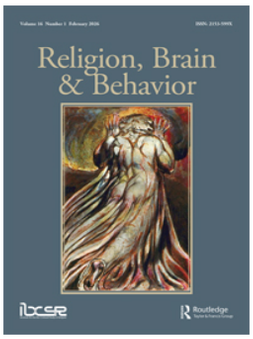

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RESEARCH ARTICLE

Examining the associations between private religious practices, daily spiritual experiences, and cardiovascular stress reactivity

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ABSTRACT

The current study aims to examine the associations between private religious practices, daily spiritual experiences, and cardiovascular reactivity. A sample of 628 middle-aged participants was drawn from the Midlife Development in the United States (MIDUS) 2 Biomarker Project. Participants completed a standardized cardiovascular reactivity protocol consisting of baseline, stress, and recovery phases, with systolic blood pressure (SBP), diastolic blood pressure (DBP), and heart rate (HR) monitored throughout. Psychometric scales captured levels of private religious practices and daily spiritual experiences. Regression models that adjusted for baseline cardiovascular activity, age, sex, body mass index, smoking status, race, and prescription medication use, showed that private religious practices were associated with lower SBP reactivity. This indicates that those who scored higher in private religious practices were found to have lower levels of SBP responses following an acute stressor. Further, these results remained when daily spiritual experiences were added to the model. There were no associations between daily spiritual experiences and any of the cardiovascular variables. Private religious practices, but not daily spiritual experiences, are related to lower SBP reactivity in this midlife sample. The current findings underscore the importance of considering private religious practices and spiritual experiences as distinct constructs when examining health outcomes.

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Cardiovascular reactivity; private religious practices; daily spiritual experiences; stress

1. Introduction

Cardiovascular disease (CVD) is the leading cause of global deaths, claiming the lives of 17.9 million people every year (World Health Organization, 2021), and accounting for 39.5% of deaths in the United States (U.S.) alone (American Heart Association, 2022). Psychological stress is linked to the onset and progression of CVD and may be just as much a prominent factor for CVD as the traditional risk factors such as smoking, family history of heart disease, obesity, diabetes, and physical inactivity (Cohen et al., 2016; Dimsdale, 2008; Steptoe & Kivimäki, 2013). Differences in physiological responses to stressors may serve as a pathway through which stress impacts health. In particular, the cardiovascular reactivity hypothesis postulates that exaggerated and/or sustained cardiovascular reactions to acute psychological stress are associated with a host of indicators of cardiovascular disease and mortality (e.g., Chida & Steptoe, 2010). In fact, research has shown that exaggerated cardiovascular responses to acute stress are associated with the development of hypertension (e.g., Carroll et al., 2011; Carroll et al., 2012a; Chida & Steptoe, 2010; Markovitz et al., 1998) atherosclerosis (e.g., Barnett et al., 1997; Everson et al., 1997; Jennings et al., 2004; Matthews et al., 1998), and increased left ventricular mass (Georgiades et al., 1997; Kapuku et al., 1999). Further,

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blunted responses to acute stress have also been linked to adverse health outcomes (Phillips & Hughes, 2011), including depression (Carroll et al., 2017; Phillips et al., 2011; Salomon et al., 2009), eating disorders (Ginty et al., 2012), behavioral disengagement (Ginty et al., 2020), and heart disease (O'Riordan et al., 2023). Alongside this, there is another body of research that examines the influence of individual differences, such as personality and depression (Grogan et al., 2024; Turner et al., 2020), as well as a small but growing literature examining religious and spiritual variables and their impact on cardiovascular responses to acute stress. The latter will be the focus of the present paper.

A meta-analysis of 69 studies found that religiosity and spirituality were negatively associated with cardiac and all-cause mortality in healthy populations (Chida et al., 2009). Importantly, this protective effect of religiosity and spirituality was independent of behavioral factors (e.g., physical activity, socioeconomic status, and social support) (Chida et al., 2009). More recently, another meta-analysis has shown that higher levels of overall Islamic religious and spiritual engagement were associated with a lower risk of coronary heart disease risk (Hemmati et al., 2019), as were other religious and spiritual dimensions (religious commitment, emotion, and beliefs; Hemmati et al., 2019). Consistent with these findings, McCullough et al. (2000) reported that religious involvement, particularly in public forms such as church attendance, was significantly linked to lower mortality risk in predominantly Western populations. Similarly, research involving mostly American Christians found that weekly religious attendance was associated with a lower risk of death compared to those who never attended (Gillum et al., 2008). Additionally, religiosity and spirituality have been associated with better cardiovascular health among African American populations (Brewer et al., 2022), and other research has found improved health outcomes in patients with heart failure (Cilona et al., 2023). Given the role of religion and spirituality for cardiovascular health, one pathway through which they may exert their effects could be through cardiovascular reactions in response to acute psychological stress.

Despite this notion, a recurring issue within the field of religion, spirituality, and health is that the terms "religiosity" and "spirituality" are often used interchangeably. Yet, with the rise of secularization, is it a priority for research to view religiosity and spirituality as multidimensional constructs consisting of related but not synonymous constructs (Hill et al., 2000; Miller & Thoresen, 2003; Zinnbauer et al., 2015). Religion is generally associated with specific foundational principles that are arranged around a system of beliefs, practices, and rituals that facilitate a connection to one's higher power or God (Koenig, 2012; Thoresen, 1999). Spirituality is more difficult to define, as its characteristics are often disputed (Miller & Thoresen, 2003). However, spirituality conveys the notion of personal search and growth, which involves the thoughts, feelings, and behaviors that occur from this search for the sacred (Larson et al., 1998). Relatively little is known about the effect of religiosity and spirituality when examined as distinct constructs on cardiovascular reactivity.

Research on religiosity, spirituality, and cardiovascular reactivity has shown inconsistent findings, a likely outcome from definitional and measurement issues. Composite scores of religiosity, spirituality and frequency of prayer were associated with lower systolic blood pressure (SBP), diastolic blood pressure (DBP) reactivity for men whereas this had the opposite effect for women (Tartaro et al., 2005). While some studies found no association between daily spiritual experiences and blood pressure (Fitchett & Powell, 2009), others showed an interactive effect of high religious involvement and social support to be associated with lower SBP reactivity (Chen & Contrada, 2007). Schnell et al. (2020) found group differences among religious, atheist, and spiritual individuals, with religious individuals showing lower cardiovascular responses. Research that makes clear distinctions between religiosity and spirituality offers a more insightful approach, as this furthers the understanding of the mechanisms in which religiosity and/or spirituality (e.g., beliefs or behaviors) can impact cardiovascular reactivity.

Church attendance has frequently been used to examine the connection between religion and health, with these beneficial effects thought to be linked to social ties and social support associated with church goings (Idler, 1987; Krause, 2006). However, church attendance does not capture the

multidimensional nature of religiosity and often underestimates the complexities of religion. This notion is further validated by existing literature on intrinsic religiosity and extrinsic religiosity (Masters et al., 2004; Steffen & Masters, 2005). Intrinsic religiosity is characteristic of individuals who embrace a religious creed, internalize it, and strive to follow it. Church attendance by those who are intrinsically religious is motivated by the opportunity for spiritual growth and closeness with one's God. Conversely, extrinsic religiosity is characteristic of individuals who utilize their religion for utilitarian purposes, such as advancing social or political objectives or boosting their status or security (Allport & Ross, 1967). Those who are intrinsically religious have displayed lower blood pressure reactivity (Masters et al., 2005; Masters et al., 2022). Furthermore, blood pressure at rest and during stress tasks may be heightened by extrinsic religiosity and lowered by intrinsic in a sample of older adults (Masters et al., 2004). Moreover, intrinsic religiosity has been linked with lower DBP during baseline (Lawler & Younger, 2002) and lower SBP at baseline, yet slower SBP recovery following a grief recall task (Palitsky et al., 2024).

Religiosity and spirituality can take many forms such as prayer, church attendance, meditation, and the search for meaning in life. These various aspects of religiosity and spirituality may have differing physiological responses. While prior studies have highlighted the effect of intrinsic religiosity on cardiovascular reactivity, the present study focuses on examining whether private religious practices that consist of prayer, meditating or chanting, and reading religious literature influence one's stress responses. Those who frequently engage in private religious practice are likely to hold deeply intrinsic beliefs, which may contribute to positive effects in adapting to acute stress. The daily spiritual experiences scale, which can be viewed independent of religious affiliation, allows spiritual experiences to be examined independent of religiosity, thus offering a better understanding of the role of spiritual experiences and cardiovascular reactivity. This distinction is important as changes in beliefs and practices are evident as there is a growing number of adults embracing more individualized spiritual practices (Fuller, 2001), thus resulting in an increasing number of people identifying as "spiritual but not religious" (Zhai et al., 2008; Zinnbauer et al., 1999). It is important to examine if these changes have an impact on cardiovascular reactivity.

Considering the above evidence, the primary aim of the present study was to examine the associations of private religious practices and daily spiritual experiences on cardiovascular reactivity to acute psychological stress. Furthermore, we examined whether these effects remain after controlling for private religious practices in the daily spiritual experiences model and vice versa. We hypothesized that both private religious practices and daily spiritual experiences would have an inverse relationship with cardiovascular reactivity and that these effects would remain after controlling for private religious practices and daily spiritual experiences in relevant models.

2. Materials and methods

2.1. Participants

Data for the present study are drawn from the MIDUS 2 psychosocial and biomarker projects, which were conducted from 2004 to 2009. A total of 4,963 participants completed psychosocial self-administered questionnaires, and 1,255 of those completed the biomarker assessment, which was collected at three general clinical research centers (Georgetown University, University of California Los Angeles, and University of Wisconsin), with 1,054 respondents being from the longitudinal survey and 201 respondents from the Milwaukee sample. In order to study health issues in minority populations, areas of Milwaukee were stratified based on the proportion of African American residents. In addition, regions with higher African American populations were sampled at higher rates than areas with lower concentrations. Only participants who had fully complete physiological data were included ($n =$ 1,115). Furthermore, based on previous studies (e.g., Keogh et al., 2022, 2023), a decision was made *a priori* to remove the total number of twins from the sample ($n =$ 363), due to the concern of potential confounding variables surrounding genetic determinants

of reactivity (Carmelli et al., 1985) and because of the assumption of independence in analyses. A further 16 participants were excluded as they completed the extended version of the stress task before the overall protocol was shortened (Ryff et al., 2022). An additional 7 participants were removed due to having pacemakers. There were 12 outliers on cardiovascular reactivity variables that were excluded, and only participants who had complete data for study variables were included in analyses; the final sample for analysis was 628 participants (56.2% female), ranging in age from 35years to 85years (M = 55.95, SD = 11.00). The sample was predominantly Christian (approximately 79%), including Evangelical Protestants (about 30%), Mainline Protestants (17%), Roman Catholics (16%), and other Christian groups (16%), such as Mormons and other denominations. Additionally, approximately 16% identified as non-religious, including atheists, agnostics, and those with no religious preference. A small portion (around 3%) reported affiliation with non-Christian religions such as Judaism, Islam, or Buddhism.

2.2. Procedure

Participants who completed the MIDUS 2 survey, which consisted of a 30-minute phone interview and two self-administered questionnaire booklets, were eligible to take part in the biomarker project. Data was collected during a 24-hour stay at one of the three sites listed above. Verbal and written consent was obtained from all participants. On day one of the visit, participants completed a medical history, self-administered questionnaires, and on day two, the biological assessment and standardized laboratory-based stress protocol were completed.

2.3. Measures

2.3.1. Daily spiritual experiences

Spirituality was assessed using 5-items taken from the original 16-item Daily Spiritual Experiences scales (Fetzer Institute/National Institute on Aging Working Group, 1999; Underwood, 2011; Underwood & Teresi, 2002). The scale is intended to measure the ordinary or "mundane" spiritual experiences as opposed to supernatural experiences (e.g., hearing voices or near-death experiences). The five items measure experiences rather than beliefs or behaviors and are designed to go beyond the boundaries of any particular religion. As such, items attributing to "God", "religion" and "blessings" are excluded. The scale items included items such as "A deep feeling of inner peace or harmony," "A feeling of being deeply moved by the beauty of life," "A feeling of strong connection to all of life," "A sense of deep appreciation," and "A profound sense of caring for others". Participants respond to how often, on a daily basis, they have these spiritual experiences on a four-point Likert scale ranging from 1 (often) to 4 (never). Items are reversed-coded and totaled so that higher scores indicate more frequent daily spiritual experiences. In the current study, daily spiritual experiences displayed strong internal consistency with Cronbach's α of 0.88. This scale has been used previously in well-being among cancer patients (Rudaz et al., 2019), health behaviors (Einolf, 2013), and perceived stress (Whitehead & Bergeman, 2012).

2.3.2. Private religious practices

Private religious practices were measured using a 3-item scale. Examples of items measuring private religious practices include "Pray in private?", "Meditate or chant?", and "Read the Bible or other religious literature?". Participants responded to each item on a 6-point Likert scale from 1 (once a day or more) to 6 (never). Responses were reverse scored, and summed, with higher scores implying more frequent engagement in private religious practices. The private religious practices scale yielded good internal consistency with Cronbach's α of 0.73. These items have been used in previous research examining hypertensive individuals (Skipper et al., 2022), and perceived growth after bereavement (Rudaz et al., 2020).

2.3.3. Self-reported stress

Participants were requested to rate their current stress levels verbally before and during both stress tasks. Responses range from 1 (not at all stressed) to 10 (extremely stressed). Self-reported stress for the present study was calculated as the average stress response during both stressors.

2.3.4. Cardiovascular assessment

Beat-to-beat monitoring of SBP and DBP was measured using a Finometer monitor (Finapres, Medical Systems, Amsterdam, Netherlands), which accurately records absolute blood pressure and is validated by the Association of Advancement of Medical Instrumentation and the British Hypertension Society (Schutte et al., 2003; Schutte et al., 2004). A finger cuff is placed on the participant's middle finger of their non-dominant hand, and an arm cuff is placed on the upper arm at heart level on the same side. Non-invasive measurements of blood pressure are taken from the finger cuff by photoplethysmography. The air pressure in the finger cuff adjusts in response to any increases in arterial pressure, reflecting blood pressure changes. The arm cuff accurately calibrates reconstruction of the intrabrachial pressure collected from the finger cuff. Heart rate (HR) is recorded using the electrocardiogram (ECG). Beat-to-beat analog ECG signals are collected and digitized at a sampling rate of 500 Hz by a 16-bit National Instruments analog-to-digital (A/D) board installed on a micro-computer. ECG waveforms were submitted to detection software to detect R waves. Research staff inspected all ECG waveforms to identify errors in R waves due to software issues. HR is collected from a series of normal R intervals computed to beats per minute.

2.3.5. Stress task

The stress-testing protocol ran for approximately 90 min and has been outlined in detail elsewhere (Ryff et al., 2022). Briefly, testing took place in the morning on the second day of the overnight visit. In the laboratory, the cardiovascular equipment was calibrated, and participants completed practice trials for stress tasks. Participants sat quietly during an 11 min resting baseline period; after this, they completed the first stress task, which was followed by a 6 min recovery period and then the second stress task. The stress tasks were the Stroop task/word inference task and a mental arithmetic task, the Morgan and Turner Hewitt (MATH) task (Turner et al., 1986), both 6 min long and presented in random order. For the modified Stroop task, participants were presented with one of four color names (e.g., green, blue, yellow or red) displayed on a computer screen in a font color congruent or incongruent with the name. Participants used one of four keys on the keypad to respond to the font color of each word. The rate of presentation was based on task performance with more accuracy leading to faster presentation.

The MATH task is a mental arithmetic task that involves participants completing addition and subtraction problems. A math problem would be displayed on screen, followed by the word "Equals" and an answer. Participants indicated by pressing on the keypad if the answer was correct or not. Problems ranged in difficulty across five levels, consisting of two 1-digit numbers (level 1) to equations involving two 3-digit numbers (level 5). The task begins at level 3 and the difficulty thereafter is dependent on the response accuracy of the previous trial.

2.4. Statistical analyses

Data were analyzed using SPPS (IBM, version 28, SPSS Inc., Chicago, IL, USA). Mean levels of SBP, DBP, and HR were computed for baseline, task, and recovery. Cardiovascular scores were calculated using the delta method, meaning baseline scores were subtracted from the average of both stress task scores for each cardiovascular parameter of interest. The two stress tasks were averaged, as prior research has proposed that this increases the reliability and generalizability of results (Kamarck & Lovallo, 2003). Preliminary analyses were conducted in order to identify outliers on cardiovascular reactivity deviating +/− 3 SD from the mean. As a result, 12 outliers were identified and excluded from all analyses.

A series of paired sample t-tests was conducted on each cardiovascular parameter to examine if the stressor successfully perturbed the cardiovascular system. Furthermore, to determine if the stress task was perceived as psychologically stressful, a paired sample t-test was conducted to examine whether self-reported stress increased from baseline to the stress task. Independent t-tests and correlations were conducted to test for differences/associations between age, Body Mass Index (BMI), sex, smoking, and race with our cardiovascular indices. This was then followed by a series of hierarchical linear regressions to test our main hypothesis in which we analyzed cardiovascular reactivity and each predictor, private religious practices and daily spiritual experiences, separately. Potential confounding variables included sex, age, BMI, current smoking status, race, and prescription medication, and baseline cardiovascular measures were entered into the model at step 1, followed by each predictor variable separately. A preliminary collinearity diagnostic showed that there was no indication of multicollinearity between private religious practices and daily spiritual experiences variables, with all variation inflation factors (VIF) < 10 (Largest = 1.12), and all tolerance statistics in final adjusted models ranged from 0.77 to 0.89. This study was preregistered on the Open Science Framework (https://doi.org/10.17605/OSF.IO/6FSTW).

3. Results

3.1. Descriptive statistics and confounding variables

The descriptive statistics for demographic, religious, and spiritual experiences variables are reported in Table 1.

As seen in Table 2, there was a positive association between age, SBP baseline, SBP reactivity, and DBP reactivity. Moreover, age was negatively correlated with DBP baseline, HR baseline, and HR reactivity. Higher BMI was associated with higher SBP, DBP baseline, and DBP reactivity. Smoking was positively correlated with most cardiovascular baseline and reactivity cardiovascular measures. Taking prescription medicine was associated with higher HR reactivity. Sex was associated with baseline cardiovascular measures and reactivity; further analysis revealed significant sex differences across several cardiovascular parameters. At baseline, males had significantly higher SBP, $t(626) = 4.68$, $p < .001$, $M = 128.35$, $SD = 18.08$, than females ($M = 121.48$, $SD = 18.46$). Similarly, males exhibited higher baseline DBP, $t(626) = 3.79$, $p < .001$, $M = 63.71$, $SD = 12.12$, compared to females ($M = 60.06$, $SD = 11.79$). Males also demonstrated greater SBP reactivity to stress, $t(626) = 2.24$, $p = .025$, $M = 12.73$, $SD = 11.16$, than females ($M = 10.73$, $SD = 10.88$). In contrast, females had significantly higher baseline HR, $t(626) = 4.41$, $p < .001$, $M = 74.43$, $SD = 10.57$, compared to males ($M = 70.70$, $SD = 10.52$) (see Table 3 for means and SDs for the entire sample). There was

Table 1. Characteristics of final sample for analysis (N = 628).

Variable	M (SD)/N (Percent)	Range
Age (years)	55.95 (11.00)	35–85
Sex (% female)	353 (56.2)	–
Race		
White	449 (71.5)	–
Black and/or African American	147 (23.4)	–
Native American or Alaska Native Aleutian Islander/Eskimo	10 (1.6)	–
Asian	3 (0.5)	–
Other	19 (3.0)	–
Body mass index (kg/m^2)	30.19 (6.69)	
Smoking (% currently a smoker)	105 (16.7)	–
Taking Prescription medication (% yes)	443 (70.5)	
Private religious practices	10.33 (4.52)	3.00–18.00
Daily spiritual experiences	15.84 (3.25)	5.00–20.00
SBP Reactivity (mmHg)	11.61 (11.04)	−21.60–46.95
DBP Reactivity (mmHg)	5.78 (4.11)	−6.20–17.60
HR Reactivity (bpm)	3.45 (3.12)	−6.40–13.60

Table 2. Correlations analysis between private religious practices, daily spiritual experiences and other study variables.

Variables	1	2	3	4	5	6	7	8	9	10	11	12	13	14
1. Private religious practices	–													
2. Daily spiritual experiences	.45**	–												
3. SBP baseline	−.01	−.02	–											
4. DBP baseline	−.05	−.10*	.68**	–										
5. HR Baseline	.06	.03	−.04	.16**	–									
6. SBP reactivity	−.08*	.03	−.04	−.06	.02	–								
7. DBP reactivity	−.03	.06	−.03	−.09*	−.05	.81**	–							
8. HR reactivity	−.04	.04	.09*	.10*	−.04	.14**	.29**	–						
9. Age	.10**	.20**	.09*	−.25**	−.11**	.26**	.22**	−.10*	–					
10. Sex	.15**	.20**	−.18**	−.15**	.17**	−.09*	−.03	.06	−.03	–				
11. Race	.16**	.03	−.12**	−.07	.06	−.09*	−.04	.05	−.14**	−.01	–			
12. Body mass index	.10*	.05	.14**	.09*	.03	−.06	−.08*	−.05	−.06	.05	.11**	–		
13. Smoking status	.06	.17**	.11**	.05	.03	.25**	.20**	.10*	.16**	.01	−.06	.07	–	
14. Prescription medication	−.06	−.06	.01	.07	−.01	−.07	−.04	.09*	−.31**	−.11**	.06	−.09*	−.11**	–

**Correlation is significant at the 0.01 level (2-tailed).
*Correlation is significant at the 0.05 level (2-tailed).

Table 3. Mean (SD) of cardiovascular parameters during baseline and stress task.

Measure	Baseline mean (SD)	Task mean (SD)
SBP (mmHg)	124.49 (18.59)	136.09 (21.26)**
DBP (mmHg)	61.66 (12.06)	67.44 (12.39)**
HR (bpm)	72.79 (10.70)	76.25 (11.02)**
Perceived stress	2.03 (1.49)	4.54 (1.92)**

Note: Stressor measures for cardiovascular parameters and psychological stress were average across two stress tasks (MATH and Stroop). SD = standard deviation; SB*P* = systolic blood pressure; DB*P* = diastolic blood pressure; HR = heart rate; mmHg = millimeter of mercury; bpm = beats per minute. **$p < .001$ level, indicating a statistically significant difference from the respective baseline value.

a positive correlation between private religious practices and daily spiritual experiences. There was evidence of a significant difference between males and females for daily spiritual experiences, ($t(626) = 5.05$, $p < .001$), with females scoring higher (M [SD] = 16.40 [3.18]) in comparison to males (M [SD] = 15.11 [3.19]). A similar trend was observed in private religious practices; $t(626) = 3.86$, $p < .001$, with females scoring higher in private religious practices (M [SD] = 10.94, [4.40]) compared to males (M [SD] = 9.54, [4.57]). Thus, given the observed correlations, we controlled for these co-variates in our main analysis.

3.2. Cardiovascular reactivity manipulation check

A series of paired sample *t*-tests confirmed that the stress task successfully perturbed cardiovascular responses for SBP, $t(627) = 26.34$, $p < .001$, $d = -1.05$, DBP, $t(627) = 35.23$, $p < .001$, $d = -1.05$, and HR, $t(627) = 27.72$, $p < .001$, $d = -1.11$. Further, paired sample *t*-tests revealed a significant increase in self-reported stress from baseline to stress task $t(627) = 35.06$, $p < .001$, $d = -1.39$. As can be seen from Table 3, all effects were in the expected direction, confirming that the stress tasks caused a significant increase from baseline to the stressor period for both physiological and psychological measures of stress.

3.3. Private religious practices, daily spiritual experiences, and cardiovascular stress reactivity

In hierarchical linear regression models, covariates of age, sex, BMI, current smoking status, race, prescription medication use, and baseline cardiovascular parameters were entered into models at step 1, followed by each predictor variable (private religious practices, daily spiritual experiences) individually at step 2. In this analysis, private religious practices were not associated with DBP reactivity or HR reactivity. However, there was a statistically significant relationship between private religious practices and lower SBP reactivity, $\beta = -0.10$, 95% CI [−0.43 – – 0.06], $t = -2.55$, $p = 0.01$. As can be seen in Table 4, higher levels of private religious practices are associated with lower SBP reactivity. There were no significant associations between daily spiritual experience and any cardiovascular reactivity parameters.

3.4. Private religious practices and cardiovascular stress reactivity when controlling for daily spiritual experiences and vice versa.

Similar regressions were conducted as above; this time, entering daily spiritual experiences as a covariate in the model. In this model, the association between private religious practices and SBP reactivity, $\beta = -.10$, 95% CI [−0.45 – – 0.04], $t = -2.35$, $p = 0.02$, remained significant (see Table 4 and Figure 1). There was no significant association between private religious practices and DBP or HR reactivity. When private religious practices were controlled in the daily spiritual experiences model, results remained not significant for any of the cardiovascular reactivity measures.

Table 4. Regression analyses for private religious practices and cardiovascular reactivity

	SBP reactivity			DBP reactivity			HR reactivity		
	B	t	*p*	β	t	*p*	β	t	*p*
Step 1									
Age	0.22	5.48	**<.001**	0.19	4.37	**<.001**	−0.10	−2.43	**0.02**
Sex	−0.10	−2.59	**0.01**	−0.02	−0.56	0.58	0.08	2.05	**0.04**
BMI	−0.38	−0.98	0.33	−0.08	−1.94	**0.05**	−0.07	−1.69	0.09
Smoking status	0.23	6.02	**<.001**	0.18	4.66	**<.001**	0.14	3.38	**<.001**
Race	−0.06	−1.46	0.15	0.01	0.11	0.92	0.05	1.27	0.20
Prescription medication	0.02	0.47	0.64	0.04	0.86	0.39	0.08	1.81	0.07
Baseline measure	−0.10	−2.64	**0.01**	−0.05	−1.27	0.20	−0.07	−1.74	0.08
Step 2									
Age	0.23	5.77	**<.001**	0.19	4.52	**<.001**	−0.10	−2.27	**0.02**
Sex	−0.08	−2.17	**0.03**	−0.01	−0.32	0.75	0.09	2.20	**0.03**
BMI	−0.03	−0.80	0.42	−0.07	−1.82	0.07	−0.06	−1.60	0.11
Smoking status	0.23	6.15	**<.001**	0.19	4.72	**<.001**	0.14	3.42	**<.001**
Race	−0.04	−1.00	0.32	0.01	0.36	0.72	0.06	1.45	0.15
Prescription medication	0.02	0.45	0.65	0.04	0.85	0.40	0.08	1.80	0.07
Baseline measure	−0.10	−2.61	**0.01**	−0.05	−1.27	0.21	−0.07	−1.70	0.09
Private religious practices	−0.10	−2.55	**0.01**	−0.06	−1.49	0.14	−0.05	−1.15	0.25
Inclusion of spiritual experiences									
Spiritual experiences	−.10	.08	0.94	0.03	0.56	0.57	0.06	1.30	0.19
Private religious practices	−.10	−2.35	**0.02**	−0.70	−1.59	0.11	−0.07	−1.59	0.11

Significance highlighted in bold.

4. Discussion

The current study aimed to examine the role of private religious practices, daily spiritual experiences, and cardiovascular reactivity to acute psychological stress. In line with our hypothesis, there was a significant association between private religious practices and lower SBP responses to acute psychological stress. The relationship between SBP reactivity and private religious practices could not be explained by baseline cardiovascular measures, demographic variables (i.e., age, sex

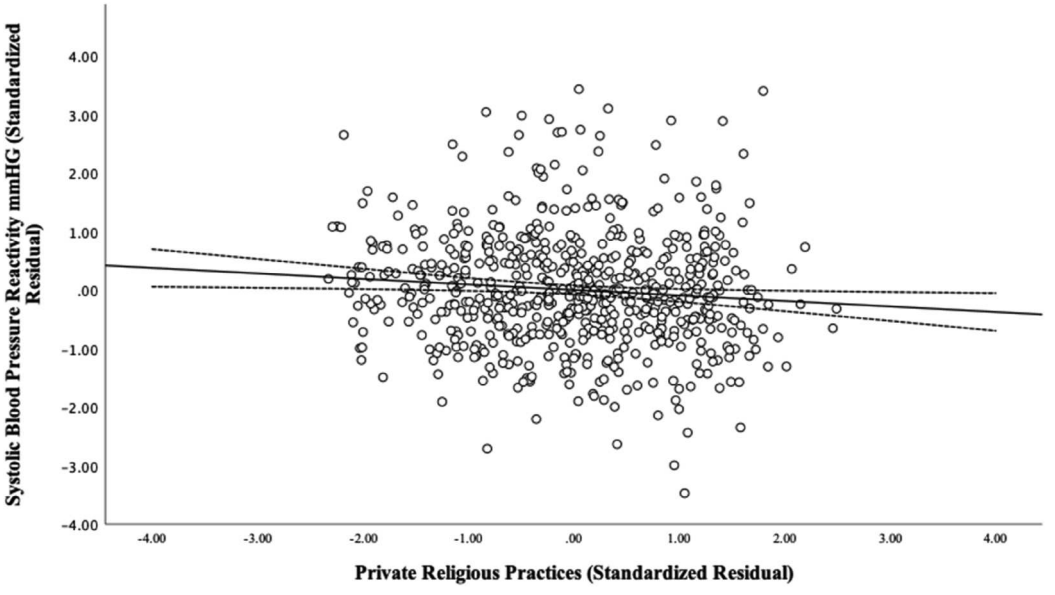

Figure 1. Scatterplot between Private religious practices and systolic blood pressure reactivity, adjusting for age, sex, body mass index, smoking, race, medication status, baseline parameters and daily spiritual experiences. Solid line represents line of best fit (linear); dotted lined represent upper and lower 95% confidence intervals around the mean.

and race), current smoking status, or prescription medication use. More importantly, these results remained after controlling for daily spiritual experiences, meaning that private religious practices predict SBP reactivity independent of spiritual experiences within this sample. Contrary to our hypothesis, there was no significant association between daily spiritual experiences and any of the cardiovascular parameters. Thus, it appears that it is private religious practices, and not daily spiritual experiences *per se* that are the more important for dealing with the biological effects of acute stress and perhaps are key to understanding how religion exerts its influence on cardiovascular health.

Private religious practices represent an important aspect of religiosity that reflects one's devoutness to religious practices in their everyday life. Therefore, individuals who engage in high levels of private religious practices embrace a religious creed and internalize it. Private religious activities have been shown to be protective against mortality in an elderly population who were free of functional impairment (Helm et al., 2000). While previous work has demonstrated that intrinsic religiosity—that is, beliefs and values—has been associated with lower cardiovascular responses to acute psychological stress in older adults (Masters et al., 2004), we extend that work by demonstrating that private religious practices are also associated with cardiovascular reactivity. We found that it was people who reported greater levels of "praying in private, meditating or chanting, reading the Bible or other religious literature" that exhibited lower SBP responses to the stress task.

The present results align with previous research, demonstrating the favorable effects that internalized religious practices and beliefs can have on cardiovascular responses to acute psychological stress, which has been shown across various age groups, including younger and older adults, along with religious and non-religious acute stressors (Masters et al., 2005; Masters et al., 2022). However, our results are at odds with a study that showed no association between intrinsic religiosity and cardiovascular reactivity in a sample of bereaved adults (Palitsky et al., 2024). Other research showed that being pro-religious, scoring high on both extrinsic and intrinsic religiosity, was associated with dampened cardiovascular reactivity in comparison to non-religious and intrinsic individuals (Masters & Knestel, 2011).

Internalizing one's religious beliefs and practices regularly provides a framework for incorporating faith into one's life; thus, individuals who adopt this orientation would likely use religion during times of stress. This in turn may lessen the perceived stress associated with stressful or negative events and may improve the individual's appraisal of the stressor and encourage the use of effective religious coping techniques (Hettler & Cohen, 1998; Park et al., 1990). Additionally, religiosity has been associated with positive psychosocial outcomes such as compassionate attitude, lower depression, lower perceived stress and enhanced social support (Steffen & Masters, 2005). Internalized religious beliefs may also benefit health by promoting positive meaning-making. Research has shown that the ability to find meaning in life events is one of the most reliable ways to generate positive emotions such as gratitude and joy (Folkman, 1997; Fredrickson, 2000, 2002). By fostering positive meaning-making, religious or spiritual beliefs and practices may lead to frequent experiences of emotions such as gratitude and joy (Fredrickson, 2002). According to Fredrickson's Broaden-and-Build Theory (2002, 2004), these positive emotional experiences can expand cognitive and behavioral flexibility, helping individuals develop enduring resources like resilience and social support, which in turn may buffer against the negative effects of stress.

The findings of both past and present research are supported by the stress-buffering hypothesis. Higher levels of private religious practices may help reduce the detrimental effects of stress on health through lowering the cardiovascular response to acute psychological stress (Hettler & Cohen, 1998; Park et al., 1990). For example, private religious activities such as prayer have been found to reduce blood pressure in older adults (Koenig et al., 1998). Similarly, devotional prayer has been shown to significantly reduce cardiovascular responses to stress among Christians exposed to religious stressors (Masters et al., 2022). However, this relationship warrants further investigation, as some studies have reported null findings (Masters & Spielmans, 2007). Another key component of private religious practices is the reading of sacred texts. Frequent Bible reading has been

found to buffer the negative effects of stress, with higher reading frequency linked to greater use of benevolent religious coping strategies (Krause & Pargament, 2018). Hamilton et al. (2013) suggest that Bible reading is often used as a mental health resource during times of stress. Meditation, a practice often integrated into religious or spiritual routines, has also been linked to reduced physiological responses. Regular meditators showed a lower resting blood pressure at a four-month follow-up compared to a control group (Wenneberg et al., 1997). Even brief mindfulness exercises among novice meditators have been found to lower blood pressure reactivity during acute psychological stress (Steffen & Larson, 2015). While meditation is not inherently religious, it may reflect internalized spiritual beliefs that could contribute to physiological regulation. In the present study, it is noteworthy that significant effects were evident only for SBP reactivity, and not for DBP or HR reactivity. Research has found that the effects of acute stress are typically stronger for SBP compared to DBP (Gordon & Mendes, 2021) and HR (Walther & Wirtz, 2023). Further, blood pressure reactivity, particularly SBP reactivity, is a powerful determinant of future hypertension (Carroll et al., 2011; Carroll et al., 2012b; Flint et al., 2019; Kannel, 2000; Walther & Wirtz, 2023). The finding that only SBP reactivity was significantly affected may reflect the distinct sensitivity of SBP to stress regulation processes that may be shaped by private religious engagement. These practices, whether explicitly religious or more broadly spiritual, appear to play a meaningful role in modulating physiological stress responses, with potential implications for both immediate psychological well-being and long-term cardiovascular health.

In the present study, daily spiritual experiences were not associated with cardiovascular reactivity. This contrasts with several other studies showing that spirituality has been linked with lower cardiovascular responses to acute psychological stress in young (Edmondson et al., 2005) and middle-aged adults (Lawler & Younger, 2002). Lawler and Younger (2002) utilized multiple spirituality scales to assess various dimensions of spirituality and religiosity. Specifically, the Stanford Spiritual Experiences scale (Thoresen, 1999; unpublished scale) and the spiritual well-being scale, religious subscale (Paloutzian & Ellison, 1991) were both significantly associated with DBP and mean arterial pressure at rest, during the stress task, and recovery (e.g., a main effect). In contrast, existential subscale of the spiritual well-being scale showed no such association with cardiovascular responses in Lawler and Younger's sample. However, Edmondson et al. (2005) reported that this same existential subscale was associated with lower HR reactivity. These mixed findings highlight the complexity of studying spirituality and physiological parameters. Inconsistent findings across studies may stem from differing conceptualizations of spirituality, whether it is framed in terms of religious beliefs, existential meaning, or spiritual experiences, as well as its inherently subjective nature. Additionally, prior research has found no significant associations using the daily spiritual experiences scale and systolic blood pressure in middle-aged women (Fitchett & Powell, 2009). One possible explanation is demographic; individuals who identify as "spiritual but not religious" are more likely to be younger (Shahabi et al., 2002), which may partially explain the non-significant findings related to spirituality and cardiovascular reactivity in the current study. As people in these older cohorts may not be spiritual, they could be more religious or neither religious nor spiritual. Thus, we aimed to pick a measure that was not tied to religion and see if this added clarity to the field, which helps to understand the differences people may have when they identify as "spiritual but not religious" and the potential implications this has on cardiovascular outcomes.

Importantly, the sample in the present study was predominantly Christian, which may have influenced the observed association between private religious practices and cardiovascular reactivity. Practices such as prayer and scripture reading are commonly used practices in Christian traditions and may have influenced participants' engagement in private religious practices. However, these findings may not generalize to individuals from other cultural or religious backgrounds, where intrinsic aspects of religiosity or spirituality may be expressed differently. For example, in Buddhist traditions, spirituality is integrated more in daily practices and rituals. Given the religious homogeneity of our sample, such cultural variations in the expression of religiosity may not have been adequately captured. These differences warrant further examination

in future research to better understand how different cultures and religious practices express their beliefs, and how these expressions may influence physiological outcomes.

This study extends previous literature by controlling for daily spiritual experiences in religiosity models (and controlling for religiosity in daily spiritual experiences models). The results of the present study offer further support that religiosity and spiritual experiences should be assessed as differentiated constructs. Much of the inconsistency within the field of religiosity and spirituality has arisen due to the constructs being used interchangeably. As secularization is on the rise, future research should examine religiosity and spirituality as independent constructs as this may have important implications for cardiovascular health and broader health outcomes. As evident in the current findings, it was private religious practices and not daily spiritual experiences that influence cardiovascular responses to acute stress. Future research should investigate whether the associations between private religious practice, spiritual experiences, and cardiovascular responses vary across different age groups, ethnicities, and cultural contexts. Such research could provide insight into how sociocultural influences and age-related differences may exist in the involvement of religiosity and/or spirituality, and how these differences may impact physiological responses.

The current study is not without limitations. Firstly, due to the cross-sectional nature, inferences about causality cannot be determined (Christenfeld et al., 2004). Second, approximately 70.5% of the sample reported taking medication; however, this was controlled within analyses. Given the age of the cohort and that the majority of participants reported having at least one chronic health condition, this was in fact normative for this sample. While the aim was to recruit an even representation of all races, the current sample is predominately white. Continued efforts should be made in future research to include a broader representation of race, ethnicities, religious, and spiritual affiliations, as these may have important implications regarding religious and spiritual beliefs and behaviors, along with stress responses. Given that the private religious practices scales demonstrated strong internal consistency in the present study, this solely measures religious practices and does not assess other potentially important aspects of religious beliefs, such as perceived closeness to God or personal significance of one's faith. Additionally, some items may reflect broader intrinsic practices, such as meditation, that are common in religious, spiritual, and even in secular contexts. Given that meditation has been shown to reduce resting blood pressure and blood pressure reactivity (Nyklíček et al., 2013; Steffen & Larson, 2015; Wenneberg et al., 1997), this may be partly responsible for the observed attenuation in SBP reactivity within the present study. Future research should incorporate more refined measures that distinguish between religious practices and forms of spirituality to help clarify the distinct contributions these constructs may have on cardiovascular responses. Additionally, research suggests that religious individuals often report better self-rated physical health compared to their non-religious counterparts. However, this association is typically stronger in countries where religiosity is a cultural norm. Cultural context plays an important role in interpreting these findings, as research indicates that the more culturally normative religion is, the greater its protective effects on perceived physical health (Stavrova, 2015). As such, the findings may not generalize to contexts where religiosity is less socially normative, highlighting the importance of considering cultural and contextual factors when interpreting the relationship between religious beliefs and health outcomes. Lastly, atypically low (i.e., blunted) physiological responses have been associated with a range of negative health outcomes (e.g., Carroll et al., 2017; O'Riordan et al., 2023; Phillips et al., 2011; Turner et al., 2020); it is important to consider that the low SBP reactivity observed among individuals who engage more frequently in private religious practices could reflect maladaptive patterns of cardiovascular responses. Although intrinsic beliefs have been widely associated with favorable health outcomes and lower reactivity (Byrd et al., 2007; Masters et al., 2005; Masters et al., 2022; Mosqueiro et al., 2015), recent evidence further supports this interpretation. For example, a review by Dempsey et al. (2025) highlights the protective role that deeply internalized beliefs can have on stress reactivity. These findings collectively support the interpretation that the lower SBP responses observed may reflect adaptive rather than maladaptive cardiovascular patterns. Nonetheless, further research is needed to replicate and clarify these associations across diverse cultural and religious contexts.

5. Conclusion

In sum, higher levels of private religious practices were related to lower levels of SBP reactivity, but not to DBP or HR reactivity to acute psychological stress. On the other hand, daily spiritual experiences were not associated with any cardiovascular parameters. Results could not be explained by baseline cardiovascular measures, age, sex, race, BMI, smoking, or prescription medication use. The present study extended previous research by using a larger sample and by controlling for private religious practices and spiritual experiences in relevant models; it is important to note that the sample was drawn from a U.S. population. Consequently, the generalizability of these findings may be limited, and different patterns may emerge in cultural contexts where religiosity is less socially normative. Future research is encouraged to explore these relationships in more diverse cultural settings. Overall, this study supports the growing body of literature suggesting that internalized religious beliefs and practices are associated with lower cardiovascular responses to stress. Careful consideration should be given to clearly distinguishing religiosity from spirituality, along with acknowledging cultural, ethnic, and age sensitivities, all of which have the potential to greatly enhance our understanding of how individual belief systems may influence stress responses.

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