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Understanding the Physiology of Mindfulness: Aortic Hemodynamics and Heart Rate Variability

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Abstract

Data were collected to examine autonomic and hemodynamic cardiovascular modulation underlying mindfulness from two independent samples. An initial sample (N = 185) underwent laboratory assessments of central aortic blood pressure and myocardial functioning to investigated the association between mindfulness and cardiac functioning. Controlling for religiosity, mindfulness demonstrated a strong negative relationship with myocardial oxygen consumption and left ventricular work but not heart rate or blood pressure. A second sample (N = 124) underwent a brief (15 minute) mindfulness inducing intervention to examine the influence of mindfulness on cardiovascular autonomic modulation via blood pressure variability and heart rate variability. The intervention had a strong positive effect on cardiovascular modulation by decreasing cardiac sympathovagal tone, vasomotor tone, vascular resistance and ventricular workload. This research establishes a link between mindfulness and cardiovascular functioning via correlational and experimental methodologies in samples of mostly female undergraduates. Future directions for research are outlined.

Keywords: blood pressure; blood pressure variability; cardiovascular; heart rate variability; hemodynamics; mindfulness.

Derived from ancient Zen Buddhism practices, mindfulness is widely promulgated as a method to reduce stress and improve well-being. Mindfulness comprises two components: self-regulation (focusing on the present and remaining aware of mental activity) and orientation (embracing change through acceptance, openness and curiosity; Bishop et al., 2004; Brown & Ryan 2003; Kabat-Zinn, 1982). Although mindfulness inducing techniques such as diaphragmatic breathing, progressive muscle relaxation, and body scanning seem to be promising alternatives to traditional emotion and stress regulation procedures (Jain et al., 2007; Speca et al., 2000), little is known about the myocardial mechanisms and autonomic nervous system functioning underlying the physiological effects of mindfulness (Krygier et al., 2013). To advance understanding of cardiovascular functioning underlying mindfulness, we utilized pulse wave analysis via applanation tonometry to examine aortic hemodynamics and myocardial work relationships with mindfulness practices in an initial sample. We then investigated the influence of a brief mindfulness intervention on cardiac autonomic function via beat-to-beat blood pressure and heart rate variability assessment.

Study

Most studies investigating the cardiovascular physiology underlying mindfulness focus only on heart rate and brachial blood pressure (BP). Only a few have found that mindfulness lowered heart rate and BP (Chen et al., 2012; Leggett, 2011), a circumstance that might be due to changes being too subtle to be detected by these measures. Although brachial cuff measurement is commonly used to identify increased cardiovascular risk, it may underestimate hemodynamic and other cardiovascular anomalies (Roman et al., 2007). For instance, compared to brachial pressure measurement, central pressure measurement derived from pulse wave analysis more accurately predicts cardiovascular outcomes such as carotid hypertrophy (Roman et al., 2009).

Additionally, some indices predictive of poorer cardiac function (i.e. increases in myocardial oxygen consumption and ventricular work, decreases in coronary perfusion) can only be obtained from assessment of central pressure (Hashimoto et al., 2007a; O'Rourke & Adji, 2005; Manisty et al., 2010; Safar et al., 2008; Vlachopoulos et al., 2010). Finally, research suggests that aortic BP may be a more sensitive marker of cardiac responsiveness than brachial BP (Hashimoto et al., 2007b; O'Rourke & Hashimoto, 2008).

We therefore examined central hemodynamic parameters associated with increased cardiovascular risk as they may be helpful in understanding the impact of mindfulness on cardiovascular functioning. To supplement standard peripheral (brachial) BP assessment, this study utilized pulse wave analysis via applanation tonometry to assess central (aortic) BP as well as myocardial work (myocardial oxygen consumption, left ventricular work, and coronary perfusion). In an initial sample we examined the following hypothesis:

Hypothesis 1. Mindfulness would be associated with decreased ventricular work (STI; systolic time integral) and myocardial oxygen consumption (RPP; rate pressure product), and ultimately would be associated with improved coronary perfusion (DTI; diastolic time integral).

We also built on this correlational hypothesis by conducting an experimental trial using beat-to-beat assessment that allows for the incorporation of psychophysiological markers of autonomic nervous system (ANS) functioning via power spectral analysis of heart rate and blood pressure variability (BPV) indices. ANS functioning complements hemodynamics in predicting cardiovascular health and well-being. Of specific interest involving ANS measurement is normalized low frequency heart rate variability (LFnu) and rhythmical oscillations in systolic (LFSBP) and diastolic (LFDBP) blood pressure in the low-frequency blood pressure variability domain (Sanchez-Gonzalez et al., 2013; Parati et al., 2015).

LFnu is an index of cardiac sympathovagal tone (i.e. the contribution of the sympathetic influence on the balance of the autonomic state resulting from sympathetic and parasympathetic influences). Extended durations of unbalanced cardiac sympathovagal tone, derivative of common everyday phenomena such as daily worry (Brosschot et al., 2007), anxiety (Chalmers et al., 2014), and depression (Kemp et al., 2010) can increase cardiovascular risk (Kemp et al., 2012) that can, in turn, lead to cardiovascular disease and death (Task Force, 1996; Parati et al., 2015).

Short term BPV has been consistently associated with adverse cardiovascular events (Parati et al., 2015). The BPV parameters LFSBP and LFDBP are considered surrogates of sympathetic vasomotor tone and total peripheral resistance, respectively. In fact, reductions in short term BPV including increased LFSBP and LFDBP have been associated with adverse cardiovascular outcomes (Manios et al., 2014; Parati et al., 2015). Moreover, recent research suggests that LFSBP may be a more appropriate indicator of global sympathetic nervous system activity than HRV, which has been shown useful in quantifying and predicting cardiovascular health (La Rovere et al., 2003; Sanchez et al., 2013). However, concurrent examination of HRV and BPV parameters may allow us to identify potential beneficial autonomic cardiovascular effects linked to mindfulness. We consequently tested a second hypothesis using a new sample:

Hypothesis 2. Compared to a control condition, a brief (15 minute) mindfulness inducing intervention will reduce blood pressure, heart rate, and sympathetic activity as indexed by reduced normalized low frequency HRV (LFnu), and decreased sympathetic vasomotor tone (LFSBP) and total peripheral resistance (LFDBP) of the BPV

Methods

As two independent samples and procedures were used to test hypotheses 1 and 2, we report the method and results pertaining to each sample in turn.

Participants. For hypothesis 1, one hundred eighty-five undergraduate students (M_{age} = 20.51 years, *SD* = 2.82, 85% Female) qualified for study inclusion. Regarding the sample evaluating hypothesis 2, one hundred twenty four undergraduate students (M_{age} = 20.14 years, *SD* = 1.37, 88% Female) qualified for study inclusion. The overall ethnic composition of the samples were 72% Caucasian, 12% African American, 8% Asian and 7% endorsed either biracial or non-disclosed ethnicity. All participants were recruited from a major southeastern university in the United States and gave their written consent prior to study participation as approved by the university's institutional review board.

To avoid potential cardiovascular functioning confounds, participants were excluded from study participation through an online health screening assessment if they exercised regularly (>120 minutes per week) in the previous 6 months (as previously specified in May et al. 2014a; 2014b), used nicotine products, were hypertensive (BP > 140/90 mmHg), were taking beta blockers, antidepressants, or stimulants, or had chronic diseases. Participants were asked to abstain from alcohol, caffeine, and strenuous physical activity for at least 24 hours prior to testing. They were also instructed not to eat any food 4 hours prior to study testing. Female participants were tested in the early follicular phase of the menstrual cycle to avoid potential variations in pressure wave morphology and cardiac reactivity (Adkisson et al., 2010).

Instruments and Measures

Pulse wave analysis. Pulse wave analysis (PWA) allows for accurate assessment of central hemodynamic functioning (Hashimoto et al., 2007b; Nichols & Singh, 2002; Safar et al., 2008). PWA was conducted using SphygmoCor XCEL PWA (SphygmoCor, AtCor Medical, Sydney, Australia). The SphygmoCor XCEL PWA system provides derivation of central aortic blood pressure indices via brachial pressure cuff inflation using a validated generalized transfer function. Collection of PWA indices takes 60 seconds to complete. In addition to brachial and aortic systolic and diastolic blood pressure, additional indices provided by PWA include: systolic pressure time integral (STI), an indicator of left ventricular work and myocardial oxygen consumption; diastolic pressure time integral (DTI), an index of coronary perfusion (Bunckberg et al., 1972); and subendocardial viability index (SVI), the percentage of subendocardial perfusion to myocardial demand that is derived from the ratio of DTI to STI (Bunckberg et al., 1972). The RPP was calculated as (SBP X HR)/100 and yields a measure of myocardial oxygen consumption (Gobel et al., 1978).

Beat-to-beat BP. Beat-to-beat heart rate (HR), systolic blood pressure (SBP), and diastolic blood pressure (DBP) were recorded via finger plethysmography (Noninvasive Blood Pressure System-100 Biopac, Goleta, CA). This method has been shown to provide accurate measurement of BP in comparison with intra-arterial BP (Imholz et al., 1991).

Heart rate variability. The BP peaks were used to calculate the time duration of intervals between heartbeats (RRI) and were automatically detected using commercially available software (WinCPRS, Turku, Finland). The RRIs were inspected for artifacts, premature beats and ectopic episodes in order to calculate HRV parameters. The main spectral components of the HRV that we calculated, by means of Fast Fourier transformation, were the low frequency (LF; 0.04–0.15 Hz) and the high frequency (HF; 0.15–0.4 Hz). LF and HF can be expressed in absolute values (ms2) or normalized units (nu). To exclude the influence of VLF and to control for changes in total power (TP) during the intervention induction, it is more appropriate to report these spectral components in nu (Pagani et al. 1986). Calculation of nu is conducted by dividing the power of a given component by the total power from which VLF has been subtracted (Sgoifo et al., 2015). Due to structural algebraic redundancy inherent in the normalized spectral HRV measures with respect to each other (LFnu=1-HFnu), we only report LFnu and denote LFnu as an index of cardiac sympathovagal tone (Task Force, 1996; Burr, 2007; Pagani 1986).

Blood pressure variability. To assess BPV, the SBP and DBP time series were resampled at 5Hz and the continuous data stream passed through a low pass impulse response filter with a cutoff frequency of 0.5 Hz. The data were then subjected to Fast Fourier transform algorithms using a Hanning spectral window and subsequently smoothed using a triangular averaging function to produce a spectrum. The power was calculated by measuring the area under the peak of the power spectra density curve for both SBP and DBP. Power spectra within the 0.04–0.15 Hz range were defined as LFSBP and LFDBP taken as estimates of sympathetic vasomotor activity and total peripheral resistance, respectively (Malliani et al., 1991).

Religiosity. Religiosity was measured with a 9 item scale used in previous religiosity research (Cohen et al., 2008). Responses range from 1 (strongly disagree) to 5 (strongly agree). Items include: ‘‘My personal religious beliefs are very important to me”; ‘‘My religion or faith is an important part of my identity”; ‘‘If someone wanted to understand who I am as a person, my religion or faith would be very important in that”; ‘‘I attend religious services regularly”; ‘‘I practice the requirements of my religion or faith”; ‘‘I believe strongly in the teachings of my religion or faith”; ‘‘I believe in God”; ‘‘I consider myself a religious person”; and ‘‘I consider myself a spiritual person.” Sample α was .94 in the sample evaluating hypothesis 1 and .92 in the sample evaluating hypothesis 2.

Mindfulness. Through an item response theory analysis of the 15 item Mindful Attention Awareness Scale (MAAS; Brown & Ryan, 2003), Van Dam, Earleywine, and Borders (2010) identified a subset of five items that demonstrated high discriminatory values which provided the majority of information within the scale and covered the span of the trait range comprehensively. Participants were given these 5 items. Items were rated on a 5-point Likert (1 = almost never, 6 = almost always) of how frequently they experienced a receptive state of mind in which attention, which is informed by a sensitive awareness of what is occurring in the present, was observed. The items included were: “It seems I am ‘‘running on automatic,” without much awareness of what I’m doing”; “I rush through activities without being really attentive to them”; “I get so focused on the goal I want to achieve that I lose touch with what I’m doing right now to get there”; “I do jobs or tasks automatically, without being aware of what I’m doing”; “I find myself doing things without paying attention”. Sample α was .88 in the sample evaluating hypothesis 1 and .87 in the sample evaluating hypothesis 2.

Mindfulness meditation task. A smartphone application (MindApps, 2014) was used for the brief task to induce mindfulness via a meditation-like format. Participants follow instructions using earphones. The guided meditation exercise had users focus on breathing and other bodily sensations for fifteen minutes. During this time users are guided to become aware of each sensation of breath, from each nostril, to the rise and fall of the abdomen. The guided exercise continues to expand focus on sensation to pressure from the chair to surrounding sounds. If thoughts began to wander, task directions from the guiding voice have listeners re-center the mind by acknowledging the drift and bringing focus back to bodily sensations.

Control task. For a control task, participants were seated in the same room, chair, and position as the participants in the mindfulness task. Control participants remained seated and were asked not to move or talk during the task as they were told they were undergoing a relaxation intervention. No outside distractions, such as cell phones were permitted in the room.

Procedure

In the procedure for evaluating hypothesis 1, participants were first introduced to the laboratory setting and familiarized with the study procedures. Body measurements (i.e. height and weight) were taken after which participants completed a health questionnaire that included a health history form and a questionnaire containing the religiosity and mindfulness scales. All data were collected in the afternoon in a quiet, dimly lit, temperature-controlled room (23 ± 1^{0}C) at the same time of the day (±2 hours) in order to minimize potential diurnal variations in cardiovascular reactivity (Muller 1999). Participants were seated and given a ten minute rest period before any measurements were performed. Following the resting period, measurements of peripheral brachial BP and applanation tonometry of the radial artery for pulse wave analysis were taken.

In the procedure for evaluating hypothesis 2, participants were randomly assigned to one of two groups: a mindfulness meditation exercise (MME) task group or a control task group. Participant height and BMI were measured and a questionnaire containing the religiosity and mindfulness scales was completed. Participants were then seated and given a 10 minute rest period in a quiet, dimly lit, temperature-controlled room. A baseline measure of beat-to-beat variation in heartbeats was taken for 5 minutes. Beat-to-beat finger BP and ECG were then recorded to assess BP, HRV and BPV during the task for 15 minutes for both experimental and control groups.

Statistical Analysis

Regarding the statistical analyses conducted for hypothesis 1, Pearson correlation coefficients evaluated univariate associations. Given the empirical association between religiosity and mindfulness (see Ying, 2009), hierarchical multiple regression (HMR) analyses were conducted to demonstrate the incremental contribution of mindfulness beyond religiosity in accounting for variance in cardiovascular parameters. An alpha level of $p < .05$ was considered to be significant.

Regarding the statistical analyses conducted for hypothesis 2, independent samples t-tests examined differences in health characteristics (height, weight, age) and scale measurements (mindfulness and religiosity) between study groups. Physiological outcomes were examined via 2 (baseline vs. intervention) x 2 (control group vs. MME group) mixed factorial repeated measures ANCOVAs, controlling for religiosity and mindfulness scores after tests of sphericity assumptions were conducted. Post-hoc univariate contrasts with Bonferroni corrections (critical value alpha = .025 served as statistical significance) were utilized for follow up analyses.

Results

Regarding the analysis and findings pertaining to hypothesis 1, Table 1 shows the descriptive statistics and correlations of the religiosity and mindfulness scales and the physical demographic characteristics of the sample. A significant Pearson correlation ($r = .24$, $p < .05$) emerged between religiosity and mindfulness. Model 2 of the hierarchical regression analyses showed that, after accounting for religiosity, mindfulness scores accounted for significant additional variance in STI, SVI, and RPP values (see Table 2). Mindfulness did not account for a significant portion of the variance in brachial or aortic blood pressures, heart rate, or DTI.

These results indicate that during a laboratory assessment, after controlling for religiosity, mindfulness was not associated with traditional measures of cardiovascular functioning (heart rate, blood pressure) but was associated with improved cardiovascular hemodynamic functioning as demonstrated by decreased oxygen consumption (RPP) and decreased left ventricular work (STI). Physiologically, it appears that decreased STI is associated with mindfulness and is accompanied by an increase in SVI, and hence may promote improved coronary perfusion. Although coronary perfusion (DTI) per se is not associated with higher mindfulness scores, mindfulness may help the heart by decreasing ventricular work and ultimately increasing the perfusion to workload ratio. Although these findings are correlational, experimental research may demonstrate that mindfulness has important clinical implications. For example, patients with coronary artery disease and angina who suffer from reduced coronary perfusion including decreased SVI, might potentially benefit from the acute cardiovascular effects of mindfulness (Gurovich et al., 2009; Gurovich & Braith, 2011; Gurovich et al., 2014).

Turning to hypothesis 2, there were no significant differences ($p > .05$) between the control condition and mindfulness group in health characteristics (height, weight, age) or scale measurements (see Table 3 for means and standard deviations). With religiosity as a covariate, a 2 (baseline vs. intervention) x 2 (control group vs. MME group) ANCOVA yielded significant interactions for DBP, $F(1, 181) = 12.91$, $p < .001$, partial eta^2 = .099; LFSBP, $F(1, 181) = 4.29$, $p = .040$, partial eta^2 = .035; LFDBP, $F(1, 181) = 129.52$, $p < .001$, partial eta^2 = .523; and LFnu, $F(1, 181) = 88.51$, $p < .001$, partial eta^2 = .429. Follow up contrasts indicated that there were greater reductions in DBP, $F(1, 60) = 5.32$, $p = .024$, Cohen's $d = .392$; and LFSBP, $F(1, 60) = 7.59$, $p = .007$, Cohen's $d = .470$; LFDBP, $F(1, 60) = 7.79$, $p = .006$, Cohen's $d = .498$; and LFnu, $F(1, 60) = 10.88$, $p = .002$, Cohen's $d = 1.95$; from baseline to intervention in MME participants than in control participants for DBP, $F(1, 60) = 2.04$, $p = .155$, Cohen's $d = .257$; LFSBP, $F(1, 60) = 1.95$, $p = .164$, Cohen's $d = .253$; LFDBP, $F(1, 60) = 1.06$, $p = .291$, Cohen's *d* = .185; and LFnu, $F(1, 60) = .392$, $p = .533$, Cohen's $d = .000$. There was a significant main effect of SBP; regardless of experimental condition, participants' SBP decreased significantly from baseline to intervention, $F(1, 118) = 52.13$, $p < .001$, partial eta^2 = .306. There were no significant differences between conditions for HR ($F < 2$, $p > .05$).

These findings suggest that a brief induction of mindfulness may contribute to positive effects on central cardiovascular hemodynamics and cardiovascular autonomic modulation. This is suggested by MME leading to decreases in DBP, decreases in rhythmical oscillations in systolic blood pressure in the low-frequency blood pressure variability domain (LFSBP) – a surrogate of sympathetic vasomotor tone, and decreases in diastolic blood pressure in the low-frequency blood pressure variability domain (LFDBP) – a surrogate of total peripheral resistance. As opposed to LFSBP which may have a respiratory component, oscillations of DBP are related to fluctuations in vascular resistance due to sympathetic and baroreflex regulation of vasomotor tone. Taken together these results suggest that a brief induction of mindfulness positively influences autonomic modulation by decreasing vascular tone and ventricular work. This experimental study shows that mindfulness leads to greater cardiac efficiency suggesting that interventions aimed at decreasing markers of cardiovascular risk, such as a brief mindfulness tasks, may prove to be clinically pertinent.

Discussion

Few studies have examined cardiovascular functioning underlying mindfulness limiting our ability to draw conclusions about mindfulness and cardiovascular outcomes. Prior studies where researchers used similar samples reported inconsistent outcomes. Of five studies that examined effects of mindfulness on cardiovascular outcomes, only two reported decreases in SBP and/or DBP (Chen et al., 2012; Leggett, 2011). The current research adds to the limited data available by linking mindfulness to cardiovascular functioning through use of both correlational (sample 1) and experimental (sample 2) methodologies.

Pulse wave analysis was used to evaluate hypothesis 1 to examine mindfulness associations with brachial BP, central BP, and myocardial physiological functioning. This produced novel contributions pertaining to mindfulness associations with cardiovascular mechanisms. Findings demonstrated that mindfulness was not significantly associated with traditional measures of cardiovascular functioning (heart rate, blood pressures). However, mindfulness was associated with improved RPP and STI, which are considered more sensitive markers of cardiovascular functioning and risk (Hashimoto et al., 2007; Roman et al., 2009).

Sample 2 provided experimental evidence for the positive influence of mindfulness on cardiovascular functioning. In sample 2 we examined the effects of a brief mindfulness inducing intervention on hemodynamics, ANS functioning, and low-frequency blood pressure variability. In comparison to a control condition, findings demonstrated that after a brief mindfulness intervention, DBP, LFSBP, LFDBP, and LFnu decreased. Effectively, the mindfulness intervention may have had positive effects on ANS modulation by decreasing cardiac sympathovagal tone, vasomotor tone, vascular resistance and ventricular workload to improve cardiac efficiency. Interestingly, LFSBP has a respiratory component and while the mindfulness task does not instruct participants on duration of inhalation and exhalation, focusing on breathing could influence these periods. This is important to point out because guided breathing exercises may influence LFSBP independent of its effects on the systemic vasculature (Bernardi et al., 2001a; 2001b; Halamek et al., 2003; Piskorski et al., 2010).

Combined, the outcomes from this research suggest that mindfulness may be clinically pertinent for patients with increased cardiovascular sympathetic activity such as those affected by congestive heart failure (CHF) and chronic hypertension. These health conditions decrease cardiac efficiency and increase workload and thus those suffering from them may benefit from mindfulness interventions. CHF can be caused by inadequate ventricular relaxation or decreased ventricular contraction, increasing end diastolic volume, resistance in pulmonary vasculature, and cardiac workload. As this research demonstrates that a brief mindfulness task can decrease vascular resistance, cardiac workload, LFSBP and oxygen consumption, it raises the possibility that mindfulness could potentially benefit those affected by CHF. Future research should be directed at this population to determine if mindfulness is effective at increasing cardiac efficiency among those affected by CHF.

There are several limitations to this research. First, sample demographics were restricted. The research used a predominantly young adult female sample (mean age of 20 years and 88% of sample was female). Furthermore, participants were excluded if they were hypertensive or had any other major chronic diseases. This healthy population is not representative of the population that may benefit fully from interventions that may produce positive cardiac outcomes. A future study should be conducted with a population that is currently experiencing cardiac disease to determine if they would benefit from a mindfulness intervention.

Furthermore, the mindfulness intervention used in sample 2 comprised a single, 15 minute dose. This suggests that brief mindfulness tasks may be a time efficient cardiovascular intervention applicable to various clinical settings including urgent care and inpatient settings. There is evidence to show that mindfulness has long-term psychological benefits, but little on the physiological benefits of a brief mindfulness intervention via smartphone application based formats. Future research should include a longitudinal component to determine the benefits of brief app based mindfulness tasks on physiological outcomes. It is possible that short, technology driven mindfulness practices could, over time, further benefit participants by decreasing the demands placed on the heart through increased oxygen consumption. Long-term benefits of mindfulness have been documented in regard to improved cognition, mood stability, and attention (Zeiden et al., 2010). There is also evidence to suggest that long-term practitioners of mindfulness meditation have increased gray matter in the brain stem which could be partially responsible for parasympathetic effects on autonomic cardiac outcomes (Vestergaard-Poulsen et al., 2009). However, research is needed on the effects of long-term meditation practice on both hemodynamic and autonomic functioning.

Declaration of Interests

All authors report that there are no financial, consulting, and personal relationships with other people or organizations that could influence (bias) the authors' work. This research was not conducted with grant support.

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Table 1. Descriptive statistics and correlations among religiosity, mindfulness and the physical characteristics.

Sample 1						
Variable	M ± SD	1	2	3	4	5
1. Mindfulness	18.53 ± 5.14	1.00	.24*	.04	.01	.04
2. Religiosity	33.04 ± 7.80		1.00	-.01	.09	.05
3. Age (yrs)	20.51 ± 2.82			1.00	.11	.09
4. Height (cm)	166.16 ± 7.96				1.00	.41**
5. Weight (kg)	65.15 ± 10.21					1.00

Note. n = 185. *p < .01, ** p < .001.

Table 2. Hierarchal multiple regression of aortic hemodynamic indices on mindfulness scores controlling for religiosity.

Criterion [*M*, *SD*]	Step	Predictors	β	*p*	Model R^2	Model ΔR^2	Model F
HR (bpm) [76.27±12.02]	S1	R	-.00	.989	.00		$F(1, 183) = 0.00, p = .989$
	S2	R	.02	.759	.02	.02	$\Delta F(1, 182) = 3.00, p = .085$
		M	-.13	.085			
BSBP (mmHg) [117.10±10.82]	S1	R	-.05	.512	.00		$F(1, 183) = 0.43, p = .512$
	S2	R	-.03	.737	.02	.02	$\Delta F(1, 182) = 2.85, p = .093$
		M	-.13	.093			
BDBP (mmHg) [74.62±8.20]	S1	R	-.03	.735	.00		$F(1, 183) = 0.12, p = .735$
	S2	R	-.01	.905	.01	.01	$\Delta F(1, 182) = 1.34, p = .248$
		M	-.09	.248			
ASBP (mmHg) [103.45±9.39]	S1	R	-.05	.490	.00		$F(1, 183) = 0.48, p = .490$
	S2	R	-.03	.668	.01	.11	$\Delta F(1, 182) = 1.85, p = .176$
		M	-.10	.176			
ADBP (mmHg) [75.66±8.36]	S1	R	-.01	.912	.00		$F(1, 183) = 0.01, p = .912$
	S2	R	.01	.892	.01	.01	$\Delta F(1, 182) = 1.74, p = .189$
		M	-.10	.189			
STI (mmHg/s.min−1) [2134.55±350.66]	S1	R	-.03	.721	.00		$F(1, 183) = 0.13, p = .721$
	S2	R	.00	.953	.03	.03	$\Delta F(1, 182) = 4.99, p = .027$
		M	-.17	.027			
DTI (mmHg/s.min−1)[3148.25±330.56]	S1	R	-.01	.853	.00		$F(1, 183) = 0.04, p = .853$
	S2	R	-.01	.901	.00	.00	$\Delta F(1, 182) = 0.10, p = .755$
		M	-.02	.755			
SVI (%) [150.88 ± 26.17]	S1	R	.01	.905	.00		$F(1, 183) = 0.01, p = .905$
	S2	R	-.02	.783	.02	.02	$\Delta F(1, 182) = 4.52, p = .035$
		M	.16	.035			
RPP [78.65 ± 14.93]	S1	R	-.03	.682	.00		$F(1, 183) = 0.17, p = .682$
	S2	R	-.00	.970	.02	.02	$\Delta F(1, 182) = 3.97, p = .048$
		M	-.15	.048			

Note. n = 185. R = Religiosity scale; M = Mindfulness scale; HR = heart rate; BSBP = brachial systolic blood pressure; BDBP = brachial diastolic blood pressure; ASBP = aortic systolic blood pressure; ADBP = aortic diastolic blood pressure; STI = systolic pressure-time index; DTI = diastolic pressure- time index; SVI = subendocardial viability index; RPP = rate pressure product.

Table 3. Means and standard deviations for height, weight, BMI, and age of participants by experimental condition.

	Control (n = 62)	Meditation (n = 62)
Height (cm)	164.11 ± 7.42	166.04 ± 7.14
Weight (kg)	64.34 ± 14.82	65.33 ± 13.89
Age (yrs)	19.07 ± 2.89	19.45 ± 2.67
Mindfulness	17.21 ± 5.65	17.97 ± 6.09
Religiosity	35.27 ± 5.56	34.89 ± 5.67

Table 4. Means and standard deviations for cardiovascular and autonomic parameters by experimental condition and task.

Experimental Group	Control		Meditation	
Task	Baseline	Intervention	Baseline	Intervention
SBP	123.21 (9.47)	117.25 (9.25)	124.42 (8.43)	119.60 (9.04)
DBP	77.95 (6.12)	76.39 (6.04)	78.25 (6.01)	75.90 (5.98)
LFSBP	3.53 (3.39)	2.82 (2.06)	3.79 (3.69)	2.22 (2.57)
LFDBP	6.28 (3.87)	5.56 (3.91)	7.32 (4.05)	5.31 (4.02)
HR	74.80 (10.91)	75.59 (8.78)	74.50 (9.15)	74.33 (11.20)
LFnu (ms^2)	.64 (.18)	.64 (.18)	.61 (.07)	.43 (.11)

Note. n = 124. Columns contain mean scores followed by standard deviations within parenthesis. SBP, systolic blood pressure; DBP, diastolic blood pressure; LFSBP, low-frequency component of systolic blood pressure variability; LFDBP, low-frequency component of diastolic blood pressure variability; HR, heart rate; LFnu, normalized low frequency heart rate variability.