to results from single session MM interventions, progressive muscle relaxation will be an appropriate alternative stress reduction technique to use in the current study, as it's easy to learn and easy to implement in a field setting.

Feasibility of single 5-minute interventions

While MM protocols are increasingly used in psychosomatic research, the focus on their acute physiological benefits in terms of anticipatory stressors needs more empirical support. However, research must first identify the lowest successful dose of MM in a lab setting prior to exploring its efficacy in real life settings. In doing so, individuals can learn to manage the stress event itself, and develop a package of life skills that promote good habits that may prevent future health problems. Lazarus and Folkman (1984) define stress as a stimulus that exceeds a person's resources or appraising something as being a danger to one's well-being. Stress involves both the physiological response of the autonomic nervous system and a psychological stress response. The psychological stress response involves regulation of emotions (Finan, Zautra, Wershba, 2011; Hellhammer & Schubert, 2012), and the physiological stress involves the body's autonomic nervous system response to stress, such as increased blood pressure, heart rate, and sweating, as well as increased secretion of stress hormones, such as cortisol (Ulrich-Lai &

Herman, 2009). Consistently elevated CV reactivity across time (months and years) may be a major risk factor for several poor health concerns and chronic diseases, including cardiovascular disease (Low et al., 2009; Steptoe et al., 2016; Treiber et al., 2003).

Thus, the review above highlights that MM likely has short-terms benefits for CV recovery to mental stress (a low as 20 minutes; Fennell et al., 2017; Shearer, Hunt, Chowdhury, & Nicol, 2016). Given this trend we would argue that an even briefer or shorter interval of MM activity may be sufficient to produce immediate CV benefits in the context of acute stress exposure. This evaluation would be important in terms of management of daily physiological stress as HR responses to acute stress occur very quickly. Therefore, an MM activity that is briefer but still effective may help prevent the immediate sympathetic withdrawal associated with acute stress exposure, in turn, reducing related daily BP responses and the accumulated stress on the body.

Of particular interest in stress reactivity is BP and HR. Of note, elevated BP levels in everyday life are better predictors of future CV disease than resting clinic BP levels (Fagard et al., 2009; Kristal-Boneh et al., 1995; Perloff, Sokolow, & Cowan, 1983; Verdecchia, 2000). Given these stress-related physiological changes in the body, there are several ways mental stress can be induced to measure physiological stress in the lab. One common validated method is the Trier Social Stress Test (TSST; Kirschbaum, Pirke, & Hellhammer, 1993). The TSST typically involves a waiting period upon arrival, anticipatory speech preparation, speech performance, and a verbal arithmetic performance. Studies have shown that both the speech and the mental arithmetic portion of this task are successful in increasing the participant's subjective measure of psychological stress as well as objective physiological measures, namely HR and BP (Brown, Szabo, & Seraganian, 1988; Goodman, Jansen, & Wolf, 2017; Hellhammer & Schubert, 2012).

Perseverative Cognitions as a Moderator of Brief Mindfulness Meditation Effectiveness

A big part of daily stress experience is worrying about and reflecting on events that can be overwhelming. Perseverative cognitions (PCs) are chronic tendencies to ruminate and worry about events that have happened in the past and/or are going to happen in the future (Brosschot et al., 2010; Ottaviani et al., 2015; Williams et al., 2017; Woody, Smolak, Rabideau, Figueroa, and Zoccola, 2015). Perseverative cognitions are related to elevated BP and increased HR (Brosschut & Thayer, 2006; Ottaviani et al., 2015; Verkuil, Brosschot, Tollenaar, Lane, & Thayer, 2016; Williams et al., 2017; Woody et al., 2015; Zawadzki et al., 2013). Although brief MM has shown positive effects for these outcomes, it is possible that some people are likely to benefit less from brief MM than others. For example, people with trait PC have more intrusive, negative thoughts about stressors in their lives (Brosschot et al., 2010; Woody et al., 2015; Zoccola et al., 2008), which can prevent them from focusing and reaping the benefits of stress relieving techniques (Merritt, Zawadzki, Di Paolo, Johnson, & Ayazi, 2017). With that in mind, it is likely that the tendency to engage in PCs will moderate the effectiveness of brief MM on CV reactivity.

Mood and Brief Mindfulness Meditation Effectiveness

Mood states vary considerably during the day (Murray, Allen, & Trinder, 2002; Stone, Smyth, Pickering, & Schwartz, 1996; Verkuil, et al., 2015), with momentary mood related to health complaints (Burton, Weller, & Sharpe, 2009; Watson, 1988). In addition to that, lower ambulatory HRV levels predict worse long-term CV health outcomes, partly as a function of maladaptive daily affect regulation (Jarczok, Koenig, Mauss, Fischer, & Thayer, 2014; Thayer, Yamamoto & Brosschot, 2010). Reduced HR levels are associated with better retrospective reports of daily moods and reduced pain sensitivity (Chelimsky, Simpson, McCabe, Zhang, & Chelimsky, 2016; Mazurak, et al., 2012; Terkelsen, et al., 2012),. For instance, Zawadzki, Smyth, & Costigan (2015) utilized electronic diaries and found that HRs were lower, and moods were more positive at times when participants engaged in leisure activities. Thus, with the link between HR, mood, and future CV disease, it would be prudent to evaluate changes in mood states pre- and post-stress induction.

The Present Study

The current study assessed the immediate CV health benefits of a 5-minute single-session of MM or PMR prior to a stressor and examined if trait PCs moderate the link between the relevant stress management technique and CV and affective reactivity. It was hypothesized that (1) the stress management groups (MM or PMR vs. no treatment control) condition would show less CV reactivity to the TSST stressors, as well as reduced perceived stress and improved mood states (reduced negative affect and/or increased positive affect), and (2) this benefit would be stronger for persons who score low (vs. high) on trait PCs.

Methods

Participants

Power analyses conducted with G*Power 3.1.9.2. (Faul, Erdfelder, Lang, & Buchner, 2007) testing for a within-between interaction for a repeated measures ANOVA, assuming alpha at .05, a medium effect size of .25, power at .8, with three groups and four measurements per group, and with outcome measures moderately correlated at .4, suggested a total sample size of 36. For the final lab portion of the study, the goal was to enroll a convenience sample of 40 students from a Midwest university to account for the power analysis as well as possible equipment malfunction, rare cases of bad data, and precedents for attrition rates. Recruitment strategies included ads on departmental research webpages, in-class notices, and flyers at various campus locations.

Inclusion criteria included English-speaking male and female students at the University of Wisconsin Milwaukee aged 18 to 35, enrolled in a psychology course. In order to generalize to the larger population and to account for the increased rate of female participants seen in previous research from this university, we attempted to oversample men by inviting more men to the lab in an effort to have equal numbers of male and female participants. Exclusionary criteria included peripheral deficits that preclude reliable assessments of finger arterial BP, resting BP readings that exceed hypertensive levels (i.e., systolic and diastolic BP levels over 140/90 mmHg), a prior diagnosis of hypertension or current use of anti-hypertensive medications, conditions related to bad HRV like arrythmias or heart ailments or lack of English-speaking status. Since hypertension is often comorbid with other chronic diseases, such as diabetes, and stroke, we excluded these conditions to fully assess how experimental treatment predicts CV responses to mental stress. Other potential extraneous variables such as caffeine, medication use, energy drinks, or large meals were abated by instructing participants to avoid consumption within two hours prior to the lab visit. The rationale for the age range is that hypertension rates begin to accelerate early in adulthood and the cutoff of 35 years allows us to discern younger adults from older risk groups and possibly develop more effective interventions for the former.

Participants received 1.5 extra course credit hours for their participation in the study, as well as a five-dollar gift card upon completion of the lab protocol. Specifically, upon IRB approved informed consent, 209 participants completed a 25-minute online survey via a link to the Qualtrics survey through the psychology department SONA system. This included demographics, health history, PC scales (see below), and meditation experience questions, and students received .5 extra credit hours for completing this step. A convenience sample of 83 eligible persons whom completed the surveys and had either higher or lower PC scores (based on extreme groups analysis) were invited to the lab, which was conducted in a psychophysiology laboratory in a campus building between 10:00 AM and 5:00 PM. With a response rate of 27%, 22 of the invited participants were scheduled for the lab visit via email, where they signed an additional informed consent and their BP and HR were continuously monitored while they performed social stress tasks (See Figure 1). They received .5 extra credit hours for coming to the lab and an additional 1 extra credit hour for completing the lab portion of the study, as well as a five-dollar gift card.

Lab participants were mostly female (72.7%) and Caucasian (59.1%; 18.2% African American/Black, 9.1% Hispanic, and 13.6% Asian), with an average age of 21. Their SES (via parents' highest educational attainment) had an acceptable range with 4.5% completed some high school, 27.3% high school diploma or GED, 27.3% some college, 27.3% Bachelor's degree, and 13.6% Master's degree. With the restricted BMI range for participation, the average BMI was 23.9. There was a range of activity levels (4.5% avoid walking/exertion , 22.7% walk/occasional exercise, 4.5% light exercise 10-60 minutes per week, 18.2% exercise over 60 minutes per week, 18.2% run less than 1 mile per week or exercise less than 30 min per week, 9.1% run up to 5 miles per week or exercise 30-60 minutes per week, 13.6% run 5-10 miles per week or exercise 1-3 hours per week, and 9.1% run over 10 miles per week or exercise 3+ hours per week.

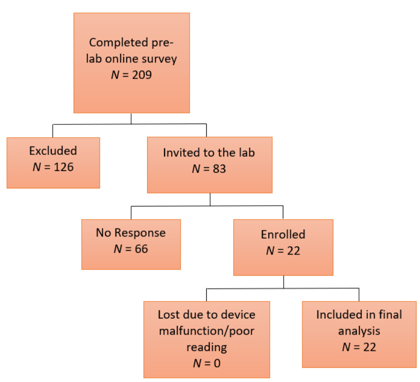


Figure 1. Recruitment flow chart

Materials

Sociodemographic measures and health history. With body mass index (BMI) being significantly related to HR and BP (Martins, Tareen, Pan, & Norris, 2003), we controlled for this in our screening protocol. BMI scores (based on in-lab weight in kilograms and height in centimeters) were computed by converting the reported height into meters, and then applied to the standard BMI equation of weight in kilograms divided by height in meters squared. Physical activity level was measured using the NASA activity scale (Appendix G). Participants were asked to indicate which option best describes their general activity level for the previous month on a scale of 0 (*avoid walking or exertion*) to 7 (*run over 10 miles per week, walk over 14 miles per week, or spend over 3 hours per week in comparable physical activity*). Participants were also asked to identify their gender (*male, female, other*), age, race/ethnicity (*Caucasian/White, African-American/Black, Spanish/Hispanic, American Indian/Alaskan, Native Hawaiian/Pacific Islander, Asian, Middle-Eastern, Other*), their mom and dad's highest level of educational attainments (*8th grade or less, some high school, high school diploma or GED, some college or associates/technical degree, bachelor's degree, master's degree, post-master's degree*), and if they have a prior or current diagnosis of hypertension, use anti-hypertensive medications, have arrythmias or heart ailments, or any other medical concerns they feel would interfere with participating in the study. (Appendix J).

Perseverative cognitions. Two scales, completed with the pre-lab Qualtrics screening survey, were used to measure PCs. First, trait rumination was assessed with the 41-item Response Style questionnaire (Nolen-Hoeksema & Morrow, 1999; Appendix A; Cronbach's α = .95) that measures brooding, reflective, and depressive coping responses to negative events (e.g., "think about a recent situation, wishing it had gone better"). Participants respond using a 4-point scale from 1 (*almost never*) to 4 (*almost always*). We summed the 22 rumination items from this scale to create a total score with higher scores indicating greater trait rumination. Second, trait worry was assessed with the 16-item Penn State Worry Scale (PSWS; Meyer et al., 1990; Appendix B; Cronbach's $\alpha = .91$) which measures lingering concerns with daily challenges (e.g. "When I am under pressure I worry a lot."). Participants responded using a 1 (*not at all typical*) to 5 (*very typical*) scale. Items were summed with higher values meaning more trait worry. Then, based on Merritt et al. (2017) we standardized each scale and average them together to make a total PCs index where higher scores specify higher PCs. We invited participants to the lab who were 1 standard deviation above or below the mean to represent high and low PCs, respectively, to avoid participants who fall in the "moderate" PC range. We matched high and low PCs levels across the 3 intervention groups as evenly as possible.

Survey of past meditation experience. As an exploratory aim, we assessed the potential influence of past meditation experience. The pre-lab Qualtrics screening survey included a brief assessment of past or current stress management technique usage (see Appendix C). Four 'yes/no' items asked, "Do you practice any meditation techniques?", "Do you practice any progressive muscle relaxation techniques?", "Do you practice deep or slowed breathing?", and "Do you practice any other relaxation techniques?". If they responded yes to one or more items, additional questions asked how many times per week they use the technique, the length of each session, and the purpose of the practice (*stress maintenance, regular health upkeep, or other)*. The goal of this survey was to create a quantifiable measure of past experience, and control for this in the analyses.

Momentary mood scale. To assess emotional reactions to the stress tasks, participants completed a 10-item positive and negative affect schedule (PANAS; Thompson, 2007), adapted for *momentary* mood assessment, at the start of baseline and after the TSST (Appendix D). The PANAS asks participants to rate the presence of each of 10 moods (i.e., Positive: determined, attentive, active, alert, inspired, and Negative: upset, hostile, ashamed, nervous, and afraid) on a 5-point scale extending from 0 (*not at all*) to 4 (*very much*). Cronbach's α = .63 for NA and .83 for PA at baseline.

Perceived Stress Scale (PSS). Given that acute stress exposure is the unit of analysis for the measurement of CVR in the present study, subjective stress during that exposure should be confirmed. Global and subjective stress impacts CV health, and researchers such as Kamarck, Shiffman, & Wethington, 2011, have adapted this global stress assessment into a more momentary assessment. Participants were asked to complete a 4-item shortened version of the Perceived Stress Scale (Cohen, Kamarck, & Mermelstein, 1983; Cohen & Williamson, 1988; Appendix E; Cronbach's α = .74 at baseline) during the same time intervals as the mood scales. Participants were asked to rate on a 5-point scale ranging from 0 (*never*) to 4 (*very often*) about their feelings and thoughts over the last month. For example, "how often did you feel you were unable to control important things in life?". Items will be summed, with a higher score indicating higher perceived stress.

Cardiovascular measures. A validated PORTApres beat-to-beat BP monitor was used to collect measures of systolic and diastolic BP and HR. PORTApres (TNO-TPD Biomedical Instrumentation, 1999) is an ambulatory monitor that uses the arterial clamp (Penaz Method) method to collect continuous BP waveforms that are analyzed offline using a Modelflow technique and BEATSCOPE 1.1 software (TNO-TPD Biomedical Instrumentation, 2002). This software uses the Wesseling Algorithm, which computes aortic flow waveform from an arterial pressure signal, based on age and gender parameters. To collect continuous BP for the stress protocol, the seated participant completed all mental tasks with a BP cuff (Portapres) placed on the middle or first phalanx of the non-dominant hand and a height correction transducer from the front-end unit of a PORTApres monitor attached to the upper arm of their non-dominant arm at heart level. Mean scores for systolic and diastolic BP were computed for each period of the study (e.g. baseline, intervention, TSST, and recovery). Recent research touts to the reliability and predictive validity of the Portapres in the context of controlled research settings (Eckert & Horstkotte, 2002). Potential outliers were assessed by reviewing the data for each period for each subject.

Survey on Participant Views of MM and PMR. To evaluate the efficacy of the MM and PMR interventions, participants took a short survey on their experience at the end of the study (Appendix H). They were asked about the following aspects of the task on a 5-point scale ranging from 1 (*not at all*) to 4 (*an extreme amount*): effort, relaxation, distraction, and absorption, as well as the difficulty of the activity on a scale ranging from 1 (*not at all difficult*) to 6 (*extremely difficult*).

Procedures

Reactivity protocol. (see Figure 2) A 45-minute lab visit was scheduled in a psychophysiology lab in the psychology department. First, the experimenter measured casual (seated) BP three times with an Omron BP monitor to assess study eligibility (the first measure was thrown out, and participants were excluded if the average of the latter two resting BP measures exceeded hypertensive levels—systolic and diastolic BP levels over 140/90 mmHg).

Next, each participant sat in a chair and were hooked up to the PORTApres device consisting of a BP cuff around one finger connected to a monitoring box attached at their wrist and a strap around their upper arm accounting for movements in the readings. Following connection, participants sat for a 10-minute baseline period to get oriented to the recording devices and to provide resting (Portapres) BP and HR recordings. Then, participants completed their first PANAS and PSS. Following these surveys participants were randomly assigned to one of three conditions using a random number table: brief mindfulness meditation, brief progressive muscle relaxation, or a time-matched, attention-only control group.

For the MM condition, they were asked to do the following (based on Kabat-Zinn, 1994) for 5 minutes: (1) Close eyes and try to set aside all thoughts of the past and the future and stay in the present. (2) Become aware of own breathing, focusing on the feeling of air moving in and out of the body as one breathes. Feel belly rise and fall, the air enter nostrils and leave mouth. Pay attention to the way each breath changes and is different. (3) Watch every thought come and go, whether it be a worry, fear, anxiety or hope. When thoughts come up in the mind, don't ignore or suppress them but simply note them, remain calm and use breathing as an anchor. (4) If one finds her (him) self getting carried away in her (his) thoughts, observe where her (his) mind went off to, without judging, and simply return to her (his) breathing. Remember not to be hard on her (him) self if this happens. (5) As the time comes to a close, sit for a minute or two, becoming aware of where one is.

For the progressive muscle relaxation condition, participants were asked to do the following (based on muscle sequences from Bernstein and Borkovec, 1973, with times adapted for a 5 minute session): (1) focus your attention on the instructed muscle group. (2) At the signal from the researcher, tense the muscle group described (see Appendix F for sequence). Feel the tension, but not so much that you feel a lot of pain. (3) Keep the muscle tensed (while the researcher counts five seconds in their head). (4) (After the five seconds, the researchers instructed the participants to) slowly release the muscles while attending to the feeling of the muscle relaxing (approx. 10 seconds).

Following Cruess et al. (2016), for the control condition, a researcherread aloud from *Journey Under the Sea*, which is part of the *Choose Your Own Adventure* series (Montgomery, 1997). This material was selected due to it being interactive, and participants having to make decisions throughout the story in an effort to keep them engaged without utilizing any stress-reduction techniques. We analyzed pilot data to verify the neutrality of this task.

Next, participants completed the stress induction task utilizing methods from the TSST (Kirschbaum et al., 1993). They were instructed to serially subtract 13 from 1022. Whenever the participant subtracted incorrectly, the researcher instructed them to stop and begin again from 1022. During this 5-minute protocol, the researcher told the participant to go faster at minutes 1 and 3.

Following the TSST, participants completed their second PANAS and PSS and then sat quietly for 10-minutes to allow their BP and HR to come down after the stress task. After the 10-minute recovery, participants completed a short survey about the exercises, including the potential for adherence, engagement, absorption, and rejuvenation (see Appendix H).

Finally, the experimenter stopped and unhooked the Portapres device and debriefed the participant. Participants received 1.5 extra credit hour and a $5 gift card for completion of the study, including the pre-lab online survey.

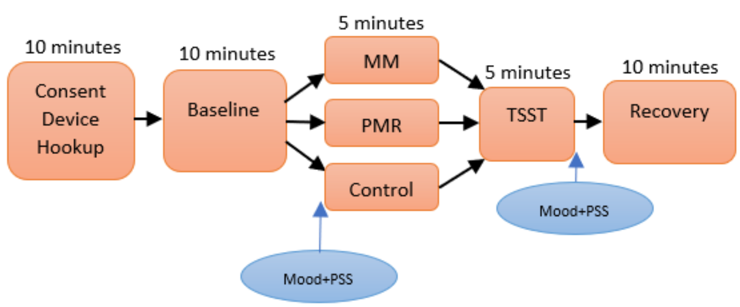


Figure 2. Procedure

Results

Table 1 provides the one-way ANOVA descriptive data on relevant sociodemographic and health variables and trait PCs overall and by condition. Post hoc tests showed that the MM, PMR and control conditions did not differ on any of these variables ($p(F)$'s > .290). Table 2 provides the one-way ANOVA results for the manipulation check (i.e. questionnaire about intervention including levels of difficulty, effort, relaxing, distracting, and absorbed) overall and by condition. Post hoc tests showed that the MM, PMR, and control conditions did not differ on any of these variables (*p*s > .089). In general, participants found the MM, PMR, and control tasks to be not very difficult, moderately effortful, moderately relaxing, not very distracting, and they felt moderately absorbed by them. Table 3 provides bivariate Pearson correlations on relevant sociodemographic and health variables and trait PCs (i.e. age, parent education, BMI, NASA, and PCs). BMI and parent education, as well as BMI and NASA, were positively correlated.

Aim 1: Do MM or PMR improve CV reactivity?

First, we hypothesized that the MM and PMR groups would show lower CV reactivity as shown by lower BP and HR during the TSST. Statistical analyses included repeated measures analysis of variance generated with SPSS-PC software to examine the interactive relationships of intervention group (3: MM, PMR, or control) and period (4: mean CV score for baseline, intervention, TSST, and recovery as a within-group dependent measure). An alpha level of .05 was adopted for all statistical tests, and the epsilon values (Ɛ) are presented as an index of statistical power for significant Greenhouse-Geisser repeated measures effects. Independent sample *t* tests were run to find the location of significant omnibus tests for intervention group on the basis of a priori hypotheses. Every omnibus test was corrected for violations of sphericity and epsilon values are shown for the statistical power for each repeated-measures ANOVA test (Vasey & Thayer, 1987). The repeated measures tactic has the advantage of optimally describing the trends in CV responses across all tasks by intervention type. Means and standard deviations for between- and within group omnibus tests for intervention type are shown in Table 4.

One participant was removed from SBP analysis as an outlier due to resting SBP being more than 2 standard deviations below the mean. Another participant was removed from our HR analysis as an outlier due to resting HR being more than 2 standard deviations above the mean. There were significant time effects for systolic BP (Figure 3; F (3, 54) = 34.05, $p < .0001$), diastolic BP (F (3, 57) = 44.19, $p < .0001$), and HR (F (1.47, 26.45) = 25.11, $p < .0001$). Bonferroni corrected post hoc tests showed that SBP significantly increased during the intervention ($p = .001$) and TSST ($p < .0001$). Further, SBP significantly decreased during the recovery period ($p = .024$). There was no main effect of group for SBP ($F(2, 18) = .415$, $p = .666$), DBP (Figure 4; $F(2, 19) = 1.2$, $p = .323$), or HR (Figure 5; $F(2, 18) = 1.32$, $p = .291$). The time by group effects were non-significant for SBP ($F(6, 54) = 1.03$, $p = .419$), DBP ($F(6, 57) = 0.736$, $p = .623$), and HR ($F(2.94, 26.45) = .914$, $p = .446$, $\mathcal{E} = .49$). Neither the time ($F(1, 19) = 1.29$, $p = .270$, $\mathcal{E} = 1$), group ($F(2, 19) = 1.59$, $p = .230$), nor time by group ($F(2, 19) = 0.308$, $p = .739$, $\mathcal{E} = 1$) were significant for perceived stress (Figure 6). Neither the time ($F(1, 19) = 2.78$, $p = .112$, $\mathcal{E} = 1$; $F(1, 19) = 0.023$, $p = .882$, $\mathcal{E} = 1$), group ($F(2, 19) = 1.123$, $p = .346$; $F(2, 19) = 0.142$, $p = .869$, $\mathcal{E} = 1$), nor time by group ($F(2, 19) = 1.89$, $p = .179$, $\mathcal{E} = 1$; $F(2, 19) = 1.209$, $p = .321$, $\mathcal{E} = 1$) were significant for negative affect (Figure 7) or positive affect (Figure 8), respectively.

Aim 2: Does trait PC moderate the relationship between MM or PMR and CV reactivity?

Second, we hypothesized that low trait PCs will strengthen the relationship we predicted in aim 1. Specifically, those in the MM and PMR interventions with lower trait PCs would show even lower CV reactivity as shown by lower BP and HR during the TSST, relative to those in the MM and PMR interventions with high trait PCs, and relative to control. Statistical analyses included repeated measures analysis of variance examining the interactive relationships of intervention group (3: MM, PMR, or control), PCs (2: high or low), and period (4: mean CV score for baseline, intervention, TSST, and recovery as a within-group dependent measure).

Means and standard deviations for between- and within group omnibus tests are shown for condition and PCs effects in Table 5. Neither the PC, time by PC, nor the time by intervention by PC effect was significant for systolic BP (Figure 9; Fs < 1.52, ps > .192), diastolic BP (Figure 10; Fs < 1.65, ps > .169), HR (Figure 11; Fs < 2.46, ps > .089, $\mathcal{E}$ = .499), PSS (Figure 12; Fs < 2.58, ps > .129, $\mathcal{E}$ = 1), NA (Figure 13; Fs < 1.97, ps > .179, $\mathcal{E}$ = 1), or PA (Figure 14; Fs < 1.02, ps > .328, $\mathcal{E}$ = 1).

Discussion

The present study had 2 main aims: (1) to assess the immediate BP and HR health benefits, perceived stress, and mood of a 5-minute single-session of MM or PMR prior to a lab stressor compared to an active control condition, and (2) to examine if trait PCs moderate the link between MM or PMR and CV and affective reactivity. First, we hypothesized that the MM and PMR conditions would show less BP and HR reactivity to the stressor than the control condition. Unexpectedly, our initial analyses do not support this hypothesis. This result goes against recent work where a 20-minute MM training, mainly focused after the stressful event, produce beneficial BP effects (Fennell et al., 2016), as well as the work showing reduced cortisol for participants that performed a mindfulness-based stress reduction technique prior to a stress task (Cruess et al., 2015). The present study, utilizing continuous BP measures, supports and extends work from Grant et al. (2013) which showed no BP reactivity or recovery improvements among participants who completed a brief mindfulness meditation session.

Further, our results indicate no changes in perceived stress, negative affect, or positive affect from pre-intervention to post-stressor. While Zawadzki and colleagues (2015) found a relationship between improved mood and participation in a leisure activity in their field-based longitudinal design, our results reveal that this relationship does not extend to a single MM or PMR session in a lab setting. However, our results do not support a 5-minute single session of PMR and MM as an effective stress buffer in this situation, and thus, mood and perceived stress would not be improved either. Future research that develops an effective short single-session of MM or PMR may in fact find significant changes in mood and perceived stress. Additionally, a limitation of the current study is that mood and perceived stress were measured at only 2 time points, which may not have been enough to properly elucidate the changes in mood and perceived stress during the stress task. Future work may consider adding more time points for evaluating these measures, specifically just prior to, and/or during the stress task.

Second, we hypothesized that reduced BP and HR reactivity and improved perceived stress and mood in the MM and PMR conditions would be stronger for persons who score low (vs. high) on trait PCs. Overall, we did not find any significant moderator effects for trait PCs. PCs is a complex and young concept with studies assessing it in several different ways (Merritt et al., 2017; Williams et al., 2017; Zawadzki et al, 2018). As measurement for this trait is increasingly being developed and refined, future studies may utilize alternative surveys to tap into this measure, such as the Thought Control Questionnaire, Thought Occurrence Questionnaire, and the White Bear suppression inventory (Zawadzki et al., 2018). Alternatively, this could be a benefit of brief MM; in other words, PC tendencies linked with negative long-term health outcomes may inhibit benefits from traditional forms of stress management, but they may not be problematic in acute interventions for anticipatory stressors such as these. Future work will have to evaluate these possibilities.

Since there are minimal lab studies using MM in this way (i.e., as a precursor to stress reactivity), we cannot fully assess related precedents. What we know from past studies is that MM after the stressor boosts CV recovery to that stressor (Fennell et al, 2017; Shearer et al., 2016). Yet this process may not be optimal if one experiences acute stressors often with little breaks for recovery to those stressors. Plus, in the real world, MM exercises likely have no true baseline (i.e., prep) periods. Thus, by adding a pre-MM baseline period we may actually lose some situational generalizability.

Nevertheless, future work should aim to continue to evaluate brief single-sessions of MM, including varying the amounts of MM in an effort to find the lowest successful dose, varying when the MM engagement occurs relative to the stressor (i.e. does it matter whether the stressor is immediately after MM, or if there is time between the MM and the stressor), varying the type of stressor to see if it differentially affects different types of stress (e.g. anger vs academic stress; e.g. we currently have a paper under review showing 5-minutes of MM is successful in reducing systolic BP during an anger recall task), and evaluating the mechanisms that might make brief MM successful (e.g. distraction). Additionally, given the lack of success with the present intervention, it would be prudent for future work to have a manipulation check of the intervention (i.e. evaluate subjective mindfulness measures among the MM group) in order to evaluate if the intervention itself needs to be adjusted, or the design of the study requires adjustment.

Further, we acknowledge the limitation of the sampling method and not properly assessing past MM experience. Specifically, we hoped to oversample for men, but that was simply impossible based on the survey response rate of men and women and trying to get enough participants in general into the study. Future work may need to utilize alternative recruitment strategies to rectify this gender discrepancy. Additionally, the use of a random numbers table made it difficult to have equal numbers of high and low PCs in each group. Thus, a stratified sampling method may be more optimal for this study design. Assessment of MM and PMR experience is a common limitation in related research, and we attempted to correct for that in this study. However, the assessment we created was not effective in generating a quantifiable evaluation of experience (i.e. participants imputed qualitative responses, rather than the requested times per week and session), and we plan to explore alternate methods of assessing such measures as meditation practices are becoming more prominent in daily life through technology that include meditation applications (Heppner & Shirk, 2018).

While our results did not support a 5-minute MM or PMR session as an effective tool in blunting CV and affective responses of participants in this study, information gathered here is helpful in developing the next steps for evaluating the lowest successful dose of MM or PMR as a proactive tool for anticipatory stress. By correcting several limitations, and utilizing the future ideas generated by this study, future work can move forward with several studies to further evaluate the acute functions of brief MM or PMR practices in the lab and subsequently in the field and how to develop proper intervention methods going forward.

Table 1

Descriptive statistics for sociodemographic measures and trait perseverative cognitions for overall sample and by condition

Variable	Overall	Mindful Meditation	Progressive Muscle Relaxation	Active Control
	M (SD)	*M (SD)*	*M (SD)*	*M (SD)*
Age	21.86 (4.4)	21.9 (5.87)	24 (4.90)	20.44 (1.88)
Highest Parent Education[1]	4.18 (1.14)	3.7 (1.11)	4.5 (1.05)	4.33 (1.22)
General Physical Activity[2]	3.5 (2.13)	3.9 (2.48)	4 (2)	2.89 (2.03)
Body Mass Index	23.9 (2.85)	24.2 (3.31)	24.74 (2.46)	23.15 (2.84)
Perseverative Cognitions	.67 (1.95)	-.50 (1.96)	.77 (2.12)	.74 (2.06)

Note. $n = 22$, no significant differences across groups at alpha *.05, F*s < 1.22, *p*s > .290. Highest parent educational attainment was operationalized as follows: (1 = "8th grade or less," 2 = "some high school," 3 = "High school graduate (Diploma/GED)," 4 = "some college or Associate/technical degree," 5 = "Bachelor's degree (BS, BA, etc.)," 6 = "Master's degree (MA, MS, etc.)," and 7 = "Post-master's degree". General physical activity was measured on an 8-point scale for the past month with a rating of 0–1 indicating very low physical activity (i.e., avoid walking or exertion or walk for pleasure), 2–3 representing moderate physical activity (i.e., 10–60 minutes or greater than 1 hour of comparable physical activity), and 4–7 indicating a high physical activity level (i.e., run 1–5 miles, or 5–10 miles, or greater than 10 miles per week, or comparable physical activity).

Table 2

Descriptive statistics for intervention measures for overall sample and by condition

Variable	Overall *M (SD)*	MM *M (SD)*	PMR *M (SD)*	Active Control *M (SD)*
Difficulty	1.45 (0.67)	1.43 (0.79)	1.67 (0.82)	1.33 (0.5)
Effort	3.27 (0.83)	3.14 (0.9)	3.67 (1.03)	3.11 (0.6)
Relaxing	3.09 (0.81)	3.43 (1.13)	3 (0.63)	2.89 (0.6)
Distracting	1.95 (1.05)	2.14 (1.21)	1.17 (0.41)	2.33 (1)
Absorbed	3.05 (0.84)	3 (0.82)	3.17 (1.17)	3 (0.71)

Note. $n = 22$, no significant differences across groups at alpha *.05,* Fs < 2.83, ps $> .083$. These measures were operationalized as follows: (1 = not at all, 2 = very little, 3 = a moderate amount, 4 = a great deal, 5 = an extreme amount). Participants found the activities to be not very difficult, to require moderate effort, moderately relaxing, not very distracting, but overall moderately absorbed in them.

Table 3

Pearson correlations for sociodemographic measures and trait perseverative cognitions

	age	parent education	BMI	NASA	PC
age	-				
parent education	-.138	-			
BMI	.121	.458*	-		
NASA	.013	.157	.484*	-	
PC	-.249	.124	.130	-.019	-

Note. * indicates significance at alpha .05. BMI = body mass index, PC = perseverative cognitions.

Table 4

Means (+/- SD) for condition effects on within group cardiovascular and perceived stress levels

	Baseline	Intervention	TSST	Recovery
MM				
SBP	118.43 (9.62)	121.21 (14.31)	130.87 (18.28)	127.52 (15.93)
DBP	68.63 (9.26)	71.94 (8.86)	78.51 (10.9)	75.6 (10.3)
HR	77.23 (11.07)	76.12 (10.07)	84.11 (13.4)	77.82 (8.39)
PSS	9 (1.15)			9.29 (1.38)
NA	8.57 (3.21)			10.29 (4.82)
PA	14.14 (4.1)			14.71 (3.35)
PMR				
SBP	121.21 (16.44)	129.92 (20.97)	143.3 (14.95)	132.44 (18.02)
DBP	72.72 (9.25)	77.8 (12.4)	87.62 (9.09)	80.53 (11.13)
HR	74.5 (6.37)	75.66 (6.62)	85.34 (12.31)	73.19 (7.67)
PSS	8.17 (4.17)			8.17 (4.17)
NA	7.17 (3.06)			7.17 (3.06)
PA	15 (5.73)			15 (5.73)
Active control				
SBP	119.73 (11.04)	128.3 (12.52)	136.51 (11.18)	130.16 (10.17)
DBP	74.52 (8.07)	79.13 (8.66)	86.28 (8.43)	80.63 (7.58)
HR	83.9 (10.12)	84.05 (11.52)	91.37 (14.22)	80.8 (9.17)
PSS	10.33 (1.8)			10.67 (2)
NA	7.78 (1.56)			8 (1.5)
PA	14 (4.39)			13.56 (3.61)

Note. MM = mindfulness meditation, PMR = progressive muscle relaxation, SBP = systolic blood pressure, DBP = diastolic blood pressure, HR = heart rate, PSS = perceived stress scale, NA = negative affect, PA = positive affect.

Table 5

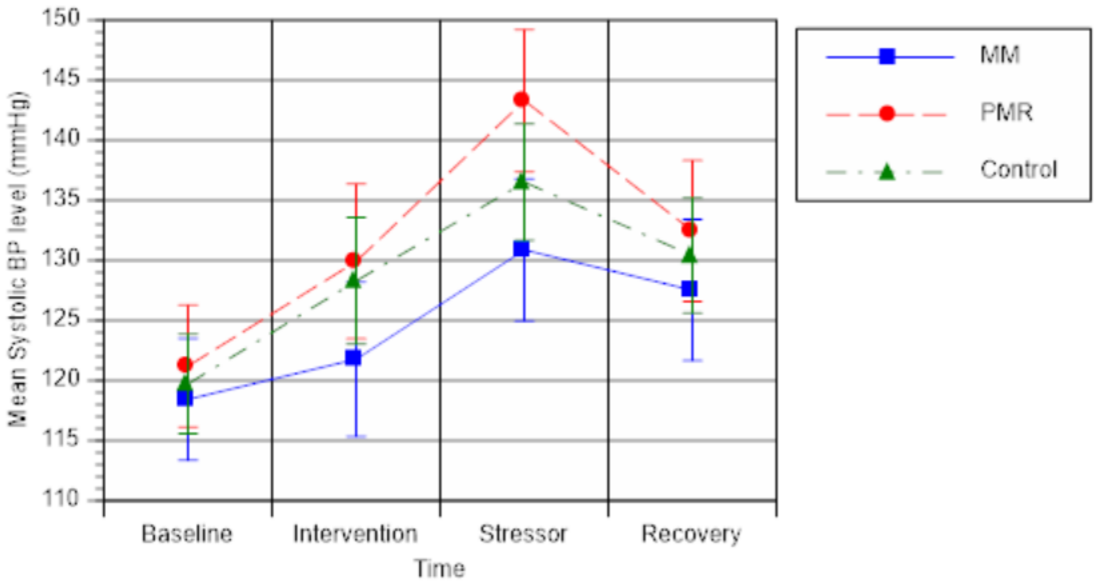
Means (+/- SD) for condition by perseverative cognition effects on within group cardiovascular and perceived stress levels

	Baseline	Intervention	TSST	Recovery
MM x low PC				
SBP	118.55 (12.32)	120.93 (12.29)	129.81 (22.39)	128.54 (15.44)
DBP	69.16 (10.5)	71.05 (11.42)	76.34 (16.22)	76.70 (12.13)
HR	69.34 (7.59)	68.94 (7.86)	73.84 (9.32)	71.87 (8.03)
PSS	9 (1)			9 (1)
NA	8 (1.73)			8 (1.73)
PA	15 (4.36)			15 (4.36)
MM x high PC				
SBP	118.3 (8.92)	122.63 (18.94)	131.93 (18.19)	126.49 (19.82)
DBP	68.23 (9.86)	72.6 (8.29)	80.13 (7.34)	74.77 (10.59)
HR	85.11 (7.89)	83.29 (6.08)	94.37 (6.77)	83.76 (2.31)
PSS	9 (1.41)			9.5 (1.73)
NA	9 (4.24)			12 (5.94)
PA	13.5 (4.43)			14.5 (3.11)
PMR x low PC				
SBP	107.41 (0.93)	114.91 (6.38)	138.75 (3.49)	117.61 (10.39)
DBP	65.82 (9.79)	69.87 (12.62)	85.19 (9.94)	72.5 (13.78)
HR	75.3 (4.02)	76.45 (4.96)	93.12 (21.51)	73.71 (5.44)
PSS	5.5 (2.12)			5.5 (2.12)
NA	5.5 (0.71)			5.5 (0.71)
PA	10.5 (4.95)			10.5 (4.95)
PMR x high PC				
SBP	128.12 (16.12)	137.43 (22.22)	145.58 (18.65)	139.86 (16.88)
DBP	76.17 (7.93)	81.77 (11.84)	88.83 (9.94)	84.55 (8.86)
HR	74.1 (7.85)	75.26 (8.02)	81.45 (6.16)	72.93 (9.37)
PSS	9.5 (4.51)			9.5 (4.51)
NA	8 (3.56)			8 (3.56)
PA	17.25 (5.12)			17.25 (5.12)
Control x low PC				
SBP	126.26 (13.04)	137.6 (17)	142.15 (15.99)	139.57 (7.65)
DBP	80.02 (7.05)	84.90 (7.94)	89.11 (8.52)	87.2 (2.78)
HR	77.71 (12.39)	77.98 (14.35)	83.63 (13.30)	78.27 (11.65)
PSS	9 (2)			8.67 (2.08)
NA	8.33 (1.15)			8.67 (1.53)

PA	16.67 (6.43)			15.67 (4.73)
Control x high PC				
SBP	116.47 (9.42)	123.65 (7.57)	133.7 (8.31)	125.81 (8.15)
DBP	71.77 (7.56)	76.25 (8.05)	84.87 (8.81)	77.35 (7.08)
HR	87 (8.25)	87.09 (9.85)	95.23 (14.11)	82.07 (8.63)
PSS	11 (1.41)			11.67 (1.03)
NA	7.5 (1.76)			7.67 (1.51)
PA	12.67 (2.8)			12.5 (2.81)

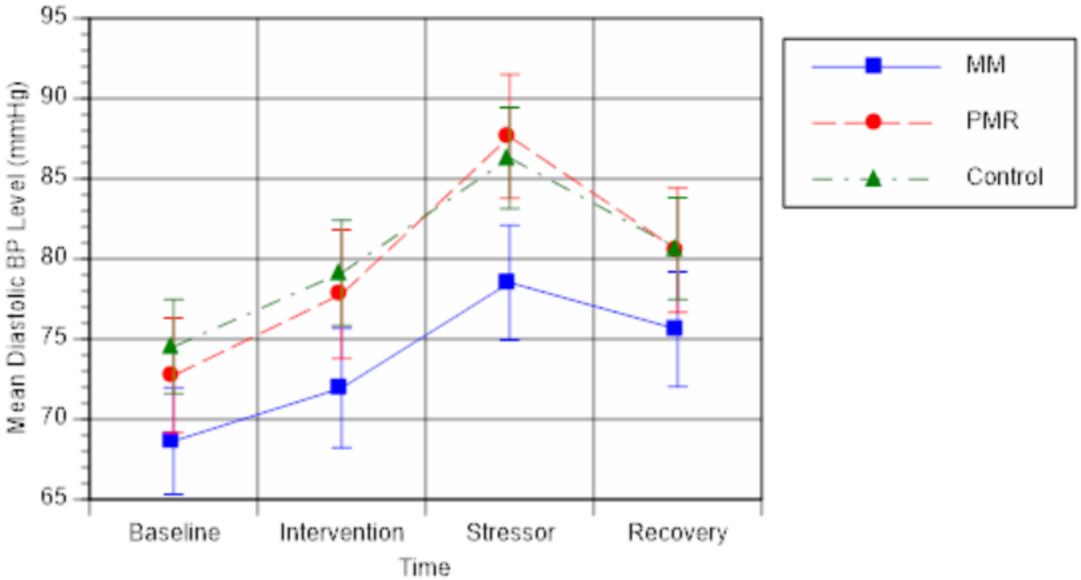
Note. MM = mindfulness meditation, SBP = systolic blood pressure, DBP = diastolic blood pressure, HR = heart rate, PC = perseverative cognitions, PSS = perceived stress scale, NA = negative affect, PA = positive affect.

Figure 3. Aim 1 Systolic Blood Pressure



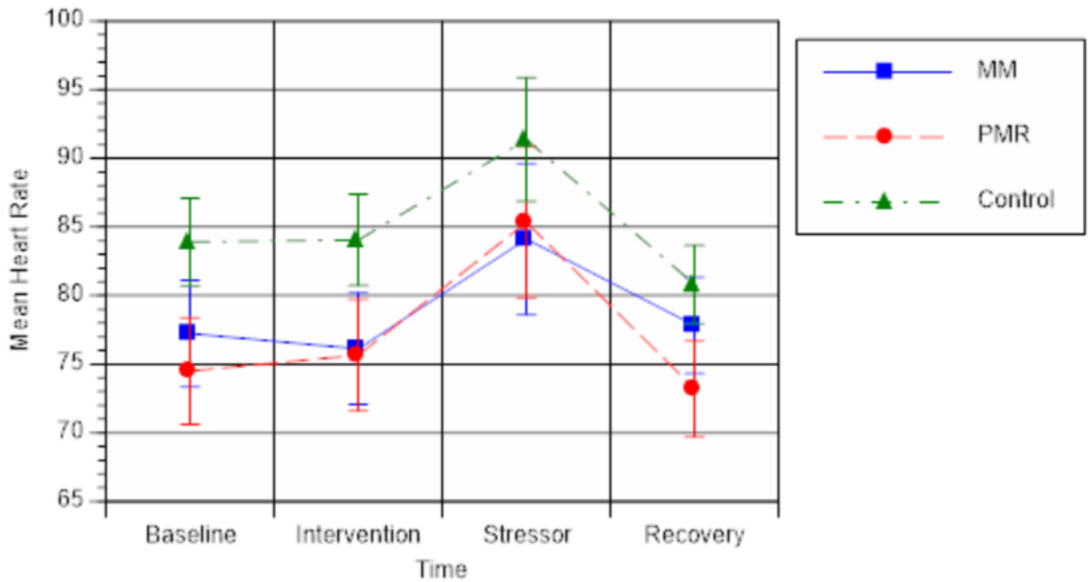
Note. Time by group effects on mean systolic blood pressure (BP) levels. The error bars are based on pooled standard errors for paired t-tests.

Figure 4. Aim 1 Diastolic Blood Pressure



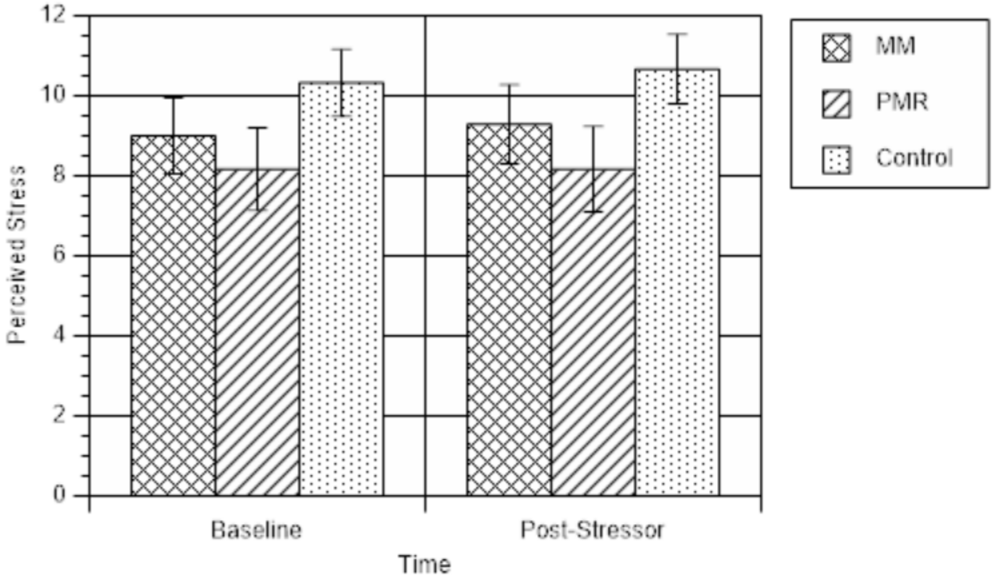
Note. Time by group effects on mean diastolic blood pressure (BP) levels. The error bars are based on pooled standard errors for paired t-tests.

Figure 5. Aim 1 Heart Rate



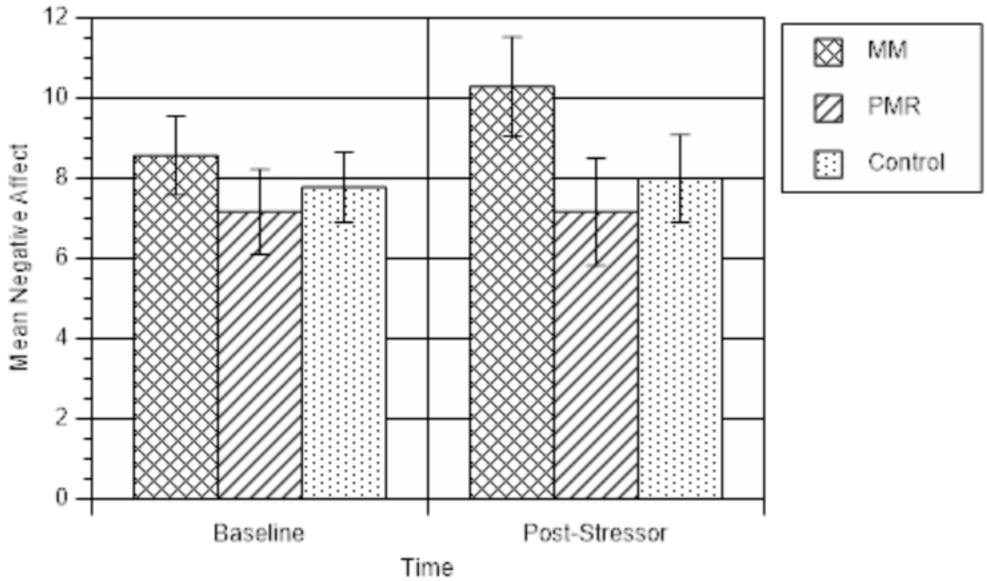
Note. Time by group effects on mean heart rate (HR) levels. The error bars are based on pooled standard errors for paired t-tests.

Figure 6. Aim 1 Perceived Stress



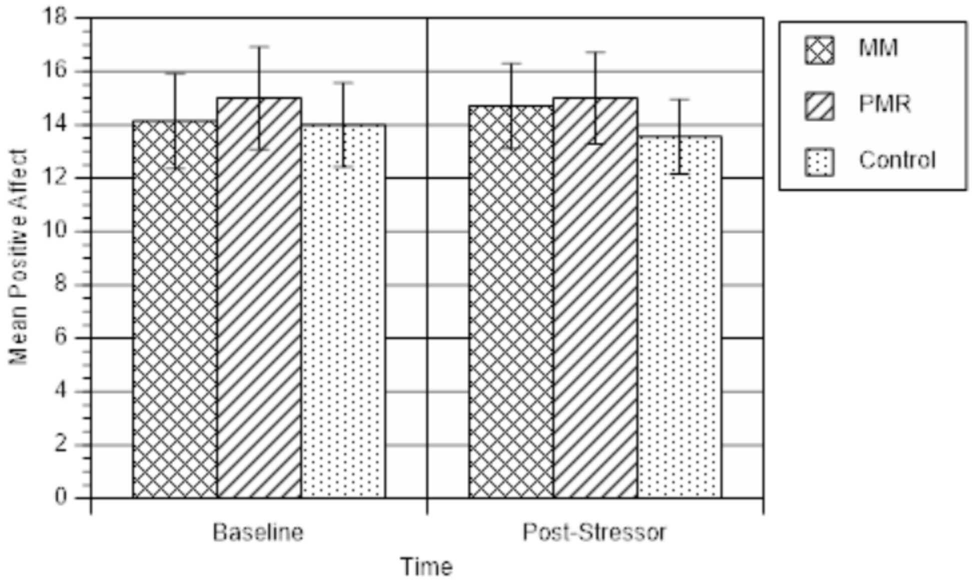
Note. Time by group effects on mean perceived stress scores. The error bars are based on pooled standard errors for paired t-tests.

Figure 7. Aim 1 Negative Affect



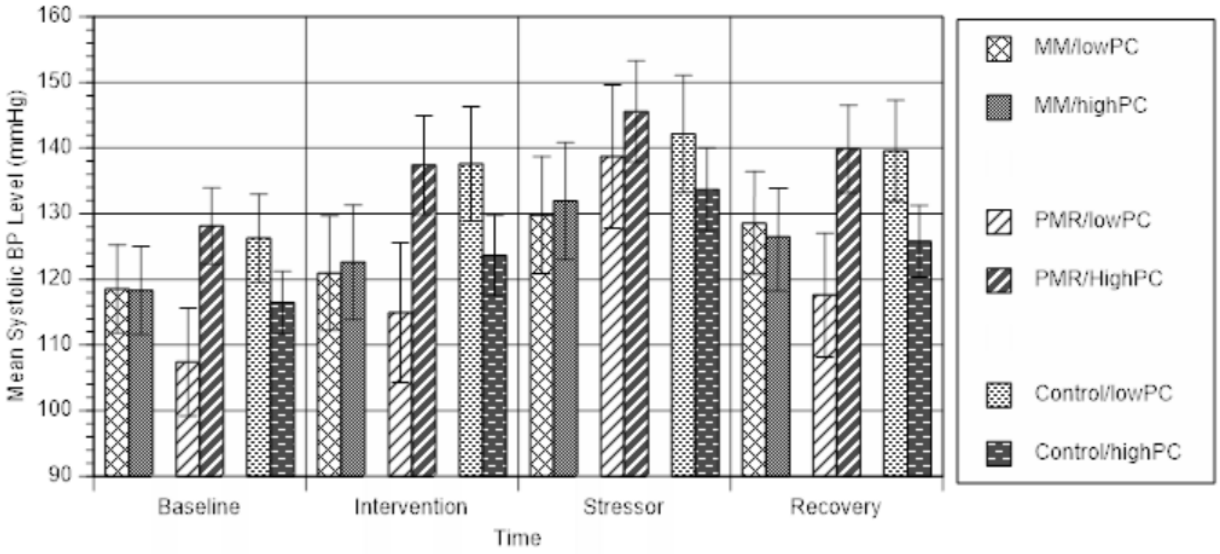
Note. Time by group effects on mean negative affect scores. The error bars are based on pooled standard errors for paired t-tests.

Figure 8. Aim 1 Positive Affect



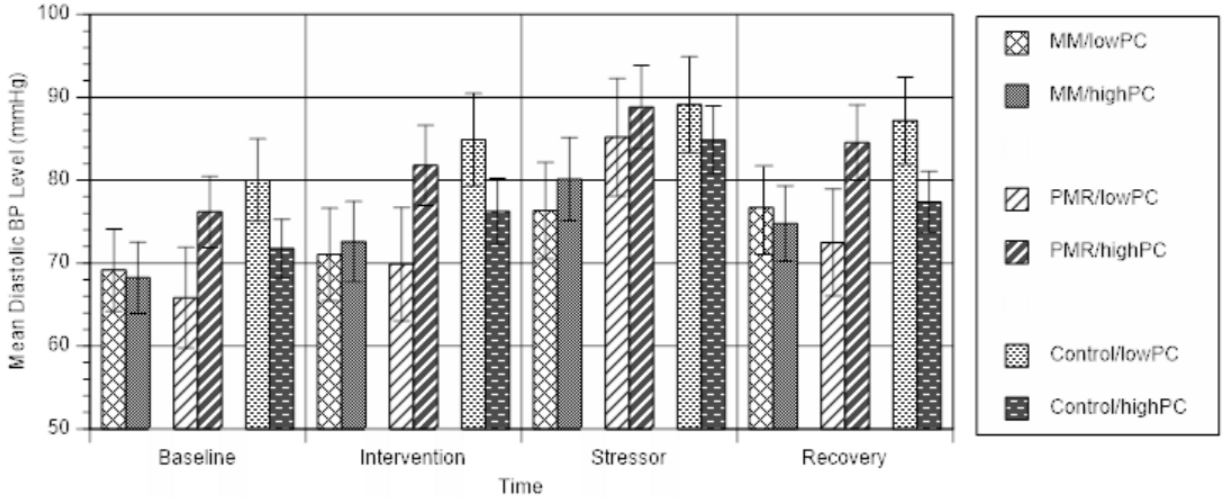
Note. Time by group effects on mean positive affect scores. The error bars are based on pooled standard errors for paired t-tests.

Figure 9.



Note. Time by group by perseverative cognitions effects on mean systolic blood pressure (BP) levels. The error bars are based on pooled standard errors for paired t-tests.

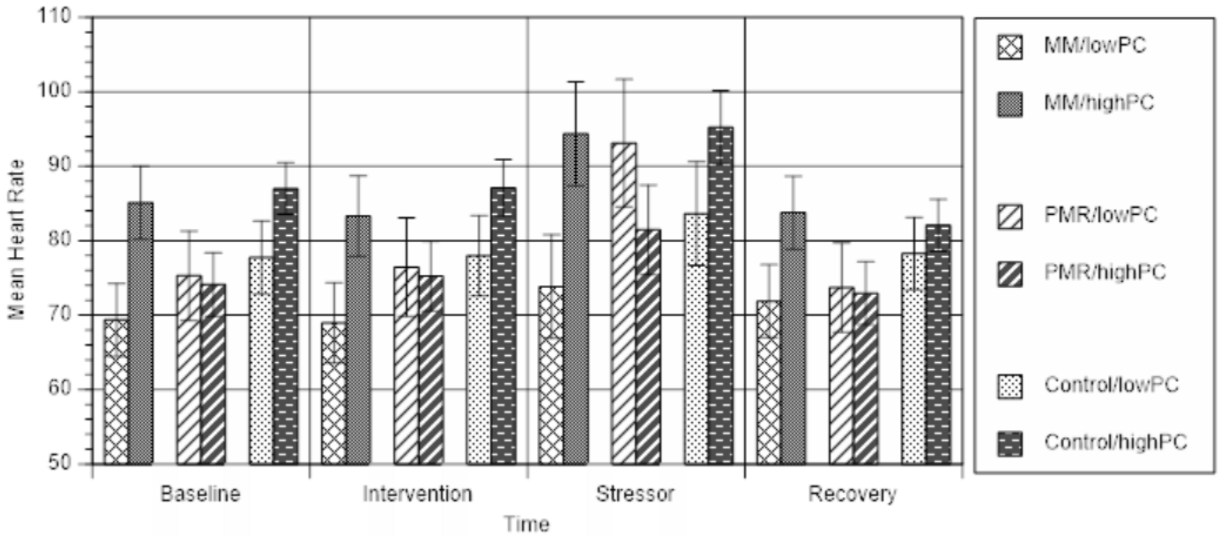
Figure 10.



Note. Time by group by perseverative cognitions effects on mean diastolic blood pressure (BP) levels.

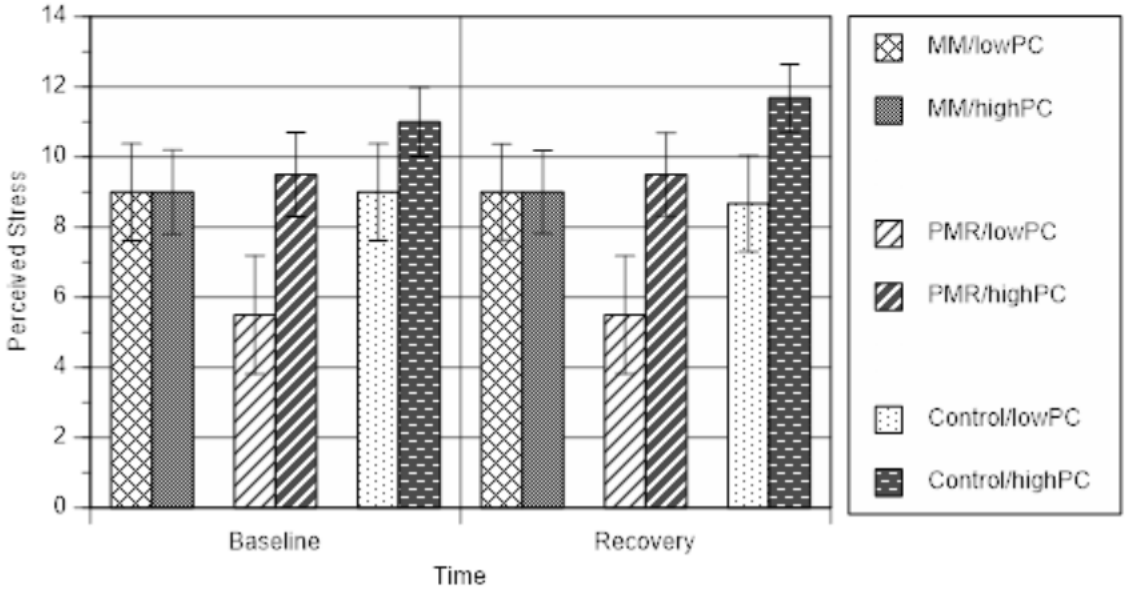
The error bars are based on pooled standard errors for paired t-tests.

Figure 11.



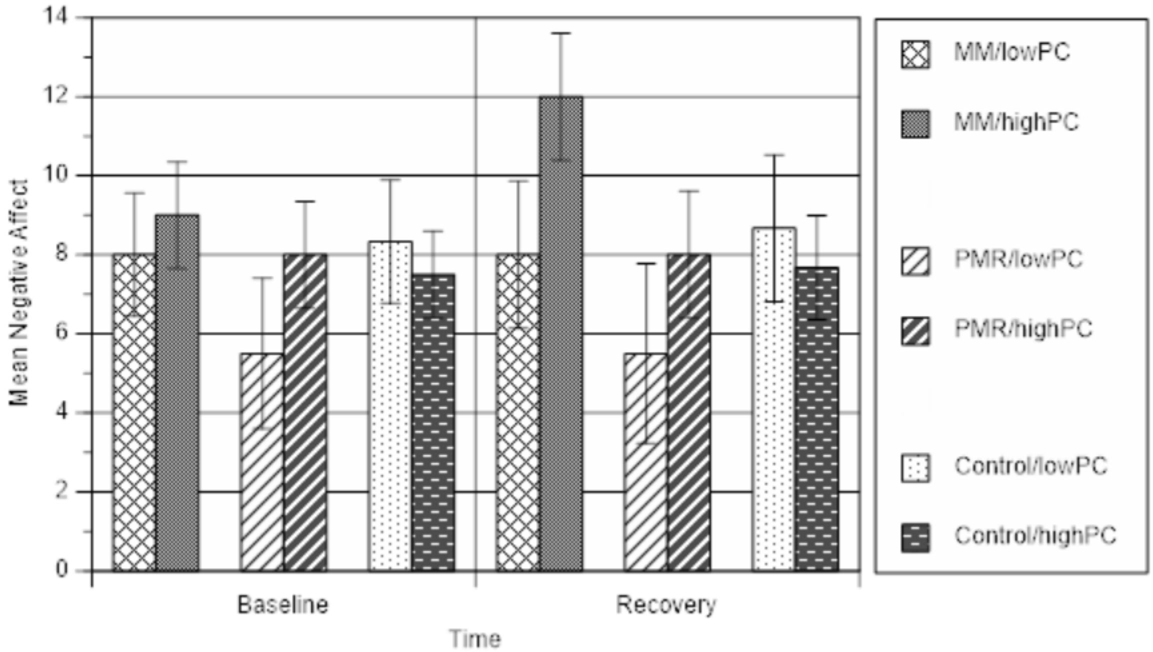
Note. Time by group by perseverative cognitions effects on mean heart rate (HR) levels. The error bars are based on pooled standard errors for paired t-tests.

Figure 12.



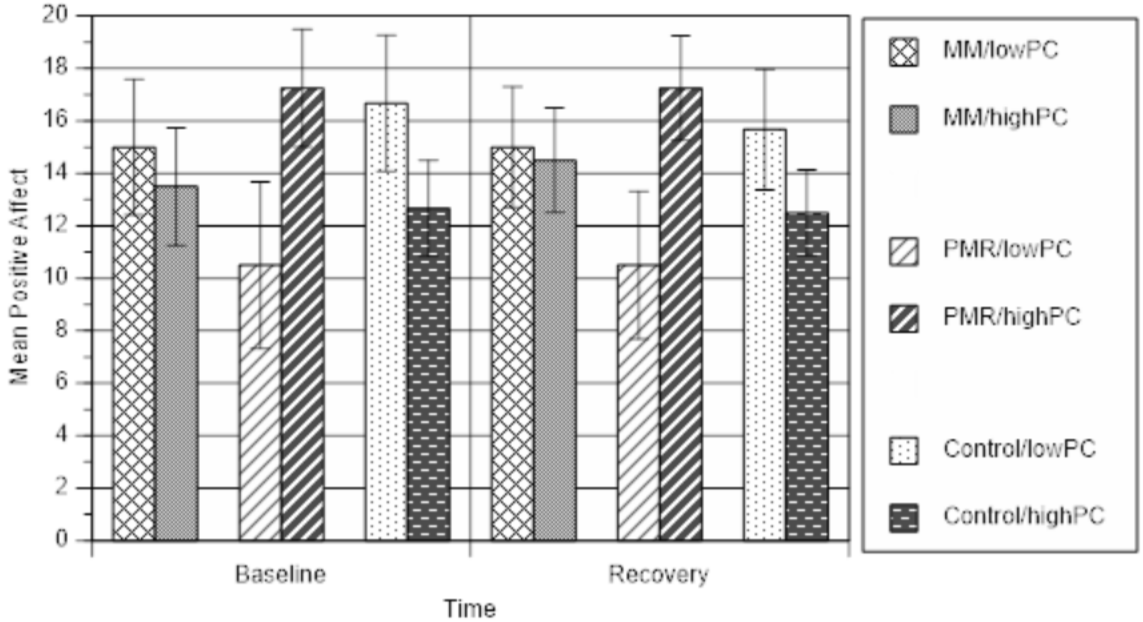
Note. Time by group by perseverative cognitions effects on mean perceived stress scores. The error bars are based on pooled standard errors for paired t-tests.

Figure 13.



Note. Time by group by perseverative cognitions effects on mean negative affect levels. The error bars are based on pooled standard errors for paired t-tests.

Figure 14.



Note. Time by group by perseverative cognitions effects on mean positive affect levels. The error bars are based on pooled standard errors for paired t-tests.

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Appendix A: Response Style Questionnaire (RSQ)

People think and do many different things when they feel depressed. Please read each of the items below and indicate whether you never, sometimes, often or always think or do each one when you feel down, sad, or depressed. Please indicate what you generally do, no what you think you should do.

1. Ask someone to help you overcome a problem.
2. Think about how alone you feel.
3. Think, "I won't be able to do my job/work because I feel so badly."
4. Think about your feelings of fatigue and achiness.
5. Think about how hard it is to concentrate.
6. Try to find something positive in the situation or something you learned.
7. Take recreational drugs or drink alcohol.
8. Think, "I'm going to do something to make myself better."
9. Help someone else with something in order to distract yourself.
10. Think about how passive and unmotivated you feel.
11. Remind yourself that these feeling won't last.
12. Analyze recent events to try to understand why you are depressed.
13. Think about how you don't seem to feel anything any more.
14. Think, "Why can't I get going?"
15. Think, "Why do I always react this way?"
16. Go to a favorite place to get you mind off your feelings.
17. Go away by yourself and think about why you feel this way.
18. Talk it out with someone whose opinions you respect (like a friend, family, or clergy).
19. Think, "I'll concentrate on something other than how I feel."
20. Write down what you are thinking about and analyze it.
21. Do something that has made you feel better in the past.
22. Think about a recent situation, wishing it had gone better.
23. Think, "I'm going to go out and have some fun."
24. Make a plan to overcome a problem.
25. Stay around people.
26. Concentrate on your work.
27. Think, "Why do I have problems other people don't have?"
28. Do something reckless or dangerous.
29. Think about how sad you feel.
30. Think about all your shortcomings, failings, faults, mistakes.
31. Do something you enjoy.
32. Think about how you don't feel up to doing anything.
33. Do something fun with a friend.
34. Analyze your personality to try to understand why you are depressed.
35. Take your feelings out on someone else.
36. Go someplace alone to think about your feelings.
37. Deliberately do something to make yourself feel worse.
38. Think about how angry you are with yourself.
39. Listen to sad music.
40. Isolate yourself and think about the reasons why you feel sad.
41. Try to understand yourself by focusing on your depressed feelings.

Values: 1 = almost never 2 = sometimes
3 = often 4 = almost always

Appendix B: Penn State Worry Scale

SELECT THE NUMBER THAT BEST DESCRIBES HOW TYPICAL OR CHARACTERISTIC EACH ITEM IS FOR YOU.

1. If I don't have enough time to do everything, I don't worry about it.
2. My worries overwhelm me.
3. I don't tend to worry about things.
4. Many situations make me worry.
5. I know I shouldn't worry about things, but I just can't help it.
6. When I am under pressure I worry a lot.
7. I am always worrying about something.
8. I find it easy to dismiss worrisome thoughts.
9. As soon as I finish one task, I start to worry about everything else I have to do.
10. I never worry about anything.
11. When there is nothing more I can do about a concern, I don't worry about it any more.
12. I've been a worrier all my life.
13. I notice that I have been worrying about things.
14. Once I start worrying, I can't stop.
15. I worry all the time.
16. I worry about projects until they are all done.

Values: 1 = Not at all typical
2 =
3 = Somewhat typical of me
4 =
5 = Very typical of me

Appendix C: Meditation Experience Questionnaire

1. Do you practice any meditation techniques?
   Yes____ No____
   a. If yes, how many times per week? ______
   b. What is the approximate length of each session?______
   c. Why do you do this?
      Stress maintenance_____ Regular health upkeep_____ Other_______
      i. If "other", please specify_________________________

2. Do you practice any progressive muscle relaxation techniques?
   Yes____ No____
   a. If yes, how many times per week? ______
   b. What is the approximate length of each session?______
   c. Why do you do this?
      Stress maintenance_____ Regular health upkeep_____ Other_______
      i. If "other", please specify_________________________

3. Do you practice deep or slowed breathing?
   Yes____ No____
   a. If yes, how many times per week? ______
   b. What is the approximate length of each session?______
   c. Why do you do this?
      Stress maintenance_____ Regular health upkeep_____ Other_______
      i. If "other", please specify_________________________

Appendix D: Positive and Negative Affect Schedule

PLEASE RATE YOUR CURRENT EMOTIONAL LEVEL FOR THE FOLLOWING ITEMS:

1. Upset
2. Hostile
3. Alert
4. Ashamed
5. Inspired
6. Nervous
7. Determined
8. Attentive
9. Afraid
10. Active

Values: 0 = Not at all
1 =
2 = A moderate amount
3 =
4 = Very much

Appendix E: Perceived Stress Scale

Directions: The questions in this scale ask you about your feelings and thoughts at this moment. In each case, you will be asked to indicate by circling how strongly you feel or think a certain way.

1. Do you feel you are unable to control important things in life?
2. Do you feel confident about your ability to handle personal problems?
3. Do you feel things are going your way?
4. Do you feel difficulties are piling up so high that you cannot overcome them?

Values:
0 = Not at all
1 = A little bit
2 = Somewhat
3 = Quite a bit
4 = Very much

Appendix F: Progressive Muscle Relaxation Sequence

1. Dominant hand and forearm
2. Dominant biceps
3. Nondominant hand and forearm
4. Nondominant biceps
5. Forehead
6. Upper cheeks and nose
7. Lower cheeks and jaws
8. Neck and throat
9. Chest, shoulders, and upper back
10. Abdominal or stomach region
11. Dominant thigh
12. Dominant calf
13. Dominant foot
14. Nondominant thigh
15. Nondominant calf
16. Nondominant foot

Appendix G: NASA Activity Scale

Use the appropriate number (0 to 7) which best describes your general ACTIVITY LEVEL for the PREVIOUS MONTH. Please choose only <u>one</u> option below.

DO NOT PARTICIPATE REGULARLY IN PROGRAMMED RECREATION SPORT OR HEAVY PHYSICAL ACTIVITY

0 - Avoid walking or exertion, e. g., always use elevator, drive whenever possible instead of walking.
1 - Walk for pleasure, routinely use stairs, occasionally exercise sufficiently to cause heavy breathing or perspiration.

PARTICIPATED REGULARLY IN RECREATION OR WORK REQUIRING MODEST PHYSICAL ACTIVITY, SUCH AS GOLF, HORSBACK RIDING, CALISTENICS, GYMNASTICS, TABLE TENNIS, BOWLING, WEIGHT LIFTING, YARD WORK.

2 - 10 to 60 minutes per week.
3 - Over one hour per week.

PARTICIPATE REGULARLY IN HEAVY PHYSICAL EXERCISE SUCH AS RUNNING OR JOGGING, SWIMMING, CYCLING, ROWING, SKIPPING ROPE, RUNNING IN PLACE OR ENGAGING IN VIGOROUS AEROBIC ACTIVITY TYPE EXERCISE SUCH AS TENNIS, BASKETBALL OR HANDBALL.

4 - Run less than one mile per week, walk 1.5 miles per week, or spend less than 30 minutes per week in comparable physical activity.
5 - Run one to five miles per week or spend 30 to 60 minutes per week in comparable physical activity.
6 - Run five to ten miles per week, walk 7-14 miles per week, or spend 1 to 3 hours per week in comparable physical activity.
7 - Run over ten miles per week, walk over 14 miles per week, or spend over 3 hours per week in comparable physical activity.

Appendix H: Participant Views on MM and PMR

1. In general, how difficult was this activity to understand?
    a. Not at all difficult
    b. A little difficult
    c. Somewhat difficult
    d. Difficult
    e. Very Difficult
    f. Extremely Difficult

2. In general, how much effort did you put into this activity?
    a. Not at all
    b. Very little
    c. A moderate amount
    d. A great deal
    e. An extreme amount

3. How relaxing did you find this activity?
    a. Not at all
    b. Very little
    c. A moderate amount
    d. A great deal
    e. An extreme amount

4. How distracting did you find this activity?
    a. Not at all
    b. Very little
    c. A moderate amount
    d. A great deal
    e. An extreme amount

5. How much did you become so absorbed in the activity that you did not notice anything else going on around you?
    a. Not at all
    b. Very little
    c. A moderate amount
    d. A great deal
    e. An extreme amount

Appendix I: PSMPR Experimenter Script

Things to get ready:

- PORTApress with 1 finger cuff and 1 height corrector
- Polar device (chest strap, connector, and watch)
- Login to computer behind screen
- 2 mood scale links and final survey on tablet (log into computer on back wall for backup)
- Paper for BP and weight/height/BMI measures
- Gift card: write down number on participant paper
- Informed consent (2 copies)

1. Informed Consent (3 minutes)
   [Have participant read up to "risks"]
   [Explain benefits, e.g., how extra credit and gift cards work, confidentiality, remaining informed consent including where to sign]

   Do you have any questions?

2. OMRON BP readings and height and weight (2 minutes)
   I now need to measure your height, weight, and blood pressure before we begin. [experimenter directs pp to the height measurer and writes down height in cm] Stand straight up with feet together and your back against the wall.

   Ok. Now we will do your weight. It will show kilograms. [experimenter directs pp to step on scale]

   Ok. Now you can sit in this chair while we measure your blood pressure 3 times. What hand do you write with? [experimenter directs pp to sit in chair next to OMRON BP device and places the cuff on the pp's arm—their NON-dominant hand—against bare skin]. Please keep your feet flat on the ground and remain quiet for accurate measures. [experimenter writes down all 3 BP measures and then unhooks pp. experimenter will double check BMI and BP measures to make sure pp meets the inclusionary criteria].

   **Exclusionary criteria:

   BMI: (multiply cm height by .01 → you now have height in meters. Now, multiply that number by itself → you now have meters squared)
   Weight in kg / height in m squared → must be 18.5-30

   BP: Throw out the first measure. Average the second and third measures and they must be below 140/90. Example: second measure 120/80, third measure 116/76. Take (120+116)/2 and (80+76)/2. You get 118/78. They qualify. If one BP number is over but the other is not from this average (ex.

130/92) they do not qualify.

Now I am going to have you sit in this chair while I hook you up to this blood pressure device. [Participant sits in chair by device]

3. Hook up to PORTApres (3 minutes)
I will be placing part of the device around your wrist, a cuff will be attached to your finger, and then a strap will be attached to your arm. This device will give us a continuous measure of your blood pressure being read from your finger. You will feel the cuff inflate much like the blood pressure cuff that was around your arm previously. [experimenter attaches device to participant on their non-dominant arm/finger]. Does everything feel comfortably tight?

4. Baseline 1 (10 minutes)

OK. I will now have you sit quietly for 10 minutes. I am about to start the device, and you will feel tingling in your finger as it starts.
[experimenter will start the BP device and make sure it is reading accurately on the computer. Let it go for about a minute to start reading accurately].

**Hit "event" once reading properly and start stop watch for 10-minute period.
**10 minutes pass → hit "event"

5. Mood and PSS scales (2 minutes)
(after 10 minutes) I will now have you take two short surveys on this tablet. Let me know when you're finished [experimenter has the FIRST survey open and hands tablet to participant].

6. Experimenter Instructions for **Mindful Meditation** group (5 minutes)
Next, I want to take you through 5-minutes of mindfulness meditation.

1. Close your eyes and try to relax just as if you were at home. Set aside all thoughts of the past and the future and stay in the present.

2. Become aware of your own breathing, focusing on the feeling of air moving in and out of the body as one breathes. Feel your belly rise and fall, the air enter your nostrils and leave your mouth. Pay attention to the way each breath changes and is different.

3. Watch every thought come and go, whether it be a worry, fear, anxiety or hope. When thoughts come up in your mind, don't ignore or suppress them but simply note them, remain calm and use your breathing as an anchor.

4. If you find yourself getting carried away in your thoughts, observe where your mind went off to, without judging, and simply return to your breathing. Remember not to be hard on yourself if this happens.

5. Now sit back with your eyes closed for about five minutes and try to set aside all negative thoughts of the past or future. Try to stay in the present, becoming aware of where you are. I will return in five minutes."

**Hit "event" and start stop watch for 5 minutes

**After five minutes hit "event" and start stress task.

<u>Experimenter Instructions for the **Progressive Muscle Relaxation** group (5 minutes)</u>

Next, I want to take you through 5-minutes of progressive muscle relaxation.

Focus your attention on the instructed muscle group. At my signal, tense the muscle group; feel tension, but not so much that it's very painful. [Keep tense for 5-7 seconds]. At my signal, slowly release the muscles while attending to the feeling of the muscle relaxing [for 10 seconds]

**Hit "event" and start stop watch for 5 minutes and go through the following sequence:

1. Dominant hand and forearm
2. Dominant biceps
3. Nondominant hand and forearm
4. Nondominant biceps
5. Forehead
6. Upper cheeks and nose
7. Lower cheeks and jaws
8. Neck and throat
9. Chest, shoulders, and upper back
10. Abdominal or stomach region
11. Dominant thigh
12. Dominant calf
13. Dominant foot
14. Nondominant thigh
15. Nondominant calf
16. Nondominant foot

[After all muscle groups, remain seated until 5 minutes is reached]

**After five minutes hit "event" and start stress task.

Experimenter Instructions for the **Attention Only Control group** (5 minutes)

Next, I want to take you through 5-minutes of this book. Please listen closely because you will be making choices about what the character does in the book as we read the chapter.

**Hit "event" and start stop watch for 5 minutes and read from book

**After five minutes hit "event" and start stress task.

7. Trier Social Stress Test (TSST; 5 minutes)
   I now will have you do an arithmetic task. Please count backwards from 1,022 by 13. You can start now. [experimenter will have the participant start over every time they make a mistake. At 1 minute and 3 minutes the experimenter will tell the participant to go faster]. *Start stop watch for 5 minutes.

   (after 5 minutes) Ok, you may stop now.

   **Hit "event"

8. Mood and PSS scales (2 minutes)
   I will now have you take two short surveys on this tablet. Let me know when you're finished [experimenter has the SECOND survey open and hands tablet to participant].

9. Recovery/Baseline 2 (10 minutes)
   I will now have you sit quietly for 10 minutes.

   **Hit "event" and start stop watch for 10 minutes.
   **after 10 minutes, hit "event"

   Remove devices from participant right away to relieve the finger discomfort.

10. Experimenter Instructions for Final Survey and Debriefing Pp (2 minutes)
    Now, I am going to ask you to answer a few short questions about your experience with this task. [Participant will answer survey on tablet]

    The experiment is now over. Do you have any questions? (If no questions.) Thank you for your participation. (Arrange compensation of subject.) Before you leave I would like to give you an idea of what this study is about. This is a study examining how cardiovascular responses to stress are influenced by coping behaviors, psychological factors, and health habits. The key variables we are examining are BP and heart rate. Such an examination is important because people need to be aware of the nature of stressful situations that are a risk for high blood pressure, and their ability to reduce this negative effect on the body.

TSST

Instructions: Tell the participant he or she must serially subtract the number **13** from the number **1022**. Each time he or she makes a mistake, he or she must start from the beginning. Inform him or her she has made a mistake by saying, "Stop, 1022."

Answers:

1,009	775	541
996	762	528
983	749	515
970	736	502
957	723	489
944	710	476
931	697	463
918	684	450
905	671	437
892	658	424
879	645	411
866	632	398
853	619	385
840	606	372
827	593	359
814	580	346
801	567	333
788	554	320

Appendix J: Sociodemographic measures and health history

1. What is your height in feet and inches?
    a. (fill in answer)

2. What is your weight in pounds?
    a. (fill in answer)

3. Please identify your gender
    a. Female
    b. Male
    c. Other

4. What is your age in years?
    a. (fill in answer)

5. What is your racial/ethnic background? (Please select any options below that are relevant for you)
    a. Caucasian/White
    b. African-American/Black
    c. Spanish/Hispanic
    d. American Indian/Alaskan
    e. Native Hawaiian/Pacific Islander
    f. Asian
    g. Middle-Eastern
    h. Other

6. What was the highest level of formal education that your mother/stepmother/female guardian completed?
    a. 8^{th} grade or less
    b. Some high school
    c. High school diploma or GED
    d. Some College or Associate/technical degree
    e. Bachelor's Degree
    f. Master's Degree
    g. Post-Master's Degree

7. What was the highest level of formal education that your father/stepmfather/male guardian completed?
    a. 8^{th} grade or less
    b. Some high school
    c. High school diploma or GED
    d. Some College or Associate/technical degree
    e. Bachelor's Degree

    f. Master's Degree
    g. Post-Master's Degree

8. Do you now, or have you ever had a prior diagnosis of hypertension?
    a. Yes
    b. No

9. Do you use anti-hypertensive medications?
    a. Yes
    b. No

10. Do you have arrythmias or heart ailments?
    a. Yes
    b. No

11. Do you have any other medical concerns you feel would interfere with participating in the study?
    a. Yes
        i. Please specify: (fill in answer)
    b. No

Appendix K: Picture of PORTApres device

This picture illustrates the PORTApres blood pressure and heart rate monitoring device used in this study. Of note, there are 2 cuffs pictured on the subject’s fingers, and we used 1 cuff for this study.