An Exploration of Stress Reactivity, Stress Recovery, Mindfulness Meditation and Prayer with the use of Heart Rate Variability

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Abstract

Heart rate variability (HRV) is a vagal nerve-mediated index of cardiac function, and is a useful tool in investigating the sympathetic and parasympathetic functions of the autonomic nervous system. This study investigated post-stress HRV changes during mindfulness meditation (MM) and while listening to a prayer passage from the Holy Quran, which comprise two stress reduction practices that are expected to elevate HRV and promote relaxation. Undergraduate Muslim students (N = 114; 65% female) were exposed to a lab-based assessment in which HRV was measured during: (1) a 5-minute baseline-resting phase; (2) a 5-minute cognitive stress-induction phase; and (3) a 10-minute post-stress phase. In the post-stress phase, participants were randomly assigned to one of the following four 10-minute audio conditions: (1) a meditation experimental (MExp) condition involving guided-MM; (2) a meditation control (MCon) condition involving a description of MM; (3) a prayer experimental (PExp) condition involving a prayer passage from the Holy Quran; or (4) a prayer control (PCon) condition involving a description of prayer. Results revealed that the mean HF-HRV was lower during the stress-induction phase, compared to mean HF-HRV at the baseline phase. Results for male participants revealed greater mean HF-HRV for participants in the MExp group than the MCon group at the 1–5 min and 6–10 min post-stress phases and results for female participants revealed greater mean HF-HRV for the MExp group than the MCon group only at the 1–5 min phase. Further analyses of females with self-reported dysphoric mood revealed greater mean HF-HRV for participants in the MExp group than the MCon group at the 1–5 min post-stress phase and it revealed greater mean HF-HRV for participants in the PExp group than the PCon group at the 6–10 min post-stress phase. These results suggest that while MM and listening to a prayer may be involved

in different processes, they both can promote relaxation following a cognitive stressor exposure for Muslim female participants with dysphoric mood.

Keywords: heart rate variability, mindfulness meditation, prayer, Quran, stress, dysphoric mood

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(Praise be to Allah, who has guided us to this. Never could we have found guidance, had it not been for the guidance of Allah; Quran 7:43).

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Rabbana taqabbal minna innaka anta alssameeAAu alAAaleemu
(Our Lord, accept [this] from us. Indeed You are the Hearing, the Knowing; Quran 2:127)

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1.0 Introduction

The common everyday challenges of prolonged stress can lead to the onset and progression of physical and mental health disorders (McEwen & Stellar, 1993; Steptoe, 1991). In 2013, 23% of Canadians (~ 6.6 million), 15 years or older, rated most days as 'extremely stressful' or 'quite a bit stressful' (Statistics Canada, 2014). In addition, a variety of studies together suggest that 60–90% of primary care visits are related to stress issues (Puchalski, 2001). Thus the stress reduction methods utilized by individuals and their effectiveness for health enhancement and/or health sustainability is a central public health concern.

In the healthy management of stress, the autonomic nervous system (ANS) regulates visceral body functions and, in this way, plays a key role in preventing mental and physical disease (Battipaglia & Lanza, 2015; Thayer & Brosschot, 2005). The dynamic equilibrium of individuals can be deranged by the stress experienced under conditions of perceived physical or psychological threat (Chrousos, 2009; Thayer, Ahs, Fredrikson, Sollers III &Wager, 2012). The stress response can be prolonged or excessive (i.e., an exaggerated cardiac response to mild-moderate stress), delaying the reinstatement of homeostasis. This excess stress, associated with sympathetic-parasympathetic imbalance (SPI), may lead to both mental (Hovey & King, 1996) and physical dysfunctions (e.g., hypertension and myalgic pain; Fechir et al., 2008), while contributing to or exacerbating diagnosable chronic diseases (Kiecolt-Glaser et al., 2003).

Flexible ANS regulation is essential for dealing with rapidly changing environmental demands (Thayer & Brosschot, 2005; Thayer et al., 2012) and is reflected in heart rate variability (HRV) defined as the variation in the time intervals between heartbeats (Thayer et

al., 2012; Thayer, Hansen, Saus-Rose, & Johnsen, 2009). HRV is a useful tool in investigating the sympathetic and parasympathetic function and balance in the ANS (Karim, Hasan, & Ali, 2011; Thayer, Yamamoto, & Brosschot, 2009). HRV has been used to index autonomic function in relation to (but not limited to) acute stress (Fabes & Eisenberg, 1997; Pattyn, Migeotte, Neyt, den Nest, & Cluydts, 2010; Radespiel-Tröger, Rauh, Mahlke, Gottschalk, & Mück-Weymann, 2003), cardiovascular diseases (Chida & Steptoe, 2010; Kemp, Quintana, Felmingham, Matthews, & Jelinek, 2012; Stein & Kleiger, 1999) such as hypertension (Masi et al., 2007; Thayer & Lane, 2007) and coronary artery disease (Carney et al., 1988); diabetes (Ewing et al., 1981; Maser, Mitchell, Vinik, & Freeman, 2003); psychopathology (Lyonfields, Borkovec, & Thayer, 1995; Marano et al., 2009; Miu, Heilman, & Miclea, 2009; Thayer, Friedman, & Borkovec, 1996) such as major depression (Chambers & Allen, 2002; Rottenberg, 2007) and anxiety (Friedman, 2007); and emotion regulation (Calkins & Johnson, 1998; Quintana, Guastella, Outhred, Hickie, & Kemp, 2012). For the purposes of studying behavioural interventions to help recover from stress, HRV was measured to index the flexible control of the ANS via peripheral physiology (Thayer et al., 2012).

In addition, HRV has been used to examine autonomic function in relation to attentional regulation (Porges, 1992). Attentional regulation involves recognizing relevant information and inhibiting inappropriate responses to maintain health in complex environments (Sarter, Givens, & Bruno, 2001; Thayer & Brosschot, 2005; Thayer & Lane, 2000). Deficits in sustained attention are detrimental to health—as they are present in mental illnesses such as depression and anxiety (Hammar et al., 2003; Sheppes, Luria, Fukuda, & Gross, 2013). It has been suggested that the decline in attention and in other cognitive

functions due to stress is related to autonomic dysfunction. With the use of HRV, the parasympathetic activity involved in top down attention regulation can be inferred (Applehans & Luecken, 2006). Therefore, it is essential to study practices that deem to improve attention regulation via cardiac autonomic response modulation, promoting healthy stress reactivity. Together, these findings justified the importance of examining the physiological effects (sympathetic-parasympathetic activity) of stress-reduction practices (i.e., mindfulness meditation (MM) and listening to a prayer passage from the Quran) in the aftermaths of a stress response (stimulated by a stress-induction task). The following literature review begins with a summary of the effect of stress on the autonomic nervous system. Next, there is a summary of HRV, including it as a marker of psychophysiological responses and stress-related illnesses, and the psychopathological theories underlying HRV. Furthermore the review includes the evidence-based benefits of MM and spiritual/religious practices. The study's rationale and hypotheses are supported by the following review. Section 3 depicts the methods of the study, including participant recruitment, the inclusion-exclusion criteria, data acquisition equipment, self-report measures, procedures, and statistical analysis. Section 4 describes the final results of this study and section 5 discusses the study's clinical implications and limitations.

2.0 Literature Review

2.1 The Autonomic Nervous System and Stress

The autonomic nervous system (ANS) is central as it controls visceral body functions (e.g., heart activation), and plays a key role in preventing mental and physical disease (Battipaglia & Lanza, 2015; Thayer & Brosschot, 2005). The ANS consists of regions in the

central nervous system and associated peripheral nerves that anatomically and functionally divide into the excitatory sympathetic (i.e., energy mobilization, "fight or flight") and inhibitory parasympathetic (i.e., vegetative and restorative function, "rest and digest") subsystems (Appelhans & Luecken, 2006; Battipaglia & Lanza, 2015; Thayer, Yamamoto, & Brosschot, 2009). The sympathetic fibers exit thoracic and lumbar segments of the spinal cord whereas parasympathetic fibers exit the brainstem and sacral segments of the spinal cord (Porges, 2003). The dynamic equilibrium of individuals can be deranged by the stress experienced under conditions of perceived physical or psychological threat (Chrousos, 2009; Thayer, Ahs, Fredrikson, Sollers III &Wager, 2012). Physical or psychological stressors trigger a "stress response" that activates physiological arousal via the sympathetic nervous system (e.g., increasing glucose, heart rate (HR) and blood pressure; Appelhans & Luecken, 2006; Chrousos & Gold, 1992; De Kloet, Joëls, & Holsboer, 2005), which is then terminated by the activation of the parasympathetic nervous system (De Kloet, Joëls, & Holsboer, 2005).

When confronting stressors, an effective system involves the rapid activation of the stress response followed by efficient termination—reinstating homeostasis. However, if the stress response is prolonged or inadequate, it becomes difficult to reinstate homeostasis and leads to risk factors for cardiovascular disorder and psychiatric illness (Brosschot, Gerin, & Thayer, 2006; Verkuil, Brosschot, de Beurs, & Thayer, 2009). Stress responses reflected in a hyperactive sympathetic system dominating a hypoactive parasympathetic system result in elevated risks for mental and physical pathology (Thayer & Brosschot, 2005). The excess stress associated with autonomic imbalance have been proposed to lead to eating disorders, substance abuse, excess smoking/alcohol consumption (Ferguson, Willemsen, & Castañeto, 2010), suicidal ideation; autonomic imbalance can also lead to depression (Hovey & King,

1996) and physical conditions such as hypertension and myalgic pain (Fechir et al., 2008), while contributing to or exacerbating most diagnosable chronic diseases (Kiecolt-Glaser et al., 2003).

During uncertain, novel and threatening situations, there is an evolutionary advantage to respond with sympatho-excitatory preparation for default "fight or flight" threat responses. Thus, it has been proposed that a 'negativity bias' may exist in human neural systems (Thayer et al., 2012), prioritizing responses to threatening situations over safe ones. While a 'negativity bias' may have maximized survival and adaptive responses during earlier evolutionary stages, continual perception of threat is maladaptive in the modern era since it induces autonomic imbalance (i.e., a hyperactive SNS and a hypoactive PNS; Thayer et al., 2012). Amongst other effects, the energy demands for the sympathetic system become particularly extreme with prolonged domination of sympathetic over parasympathetic systems (Thayer & Brosschot, 2005). Thus the discriminative recognition of a safe situation versus a threatening situation is essential for energy conservation. In safe situations, the ventral medial prefrontal cortex (vmPFC) inhibits the fear/threat circuits of the amygdala, which, in turn, reduces the "stress" or "fear" behaviours (Thayer et al., 2012). The vmPFC is involved in the consolidation/retrieval of memories of safe contexts, which can assist the discrimination of safe versus threatening situations. Patients with damage to their medial prefrontal cortex (mPFC) report social situations as more threatening than healthy controls (Thayer et al., 2012). Since living in a chronic state of threat is detrimental to health, the proper functioning of the prefrontal cortex (PFC) is vital. Prolonged dysfunction of the PFC leading to sympathetic dominance over parasympathetic inhibition is pathogenic and associated with system inflexibility (Thayer & Brosschot, 2005).

2.2 Heart Rate Variability and Stress

Flexible ANS regulation is essential for dealing with rapidly changing environmental demands (Thayer & Brosschot, 2005; Thayer et al., 2012) and is reflected in HRV (Thayer et al., 2012; Thayer, Hansen, Saus-Rose, & Johnsen, 2009). The heart is dually innervated, receiving both excitatory sympathetic (i.e., increased HR) and inhibitory parasympathetic (i.e., decreased HR) input and HRV is a useful tool in investigating the sympathetic and parasympathetic function of the ANS (Karim, Hasan, & Ali, 2011). Since the PNS and SNS have antagonist functions is it essential to take both branches into consideration when interpreting the cause of a change in HR. For instance, an increase in HR can be due to (a) an increase in sympathetic excitation or (b) a decrease in parasympathetic inhibition (vagal withdrawal; Appelhans & Luecken, 2006).

The dynamic equilibrium of individuals can be deranged by the stress experienced under conditions of perceived physical or psychological threat (Chrousos, 2009; Sollers III & Wager, 2012; Thayer, Ahs, Fredrikson). When confronting stressors, an effective system involves the activation of the stress response where sympathetic nerve fibres release epinephrine and norepinephrine onto sinoatrial (SA) and atrioventricular nodes of the heart (i.e., increases heart rate) via a slow time course (i.e., time scale of seconds; Appelhans & Luecken, 2006; Cacioppo, Tassinary, & Bernston, 2007; Karim, Hasan, & Ali, 2011; Thayer, Ahs, Fredrikson, Sollers, & Wager, 2012). This stress response is followed by proficient termination via parasympathetic vagal nerve fibres, which release acetylcholine to efficiently terminate that response (i.e., inhibiting the SA node; reducing HR), reinstating the cardiac resting state and re-establishing homeostasis via a faster time course (i.e., time scale of milliseconds). During resting conditions, the parasympathetic (vagal) tone dominates and

HRV is mainly dependent on vagal modulations (Task Force of the European Society of Cardiology, 1996). The vagus nerve—the tenth cranial nerve—extends from the medulla oblongata and innervates the heart, lungs, esophagus, and liver, along with other organs and plays an important role in cardiovascular tone (Thayer, Loerbroks & Sternberg, 2011).

Accordingly, reduced HRV indicates a dysregulated system "locked" into patterns unresponsive to physical and environmental demands, and often associated with conditions of worry (Brosschot, Van Dijk, & Thayer, 2007) and mental stress (Fabes & Eisenberg, 1997); reduced HRV is a biomarker for low parasympathetic activation, prefrontal hypoactivity (Thayer & Brosschot, 2005) and disease risk (e.g., cardiovascular morbidity and all-cause mortality; Thayer et al., 2012). For example, in response to non-threatening stimuli, individuals with reduced HRV activate their defensive behaviour system and engaged in hyper-vigilant behaviour (Thayer & Brosschot, 2005). The lack of recognition of safe signals can lead to such chronic states of threat that are maladaptive, pathogenic, induce autonomic imbalance (i.e., sympathetic nervous system over activity) and demonstrate inappropriate energy regulation (Thayer et al., 2012). Alternatively, increased HRV suggests heart health and a system that adaptively oscillates in response to physical and environmental demands. For example, individuals with increased HRV were able to respond appropriately to neutral, non-threatening and positive stimuli, demonstrating appropriate energy regulation (Thayer et al., 2012). Thus, with the use of HRV measurements, a dysregulated "locked in" system (i.e., reduced HRV) is readily distinguished from a regulated "oscillating" system (i.e., increased HRV).

2.3 Heart Rate Variability Mechanisms & Measurement

The vagus nerve also plays an important role in respiratory tone (Thayer, Loerbroks & Sternberg, 2011). Respiration is essential to help maintain homeostasis between the internal and external environments of the human body (Yasuma & Hayano, 2004). The ANS is involved in the interaction between the respiratory and circulatory systems. Respiratory sinus arrhythmia (RSA) represents the physiologic interaction between the respiration and circulation and is seen as an index of cardiac vagal function. RSA involves HRV being synchronized with respiration, where there is a decrease and an increase in HRV during inspiration and expiration, respectively (Allen et al., 2007; Force, 1996; Yasuma & Hayano, 2004). In other words, there is increased HR (sympathetic activation) during inhalation as the parasympathetic influence is temporarily blocked, and decreased HR (parasympathetic activation) during exhalation as the parasympathetic influence is reinstated—which can be visually depicted in electrocardiograph (ECG) readings (Appelhans & Luecken, 2006; Grossman & Taylor, 2007; Grossman, Stemmler, & Meinhardt, 1990; Katona & Jih, 1975; Magagnin, Mauri, Cipresso, Mainardi, & Brown, 2013; Yasuma & Hayano, 2004). It is suggested that the energy conservation via suppression of heartbeats during exhalation can lead to efficient gas exchange, assisting with ventilation and perfusion. Since the sympathetic influence is not rapid enough to correspond with respiration, it has been suggested that RSA is mediated entirely by the PNS via the vagus nerve. Thus the magnitude of RSA can be used as a marker of vagal-meditated HRV (Appelhans & Luecken, 2006).

As previously mentioned, the decrease in HR occurs in response to the secretion of acetylcholine via parasympathetic vagal nerve fibres whereas an increase in HR occurs as a response to the secretion of the epinephrine and norepinephrine via nerve fibres onto

sinoatrial (SA) and atrioventricular nodes of the heart (Cacioppo, Tassinary, & Bernston, 2007; Karim, Hasan, & Ali, 2011; Thayer, Ahs, Fredrikson, Sollers, & Wager, 2012). Studies using pharmacological blockage techniques demonstrated that there is a greater magnitude of suppression of the RSA following cholinergic nerve pathway blockage (Grossman, Stemmler, & Meinhardt, 1990; Katona & Jih, 1975; Yasuma & Hayano, 2004), compared to adrenergic pathway blockage (Clancy et al., 2014; Coker, Koziell, Oliver, & Smith, 1984; Houtveen, Rietveld, & de Geus, 2002). These findings suggest that the vagal cholinergic pathway mediate RSA. Therefore, the variations in the time between heartbeats (i.e., HRV) can be used to infer vagal activity, with increased HRV being indicative more vagal (parasympathetic) tone (Allen et al., 2007; Force, 1996; Grossman et al., 1990; Pattyn et al., 2010).

HRV can be evaluated by numerous methods, including time domain and frequency domain methods (Karim, Hasan, & Ali, 2011; Task Force of the European Society of Cardiology, 1996). Time domain methods are deemed the simplest measures to perform, as they involve the measure of either HR during a certain time or the normal-to-normal (NN) intervals (the time between two adjacent QRS-complexes). When examining HR, one can measure the mean rate, the difference between night and day heart rate etc. When examining the NN interval, one can measure the mean NN interval, the standard deviation of the NN interval (SDNN), the difference between the largest and shortest NN interval, the mean of the absolute value of the difference between successive interbeat intervals (MSD), the square root of the mean of squared successive differences between interbeat intervals (RMSS) etc. (Berntson, Lozano, & Chen, 2005; Karim, Hasan, & Ali, 2011; Task Force of the European Society of Cardiology, 1996; Kleiger et al., 1991). SDNN is dependent on the length of the

ECG recording, where SDNN increases with longer recordings. Thus, it is essential that SDNN is compared between recordings of the same duration and the Task Force (1996) has recommended either short-term 5-minute recordings or long-term 24-hour recordings. Both MSD and RMSSD are respiratory-linked measures that represent the vagal (parasympathetic) influence on changes in HR.

HRV can also be evaluated by frequency domain methods, to examine how HRV varies with respect to specific frequency components (Karim, Hasan, & Ali, 2011; Task Force of the European Society of Cardiology, 1996). Through the use of power spectral density (PSD) analysis, the distribution of power (i.e., variance) as a function of frequency is determined. The non-parametric Fast Fourier Transform (FFT) method separates the power measure for short-term recordings into the following frequency components: very low frequency (VLF; < 0.04 Hz), low frequency (LF; 0.04-0.15 Hz) and high frequency (HF; 0.15-0.4 Hz) components measured in absolute values of power (ms^2) or normalized units (n.u.; e.g., for LF and HF). The Task Force (1996) does not recommend using the VLF when assessing short-term recordings, as its physiological explanation is less defined. However, it has been suggested that the LF and HF components vary with respect to autonomic regulation of the heart. In addition, normalized measures of LF and HF represent the control and balance of the SNS and the PNS deeming them important measures. Furthermore, the HF component is primarily attributed to fluctuations in parasympathetic control associated with respiration (RSA; i.e., represents respiratory-linked beat-to-beat changes) and is used extensively as an index of parasympathetic (vagal) control of the heart—making it the component of most interest for HRV analysis (Allen et al., 2007; Berntson et al., 1997; Cacioppo et al., 2007; Force, 1996; Pittig, Arch, Lam, & Craske, 2013). Altogether, through

the recommendations of the two international committees (Berntson et al, 1997; Force, 1996), this study will focus on frequency domain methods to interpret vagal-meditated HRV in the aftermath of a stress task.

2.4 Psychophysiological Theories of Heart Rate Variability

One of the two main psychophysiological theories that attempt to explain the flexible ANS regulation represented by HRV is the polyvagal theory (Porges, 1998; Porges, 2001). The polyvagal theory uses an evolutionary framework to describe the development of the human ANS and its involvement in social processes (Appelhans & Luecken, 2006). These proposed phylogentic developmental stages begin with the slow-acting unmyelinated dorsal vagus nerve (immobilization; e.g., passive avoidance via freezing in response to threat), then it leads to the development of the SNS (mobilization; i.e., active avoidance via fight-or-flight response) and finally it results in the fast-acting myelinated ventral vagus nerve (i.e., social communication, rapid vagal withdrawal and reinstatement; Appelhans & Luecken, 2006; Porges, 2003; Porges, 2009). According to the polyvagal theory, these three circuits are highly adaptive responses to safe and dangerous situations and respond in order from the newest to the oldest circuit (Porges, 2009). For instance, the vagus nerve's ability to withdraw and reinstate its influence on the SA node activity facilitates the engagement and disengagement with the environment (Appelhans & Luecken, 2006). The withdrawal of the fast-acting vagus nerve's inhibitory influence has a lower metabolic cost than the activation of the slow responding SNS, making the former the more adaptive mechanism. This newer efferent vagal pathway stems from the nucleus ambiguous (in the brain stem) and terminates onto visceral organs (e.g., heart, social palate, pharynx, larynx, esophagus, bronchi, facial muscles; Rottenberg, 2007). When the environment is perceived as safe, not only does the

myelinated vagus nerve influence the SA node to reduce HR, but it also influences social engagement behaviours (e.g., facial expressions, listening, head turning) via its termination on the nuclei on the facial and trigeminal nerves. In order to survive, it is not only important to discern a safe environment from a dangerous environment, but it is also essential for mammals to communicate with their social unit (Porges, 2003). While vagal withdrawal leads to sympathetic behaviour (i.e., fight-or-flight response), vagal reinstatement leads to social engagement behaviours (Appelhans & Luecken, 2006). Thus the polyvagal theory suggests that the inhibitory vagal nerve also plays a role in emotional arousal and regulation, which underlies social behaviour and it is bidirectionally-coupled with bodily sensations. In addition, the phylogentically recent neural circuits stimulate calm states via the regulation of visceral organs (Porges, 2003). Therefore the polyvagal theory states that positive behaviour, social support and positive affect promote health, whereas in contrast, the withdrawal of newer neural circuits prolong mobilization behaviours (i.e., flight-or-flight response) and is detrimental to health. According to this neurobiological model, individuals diagnosed with psychiatric conditions that involve increased social withdrawal, may be exerting more defensive responses than social responses.

The second psychophysiological theory that attempts to explain the flexible ANS regulation represented by HRV is the neurovisceral integration model (Thayer & Lane, 2000). It is argued that HRV is not only a marker of stress and resilience (i.e., ANS balance), but according to the neurovisceral integration model, HRV is also associated with a set of neural structures. Benarroch (1993, 1997) describes how the brain and the heart are bidirectionally connected in the central autonomic network (CAN). The CAN receives sensory input from the heart and also sends output to the SA node of the heart to produce

heart rate fluctuations (Thayer & Brosschot, 2005; Thayer et al., 2009). The primary output of the CAN is sent via sympathetic stellate ganglia and the parasympathetic vagus nerve that innervate the heart. The parasympathetic influences keep the heart under inhibitory control. Since the CAN produces heart rate fluctuations, HRV can be used to index vagal activity and vagally-mediated HRV may serve to index prefrontal neural functioning (Thayer et al., 2009). Thayer et al. (2009) provided a model where the prefrontal cortical areas inhibit the central nucleus of the amygdala (CeA)—the major source of cardiovascular and autonomic modulation—via vagal pathways. According to this model, the disinhibition of the CeA may lead to an increased heart rate and a decreased HRV. Since the vmPFC inhibits the fear/threat circuits of the amygdala in safe situations and inhibits the brainstem's sympathoexcitatory circuits that have an effect on heart rate (Thayer & Brosschot, 2005), it is possible that the perception of threat and safety may be linked to heart rate variability (HRV) via the vmPFC (Thayer et al., 2012).

2.5 Heart Rate Variability as a Marker of Psychopathological Risk

Since HRV is related to emotional regulation, it is essential to consider HRV when examining emotional states in psychopathological conditions such as depression (Thayer et al., 2012). The risk of cardiac mortality is substantially increased in major depressive disorder (MDD) patients (Barth, Schumacher, & Herrmann-Lingen, 2004; Nicholson, Kuper, & Hemingway, 2006; Penninx, Beekman, Honig, Deeg, & Schoevers, 2001; Whang, Kubzansky, Kawachi, Resrode, & Kroenke, 2009). Autonomic dysfunction in MDD patients has been measured via HRV (Nugent, Bain, Thayer, Sollers III, & Drevets, 2011). A meta analysis revealed that depression is associated with a reduction in cardiac vagal control (CVC; small-to-medium effect size) and that depressive symptoms were related to reduced

HRV (Rottenberg, 2007; Vaccarino et al., 2008). CVC—an index to the vagal influence on the heart with respect to the respiratory cycle—has been used substantially in the literature a biological predictor of health (Rottenberg, 2007). The polyvagal theory proposes that CVC influences the adaptation to the environment and underlies social behaviour. Thus according to the polyvagal theory, patients with depression who cannot adjust to the environment (e.g., unresponsive or fewer facial expressions during social interactions; Ellgring, 1989), who suffer from social withdrawal and experience social impairments (e.g., rejection, social isolation etc.) would have CVC deficits. In addition, depression (along with anxiety, post-traumatic stress disorder and schizophrenia) is associated with prefrontal hypoactivity and disinhibition (Thayer et al., 2012) and according to the neurovisceral integration model, the disinhibition of the CeA would explain the reduced HRV discovered in these patients. The lack of inhibition would result in an increased negativity bias towards threatening situations leading to "stress" or "fear" behaviours (Thayer et al., 2012). However, the effect of depression on CVC is not only low but also inconsistent with the literature having mixed results when analyzing CVC in depression (i.e., depressed patients have lower CVC than non-depressed controls or there are no differences CVC levels between depressed patients and non-depressed controls; Rottenberg, 2007). Thus it is essential to consider alternative factors that could influence CVC such as medication and physical health.

HRV, and more specifically HF-HRV, should also be considered when examining anxiety disorders (Thayer et al., 2012). HF-HRV is primarily attributed to fluctuations in parasympathetic control associated with respiration (i.e., RSA; Pittig, Arch, Lam, & Craske, 2013; Force, 1996) and has been used to examine autonomic dysfunction in patients with anxiety disorders (Friedman & Thayer, 1998a, 1998b; Klein et al., 1995). Many studies have

revealed that patients with anxiety disorders have lower tonic HF-HRV at rest and in response to anxiety stressors, in comparison to healthy controls (Friedman and Thayer, 1998a, 1998b; Klein et al., 1995). The latter demonstrates how patients with anxiety have an over-reactive and maladaptive response in HR and HRV to certain anxiety stressors (Pittig, Arch, Lam, & Craske, 2013). Pittig, Arch, Lam, & Craske (2013) examined HF-HRV in panic (PD), social anxiety (SAD), obsessive-compulsive (CD) and generalized anxiety disorders (GAD) during rest and during a relaxation task (i.e., silently and passively repeating "ah-nam"). Compared to matched healthy controls, all patients showed reduced HRV after controlling for age, sex, respiratory cycle time and the use of psychotropic medication, which was maintained during the relaxation task. The magnitude of the effect was larger in PD patients than the other anxiety disorders, which is a consistent result in the literature (Friedman & Thayer, 1998b; Friedman, 2007; Klein et al., 1995; Yeragani et al., 1990, 1992, 1994). These results are in line with the neurovisceral model where vagally-mediated HRV may serve to index prefrontal neural functioning (Thayer et al., 2009). According to the model, patients with anxiety disorders have deficits in inhibitory processes in the prefrontal cortical areas, resulting in reduced HRV. For instance, the lack of adequate inhibition of inappropriate anxious responses and of attentional responses, can explain the anxious responses during safe situations and the hypervigilance to threat seen across all anxiety disorders, respectively.

Anxiety disorders, trait anxiety and depression are risk factors for cardiovascular disease (CVD)—linking mental and physical conditions (Brosschot, Gerin, & Thayer, 2006). The underlying symptoms of these mental conditions revolve around preservative cognitions (e.g., excessive worrying) and it has been suggested that worry is a potential mediator of the

CVD risk. Perseverative cognitions link thoughts to stress as it has been defined as, "the repeated or chronic activation of the cognitive representation of one or more psychological stressors" (Brosschot, Gerin, & Thayer, 2006). In terms of worrying, Tallis & Eysenck (1994) proposed that it can occur in three stages: (1) focusing on an issue that needs to be solved immediately (2) maintaining focus and awareness on the unresolved threatening issue (3) preparation of the mobilization response of the SNS in anticipation of threat. Though mobilization does not partake per se, it is theorized that individuals who participate in excessive worrying suffer from a prolonged states of psychophysiological "action preparation" (Brosschot, Gerin, & Thayer, 2006).

2.6 Heart Rate Variability as a Marker of Physical Illnesses

The excessive stress associated with autonomic imbalance may not only lead to mental dysfunctions (Hovey & King, 1996), but physical dysfunctions as well (Fechir et al., 2008), while contributing to or exacerbating most diagnosable chronic diseases (Kiecolt-Glaser et al., 2003). Autonomic imbalance indicated by HRV have been associated with numerous conditions including CVD, diabetes, hypertension, osteoporosis, arthritis, Alzheimer's disease, periodontal disease, myalgic pain and certain types of cancers, in addition to muscle weakness (Fechir et al., 2008; Thayer, Yamamoto, & Brosschot, 2009). Reduced HRV can be seen in patients with coronary artery disease and congestive heart failure (Kleiger, Miller, Bigger, Moss, & the Multicenter post-infarction research group, 1987). It has been suggested that autonomic imbalance inclines patients to cardiac arrhythmias thus HRV can be used to assess cardiovascular autonomic function (Gerritsen et al., 2001). In addition, HRV can be used to predict morbidity and mortality rates in patients with a history of cardiovascular disease and conditions such as diabetes and hypertension

(Gerritsen et al., 2001; Thayer, Yamamoto, & Brosschot, 2009). HRV of 808 post-acute myocardial infarction (AMI) survivors were analyzed, while adjusting for demographics and clinical factors (Kleiger, Miller, Bigger, Moss, & the Multicenter post-infarction research group, 1987). HRV was the strongest predictor of mortality in AMI survivors, with the relative risk of morality being 5.3 times higher in the patients with low resting HRV than high resting HRV. HRV was also measured for a glucose tolerance-stratified sample (n = 605) of the general population during rest and during metronome breathing. During a 9-year follow-up, HRV measures were associated with morality rates (approaching significant levels of $p < 0.10$), while controlling for age, sex and glucose tolerance. Patients with diabetes, hypertension or cardiovascular disease suffered from an elevated risk for mortality, for instance, patients with diabetes having doubled risk of mortality than individuals without diabetes. Taken together, excess stress associated with autonomic imbalance may be linked to both mental and physical dysfunctions, thus it is essential to study stress-related psychological factors and their risk on psychophysiological conditions.

2.7 Mindfulness Meditation (MM)

Meditation is a spiritual practice and many religions have meditative elements (Phongsuphap, Pongsupap, Chandanamattha, & Lursinsap, 2008). More specifically, mindfulness meditation (MM) is an element of the Buddhist traditions that has been proposed as a non-invasive alternative or adjunct to multiple medical and psychiatric treatments in order to reduce stress. Kabat-Zinn (1982) was the first to introduce MM to the West as a clinical intervention and since then it has been reported to have positive changes in cognitive function (Chiesa, Calati, & Serretti, 2011; Ramel, Goldin, Carmona, & Mcquaid, 2004; Sedlmeier et al., 2012), attention (Anderson, Lau, Segal, & Bishop, 2007; Frewen, Lundberg,

MacKinley, & Wrath, 2011; Levinson et al., 2014; Lutz et al., 2008; Tang et al., 2007) and emotion regulation (Lutz et al., 2008; Shapiro, Brown, & Biegel, 2007; Young & Baime, 2010), as well as reductions in chronic stress (Mankus, Aldao, Kerns, Mayville, & Mennin, 2013; Ritvo et al., 2013) in its secularized form. MM, increasingly valued for its low cost physiological, psychological, and neurophysiological benefits, is characterized as a nonjudgmental awareness of present moment experiences aided by attentional focus to breathing sensations (Didonna, 2009, p. 19). During MM, participants are instructed to attend to breathing sensations for attentional anchoring. Attention is then returned to breathing sensations after thoughts, emotions and other sensations are related to as distractions. Attention to breathing sensations reminds the meditator to focus on the present moment instead of letting distractions draw awareness back to the past or forward to the future.

Current research supports the effectiveness of these programs for anxiety disorders, mood disorders, chronic pain, substance abuse, binge eating, fibromyalgia, and stress-responsive skin diseases (Astin, 1997; Kabat-Zinn, 1990; Kabat-Zinn et al., 1992; Kabat-Zinn, Lipworth & Burney, 1985; Kristeller & Hallett, 1999; Marlatt & Kristeller, 1999; Teasdale et al., 2000). Psychological benefits of MM include enhanced forgiveness (Shapiro et al., 2008), reduced anxiety, depression, perceived stress, psychological distress, binge drinking and increased mindful awareness (Song & Lindquist, 2015), self compassion, self efficacy and dispositional mindfulness (Greeson et al., 2014; Bergen-Cico, Possemato, & Cheon, 2013; Mermelstein & Garske, 2014). Through the MM practice of attending to the breath, meditators can alleviate psychological distress by focusing on the present moment instead of 'ruminating' about the past or 'worrying' about the future—which are symptoms of depression and anxiety, respectively (Brown & Ryan, 2003; Grossman, Heidenreich, &

Michalak, 2004; Masuda & Tully, 2012). In addition, MM has neurological benefits including changes in neural oscillations (Ahani et al., 2014; Chiesa & Serretti, 2010), cortical activity (Berkovich-Ohana, Glicksohn, & Goldstein, 2012; Brewer et al., 2011), and cortical plasticity (Hölzel et al., 2011; Lazar et al., 2006).

2.8 Physiological and Relaxation effects of Meditation

Additional physiological evidence suggests that meditation increases parasympathetic tone and counters the typical stress response, suggesting meditation may also be beneficial under conditions where sympathovagal balance is shifted towards sympathetic activity due to stress or disease (Phongsuphap, Pongsupap, Chandanamattha, & Lursinsap, 2008). HRV was measured in 23 undergraduate psychology students (n = 23) while they completed a mindfulness exercise that compromised of reading about mindfulness and meditation, and an exercise involving a button press to indicate periods of 'mindfulness' (i.e., mindful awareness of the breath) and periods of 'mindlessness' (i.e., not aware of the breath; Burg, Wolf, & Michalak, 2012). Results indicated that participants that exhibited more periods of 'mindfulness' had higher HRV, suggesting that higher HRV during MM may elude to heighten self-regulated attentional processes. HF-HRV was examined in maladaptive perfectionist (n = 24) and non-perfectionist (n = 43; score on the Perfectionism Cognitions Inventory $\geq$ 66) that listened to guided MM instructions or a MM control audio in the aftermath of a stress-induction task (Azam et al., 2015). Results indicated that compared to maladaptive perfectionist, only non-perfectionist had an increase in HF-HRV in response to meditation post-stress, demonstrating that meditation promoted relaxation in non-perfectionists following a cognitive stressor. To date, there has not been an investigation comparing the effects of MM on relaxation to other alternative methods of stress reduction.

The purpose of this current study was to introduce prayer as a possible alternative method of stress reduction and to examine how its physiological effects compare to the effects of MM.

2.9 Physiological and Relaxation effects of Spiritual and Religious Practices

Another non-invasive method of reducing stress is prayer, the spiritual/religious practice that can enhance cognition, communication and creativity, as well as physical and emotional health (Newberg & Waldman, 2010). There are meditative elements to most spiritual practices and particularly to prayer, which typically takes the form of a focus on words that express and support intentions to engage in positively transcendent activities. Transcendent activities go beyond the physical human experience and revolve around strengthening the connection between the practitioner and the Higher Power (i.e., God).

Given the health benefits of MM, it is relevant to point out that one difference between Buddhist meditation and contemplative prayer is that prayer revolves around connecting with a Higher Power (i.e., God) via cognitions and behaviours believed to be transcendent (Ferguson et al., 2010) whereas MM follow the Buddhist principle of non-theism and the individual engages in practices that do not necessarily require belief in external intervention. Nonetheless, similar to meditation, prayer also involves focusing attention on the present moment, while additionally focusing on transcendent actions. When individuals focus on transcendence in the present moment, they are less likely to allow distractions to draw their attention back to past or future concerns. Individuals tend to return their focus to transcendent actions after non-avoidantly accepting thoughts, emotions and external stimuli as distractors.

Prayer can have psychological benefits such as peace of mind, while supporting the release of tension and reducing distress (Johnson et al., 2009). In addition, prayer leads to

physiological benefits like feelings of relaxation and calmness, and, specifically, to more relaxed breathing. A meta-analysis recently revealed that prayer has a significant positive effect on mental health (Possel, Black, Bjerg, Jeppsen, & Wooldridge, 2014). Prayer frequency, specifically, the frequency of private (individual) prayer, positively correlates with self-reported indications of mental health. For example, prayer frequency has been inversely related to depression in caregivers of patients with dementia and inversely related to psychoticism in Catholic and Protestant 6th grade students. The stress-buffer hypothesis suggests that under high stress conditions, religiousness (i.e., prayer frequency, religious orientation, secure attachment to God, spiritual life integration, service attendance) reduces the negative effects of stress. For example, cardiac patients who used prayer to cope with the stress of their heart surgery had higher levels of self-reported hope and optimism (Possel et al., 2014). In addition, adults in the United States (USA) who prayed more frequently, reported lower levels of anxiety symptoms (Possel et al., 2014). The positive effects of prayer on mental health can be perhaps partly explained by expectancy theory (Olson et al., 1996), which predicts enhanced well-being when expectations are fulfilled. In relation to prayer, the well-being of a practitioner can be specifically enhanced by feeling more secure and close to God when prayer expectations are fulfilled. Possel et al. (2014) further examined prayer expectancy by analyzing trust-based belief about whether, when and how prayers are answered. Individuals with flexible beliefs believe prayers are answered when God feels it is best (as opposed to being answered immediately) and that they will receive what is needed most (as opposed to exactly what is prayed for). As trust-based believers are more likely to believe prayers are fulfilled, according to expectancy theory, trust-based believers would have better mental health. Prayer, and specifically prayer frequency, has also been shown to

be negatively associated with self-reported symptoms of mental health (and positively associated with anxiety, depression, obsessive-compulsive disorder, paranoid ideation, phobic symptoms and somatization; Possel et al., 2014). These relationships may also be predictable with expectancy theory, as detriments to well-being are predictable when expectations are not fulfilled (Possel et al., 2014). In relation to prayer, the well-being of a practitioner can be reduced when prayer-related expectations are not met leading to uncertainty, confusion, anxiety and depression.

Given the positive impact of spirituality on mental health and wellbeing, a number of mental health interventions have sought to employ spiritual practices as their main therapeutic element (See Appendix for a systematic review of spirituality based psychological interventions). While the effects of Asian forms of meditation like MM have been widely studied, to date, no empirical study has compared the physiological effects of MM to listening to the a prayer passage. This study will explore the effect of listening to guided MM versus listening to a prayer passage from the Quran (i.e., the religious text of Islam). Stress reactivity outcomes will be measured by HRV following meditation and prayer in healthy individuals. Findings from this research will be used to help inform targeted interventions aimed at promoting stress-reduction.

3.0 Methods

3.1 Participants

This study was conducted at York University, a large public university where undergraduate students of all years of study and majors were recruited through an online undergraduate participant pool that grants course credit and through the on-campus organization called the Muslim Student Association (MSA).

Students were required to be enrolled in an undergraduate program (15–29 years old) at York University and to self-identify as a Muslim (i.e., a follower of the religion of Islam) and believe in a Higher Power. Prior to the experimental protocol, participants were screened for self-reported cardiac conditions (e.g., hypertension and heart disease) and psychiatric conditions (e.g., depression and anxiety) associated with ANS dysregulation and, by implication, abnormal HRV. Students disclosing any of the aforementioned conditions (past or current) were excluded from the study, as they would confound the normative phasic HRV changes expected (Kemp et al., 2012; Marano et al., 2009). Participants were also excluded if they had a history of practicing MM or had minimal MM exposure (> 60 minutes).

Although there were no risks in undergoing HRV recording assessments, some participants may have felt uncomfortable answering questions related to medical history, automatic thoughts, religious beliefs, prayer experiences or performing a cognitively demanding task. If uncomfortable answering particular questions, participants had the option to select "prefer not to answer" for the questionnaires and in addition, participants have the option to terminate participation at any time without any penalties.

3.1.1 Sample size estimation. Using G* Power 3.0 (Erdfelder, Lang, & Buchner, 2007), it was estimated a priori that a total sample of 64 participants would provide an acceptable power (0.80) to detect a medium effect size (Cohen's $f = 0.25$, partial $\eta^2 = 0.06$) with an alpha set at 0.05 to detect between-group differences in mean HF-HRV using a factorial ANOVA design. According to the literature, changes in mean HF-HRV during mindfulness meditation (MM) have been reported to be in ranges of medium (Burg & Wolf, 2012; Takahashi et al., 2005) to large effect sizes (Krygier et al., 2013). In relation to prayer, however, there is a paucity of research changes in HF-HRV in response to prayer. Given that

prayer has meditative elements (Phongsuphap, Pongsupap, Chandanamattha, & Lursinsap, 2008), we based sample size estimation for a medium-ranged effect size (Cohen's $f = 0.25$, partial $\eta^2 = 0.06$).

3.1.2 Random allocation and stratification. Participants were stratified based on their sex and the Centrality of Religiosity Scale-15 (CRS-15; non-religious (0–2.0), religious (2.1–3.9) or highly-religious (4.0–5.0)) scores (Huber & Huber, 2012). Stratification by sex and religiosity was aimed at obtaining an identical number of non-religious, religious and highly religious females and males per condition.

After the experimenter (or the trained assistant) calculated CRS-15 scores, they randomly allocated participants to one of the four study conditions (i.e., MExp, MCon, PExp or PCon) based on their sex and their CRS-15 scores (see Appendix for randomization chart and details on the randomization method). Allocation concealment was used to conceal the allocation sequence until the moment of the assignment. The experimenter (or the trained assistant) did not have foreknowledge of the forthcoming random allocations, as the allocations were based on CRS-15 scores. This randomization procedure took place before Phase 1 of the study. However, no indication was provided to the participants as to which condition they were assigned to.

3.2 Materials

3.2.1 Heart rate variability (HRV) data collection & analyses. Electrocardiogram (ECG) recordings were collected using ADInstruments' (ADI) PowerLab 4-channel data acquisition system (Colorado Springs, United States), which utilizes 2 adhesive electrodes applied to the chest and 1 ground electrode on the ankle. An ADI respiratory belt-transducer was also used to obtain respiratory measures. The belt was securely placed across a

participant's midsection in order to acquire respiration rate data (Allen, Chambers, & Towers, 2007). This current paper will focus only on the HF-HRV data and not the respiration data collected.

3.3 Measures

3.3.1 High-frequency heart rate variability (HF-HRV) measure. LabChart Pro software by ADI, integrated with the PowerLab unit, was used to calculate frequency-based HRV metrics (Allen et al., 2007). As previously mentioned, frequency-based metrics are considered a better representation of the sympatho-vagal response than time-domain metrics (Force, 1996). Thus, following the recommendations of two international committees (Berntson et al, 1997; Force, 1996), frequency domain methods were analyzed to interpret vagal-mediated HRV.

The non-parametric Fast Fourier Transform (FFT) method separates the power measure for short-term recordings into the following frequency range components: very low frequency (VLF; < 0.04 Hz), low frequency (LF; 0.04–0.15 Hz) and high frequency (HF; 0.15–0.4 Hz) components. The HF component (with power computed as units of milliseconds) is used extensively as an index of parasympathetic (vagal) control of the heart (Allen et al., 2007; Berntson et al., 1997; Cacioppo et al., 2007; Force, 1996; Pittig, Arch, Lam, & Craske, 2013). HF-HRV is primarily attributed to fluctuations in parasympathetic control associated with respiration (RSA; i.e., represents respiratory-linked beat-to-beat changes). Since MM involves attentional focus on breathing sensations (i.e., respiration), HRV can be used as a physiological tool with which to assess mindful states, on which respiration measures can be controlled for (Allen, Chambers, & Towers, 2007; Grossman &

Taylor, 2007; Porges & Byrne, 1992). This study reports on both HF-HRV and respiration rate measures.

3.3.2 Self-report measures.

Automatic Thoughts Questionnaire (ATQ; Hollon & Kendall, 1980). The ATQ (see Appendix) was developed by Hollon & Kendall (1980) to evaluate four dimensions of self-directed automatic negative statements: 1) personal maladjustment and desire for change, 2) negative self-concepts and negative expectations, 3) low self-esteem, 4) helplessness. The ATQ consists of 30 items, each item being the thought (e.g., "I feel like I'm up against the world"), with scores ranging from 30 to 150. The participant assessed the frequency of the thought on a 5 point likert scale (1 = not at all; 2 = sometimes; 3 = moderately-often; 4 = often; 5 = all the time). It has been found to reliably distinguish depressed from non-depressed groups, with a Cronbach's alpha of 0.96 (Hollon & Kendall, 1980). This questionnaire was administered to all the participants before Phase 1 of the study.

The Centrality of Religiosity Scale-15 (CRS-15; Huber & Huber, 2012). The CRS-15 (see Appendix) measures the centrality, importance or salience of religious meanings by examining five dimensions of religiosity: public practice, private practice, religious experience, ideology and intellectual dimensions. The CRS-15 consists of 15 items (e.g., "To what extent do you believe that God or something divine exists?") and options are divided into categories of a five-level answer-scale (e.g., very much so, quite a bit, moderately, not very much and not at all). Reliability of the individual dimensions ranged from 0.92 to 0.96 for the CRS-15. The CRS-15 is scored on a 5-point scale: 1.0–2.0 as not religious; 2.1–3.9 as religious; and 4.0–5.0 as highly religious. This questionnaire was administered to all the participants before Phase 1 of the study.

3.3.3 Other questionnaires.

Demographics and religious characteristics questionnaire. The demographics and religious characteristics questionnaire (see Appendix) involved a series of questions about their demographics (e.g., age, sex, major, ethnicity etc.), religious characteristics (e.g., sect of Islam, prayer-related trust-based beliefs, familiarity with the Quran, religious rituals/prayers etc.) and additional questions (e.g., physical activity levels, irregular menstrual cycles, caffeine intake, nicotine and alcohol consumption). This questionnaire was administered to all the participants before Phase 1 of the study.

Pattern Recognition Task (PRT) questionnaire. The PRT questionnaire (see Appendix) involved a total of 3 questions. The experimenter (or the trained assistant) asked the participants to verbally rate the level of difficulty of the PRT on a scale of 5 (1 – Extremely easy; 2 – Easy; 3 – Average; 4 – Difficult; 5 – Extremely difficult), to verbally rate how stressful the PRT task was on a scale of 5 (1 – Not stressful at all; 2 – A little stressed; 3 – Moderately stressed; 4 – Stressed; 5 – Extremely stressed) and to verbally rate their performance on the PRT task on a 5-point scale (1 - Poor Performance; 2 - Below Expectations; 3 - Met Expectations; 4 - Above Expectations; 5 - Exceptional Performance) This questionnaire was administered to all the participants immediately after the end of the stress-induction phase (Phase 2).

Comprehension of Surah Rahman questionnaire. The comprehension of Surah Rahman questionnaire (see Appendix) involved the participant verbally translating 25 verses from Surah Rahman (i.e., the prayer passage used in the PExp group) From Arabic to English. This questionnaire was administered only to participants in the PExp group immediately after the post-stress phase (Phase 3). After the entire experiment was completed,

the experimenter calculated the percentage of the passage understood by the participants by dividing the total number of verses understood by 25.

3.4 Procedure

The research proposal was reviewed and approved by the York University Human Participants Review Sub-Committee. All participants provided written informed consent upon arriving at the laboratory session. Upon arrival at the lab, and after obtaining informed written consent to participate, all participants completed computer-based self-report questionnaires and a demographics and religious characteristics questionnaire. Following this, all participants were first measured during a baseline rest phase (Phase 1), followed by a cognitive stress-induction phase (Phase 2), and a post-stress condition (Phase 3) while attached to and measured by the electrocardiogram unit (ECG). During all study phases (Phases 1–3), participants were wearing 3 adhesive electrodes and a respiratory belt-transducer to measures HF-HRV and respiration, respectively. No indication was provided to the participants as to which condition they were assigned to, or to the purpose of the stress-induction and post-stress phases.

The protocol consists of three phases which each participant had undergone in the same order: (1) Baseline phase (5 minutes); (2) Stress-induction phase (5 minutes); and then the (3) Post-stress phase where participants were random assignment to undergo one of the following four 10-minute post-stress conditions listening to: (i) guided MM (MExp), (ii) a description of meditation (MCon), (iii) a prayer passage from the Quran (PExp), or (iv) a description of prayer (PCon).

Baseline phase (Phase 1). Participants were instructed to sit with their eyes closed. They were instructed to not make any sudden movements or speak during this time.

Stress-induction phase (Phase 2). A stress-induction phase was used in attempt to elicit cardiovascular stress. This condition required participants to work through a Pattern Recognition Task (PRT) for 22 trials in total. The PRT elicits sympathetic activation as a response to real-time error detection (Fechir et al., 2008; Hajcak, McDonald, & Simons, 2004).

In this task, participants needed to determine the pattern of 4 alphanumeric characters were presented at the top of the screen for 8 seconds (Figure 2.1). After 8 seconds, a 5th character will be shown and the words "True or False" will appear in the middle of the screen (Figure 2.2). Participants indicated whether or not this 5th character follows the pattern, by choosing the corresponding key presses that indicate "True" or "False" (see Appendix for set of patterns used). All patterns were created so that they did not have a correct solution, however immediate feedback for the task was configured using a pre-determined random order, to provide an equal number of "Right" and "Wrong" answers. Immediately after the response, feedback appeared for "Right Answer" (bottom right of the screen) or "Wrong Answer" (bottom left of the screen) for 4 seconds until the next trial begins (Figure 2.3). The total "Correct" and "Incorrect" score were displayed throughout the duration of the task. Participants were informed of the following, "*this task will measure your capacity for cognitive processing. The average score on this task is 80–85% correct answers, with a response time of less than 1 second. This is a required minimum performance and your individual performance must be close to or equal to the average performance of all subjects, therefore please respond as quickly, but as accurately as possible*" in order to motivate participants to perform to the best of their abilities (instructions adapted from Dedovic et al.,

2005). At the end of 22 trials, all participants viewed the same final score of 50% (Figure 2.4).

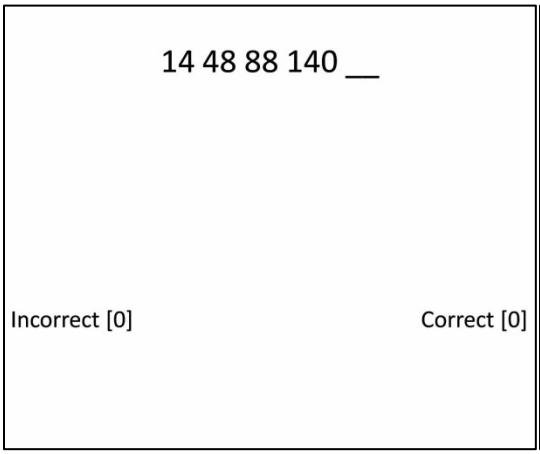

Figure 2.1

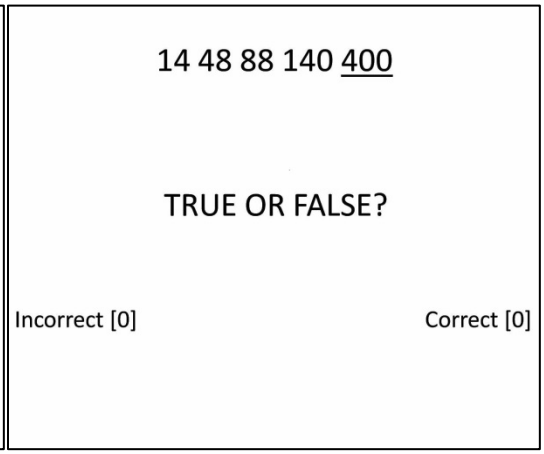

Figure 2.2

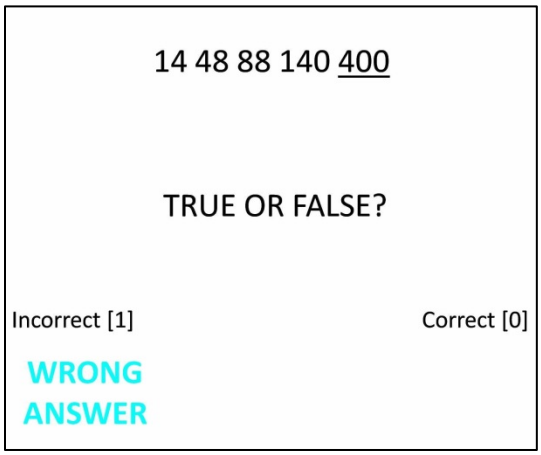

Figure 2.3

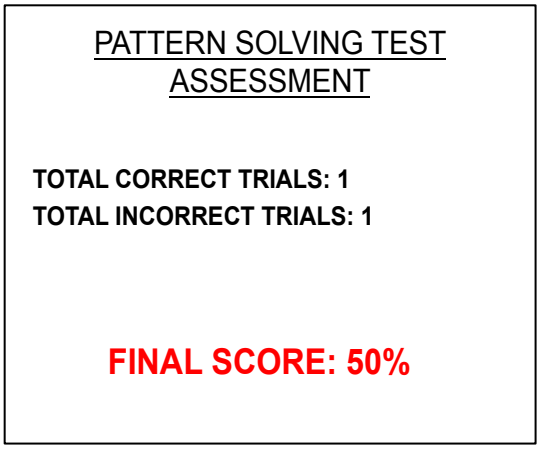

Figure 2.4

Figures 2. Figures 2.1–2.3 demonstrate the three phases of a trial in the PRT. Figure 2.4 deomnstrates the total performance feedback

After the stress-induction phase, all participants completed the Pattern Recognition Task (PRT) questionnaire (see Appendix).

Post-stress phase (Phase 3). Immediately following the PRT, participants were in one of the four post-stress conditions (MExp, MCon, PExp or PCon). Each experimental and control condition was 10 minutes in duration and was played via headphones.

Meditation Experimental (MExp) vs. Meditation Control (MCon) Condition. The audio presented to participants assigned to the MExp group involved a guided recording that provided MM instructions, which emphasized sustained attention to breathing sensations and a reorientation to breathing sensations once aware of thoughts, emotions, and other sensations (Ritvo et al., 2013).

The MCon involved a descriptive recording of historical and scientific information on MM but did not explicitly include any specific MM instruction. The audio used for the MCon group was designed to be structurally identical to the audio used for the MExp group in non-specific factors of eyes closed, seated position, and duration. This corresponds to the approach taken in studies of MBSR, wherein an active control condition involved health education (e.g., nutrition, chronic disease) but did not feature any specific mindfulness training (MacCoon et al., 2012; Rosenkranz et al., 2013). This approach was adapted to examine if MM differs from a listening to a description of MM.

Both recordings used in the MExp and MCon groups featured the voice of a clinical health psychologist experienced in the practice of MM and its administration.

Prayer Experimental (PExp) vs. Prayer Control (PCon) Condition. The prayer experimental condition involved a 36-year old male reciting a prayer passage from the Quran called Surah Rahman in Arabic (surah/chapter 55). It was essential to select a reciter who has

studied the rules governing pronunciation *(tajweed)* during recitation of the Quran. Qari Ziyaad Patel's recitation of Surah Rahman was used for the purposes of this study, as he is a renowned reciter, who perfected this *tajweed* under the supervision of Hafiz Dr. Abdul Qadir Hansa Sahib and has further studied *tajweed* at Al-Azhar University in Cairo, Egypt. Only participants in the PExp group completed the comprehension of the meaning of Surah Rahman questionnaire (see Appendix) immediately after the end of the post-stress phase (Phase 3).

The PCon involved a descriptive recording of historical and scientific information on prayer in general and specifically on Islamic prayer, but did not explicitly include any prayer passages from the Quran. The PCon group was designed to be structurally identical to the PExp group in non-specific factors of eyes closed, seated position, audio being played of equal duration to the PExp group. This recording was presented in English, to ensure that all participants understand what is being said. The PCon group was included to examine if listening to prayer differs from a listening to a description of prayer.

The recording used for the PCon group featured the voice of the same clinical psychologist who was used for the MExp and MCon groups.

Debrief. During the debriefing period, participants were informed that their results on the cognitive stress-induction task are not a reflection of their personal abilities. Participants were informed of the design of the PRT in providing randomly pre-determined feedback, and were asked that they do not share this information with other students who may partake in the experiment in the future. The participants in the PExp group were asked how much of the recording they understood (see Appendix) and then were provided with the translation of the prayer.

3.5 Data Extraction and Pre-processing of Physiological Measures

For ECG analysis, 5-minutes from the baseline phase, the first 5-minute epochs from the stress induction phase and 10-minute from the post-stress phase were used. The 10-minute post-stress recordings were divided into two 5-minute segments in order to: a) keep the time-length of the ECG recordings used to calculate HRV consistent (i.e., 5 minutes for baseline, stress-induction, and two post-stress phases); and b) to allow for an additional time-point to assess HF-HRV changes within each study condition.

The software automatically detected QRS complexes of the raw ECG recordings. An assistant visually inspected heartbeats in order to check whether all QRS complexes were included. If the software did not include a QRS complex, the assistant manually set the label to include it. Data sets were only fully excluded from further analysis if there were unanalyzable ECG data (e.g., insufficient analyzable beats recorded or signal noise preventing the detection of QRS complexes).

3.6 Hypotheses

The following stress reactivity and stress recovery (see Figure 1) hypotheses were evaluated:

1) **Hypothesis 1 – Stress Reactivity.** Stress-induction phase (Phase 2) mean HF-HRV will be significantly lower than baseline phase (Phase 1) mean HF-HRV for all participants.
2) **Hypothesis 2 – Stress Recovery during Mindfulness Meditation.** At the post-stress-induction phase (Phase 3a and 3b), participants assigned to the MExp group will exhibit significantly greater mean HF-HRV than participants assigned to the

MCon group. Differences in HF-HRV in response to the MExp and MCon groups will be examined separately for males and females.

3) **Hypothesis 3 – Stress Recovery while Listening to Prayer.** At the post-stress-induction phase (Phase 3a and 3b), participants assigned to the PExp group will exhibit significantly greater mean HF-HRV than participants assigned to the PCon group. Differences in HF-HRV in response to the PExp and PCon groups will be examined separately for males and females.

4) **Hypothesis 4 – Stress Recovery during Mindfulness Meditation vs. Listening to a Prayer.** At the post-stress-induction phase (Phase 3a and 3b), participants assigned to the MExp group will exhibit no statistically significant differences in mean HF-HRV compared to participants assigned to the PExp group. Differences in HF-HRV in response to MExp and PExp will be examined separately for males and females.

5) **Hypothesis 5 – Stress Recovery and Negative Automatic Thoughts.** At the post-stress-induction phase (Phase 3a and 3b), participants with elevated negative automatic thoughts (ATQ scores ≥ 60) assigned to the MExp and the PExp groups will exhibit significantly greater mean HF-HRV compared to participants assigned to the MCon and PCon groups, respectively. Differences in mean HF-HRV in response to the PExp and MExp groups compared to their respective controls (i.e. MCon and PCon) will be examined separately for males and females, stratified for low (< 60) vs. high ATQ scores (≥ 60).

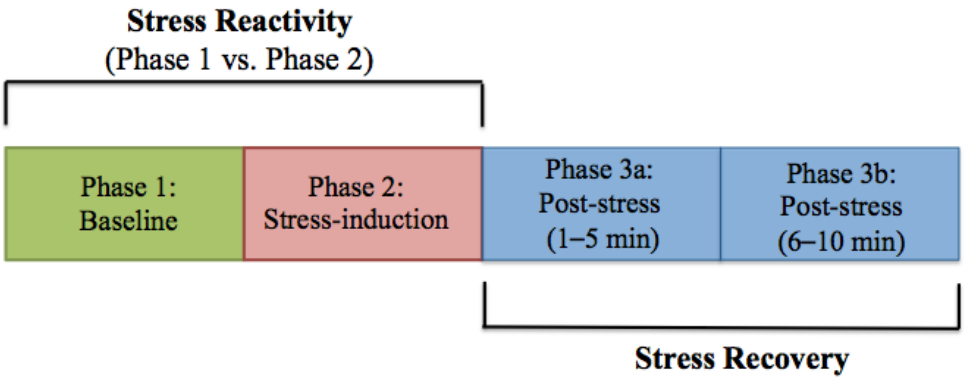

Figure 1. Stress reactivity and stress recovery illustrated based on the three study phases. During Phase 1, baseline HF-HRV was measured for 5 minutes. During Phase 2, HF-HRV was measured for 5 minutes during a stress-induction task called the Pattern Recognition Task (PRT). During Phase 3, HF-HRV was measured for 10 minutes during a post-stress listening task (i.e., MExp, MCon, PExp or PCon). During the analysis, the 10-minute post-stress-induction phase was divided into 5-minute components (i.e., 1–5 min and 6–10 min) and analyzed separately.

3.7 Statistical Analyses

Preliminary analyses entailed the examination of outliers and normality in the distribution of HF-HRV during each study phase (i.e., baseline phase, stress-induction phase, 1–5 min post-stress-induction phase, 6–10 min post-stress-induction phase). Given the positive skew in the mean HF-HRV distributions at the stress-induction phase, 1–5 min post-stress, 6–10 min post-stress, mean HF-HRV was log-transformed to approach normality prior to statistical analyses. This process was followed by the calculation of descriptive statistics for all demographic variables (e.g., age, study major, year of study, and religious characteristics) and psychometric indices (e.g., ATQ). Next, possible differences in demographic and psychological characteristics between study groups (i.e., MExp, MCon, PExp, PCon) at baseline were evaluated using one-way analysis of variance (ANOVA) for numeric and chi-square test of independence for categorical variables.

To evaluate changes in mean HF-HRV following the stress induction task in all participants (i.e., Hypothesis 1 – Stress reactivity), a 2 × 2 repeated measures analysis of variance (ANOVA) was conducted with sex (male vs. female) as the between-subjects and phase (baseline phase and stress-induction phase) as the within-subjects factor. Statistically significant main effects or interactions will then be followed by the analyses of simple main effects.

To evaluate changes in mean HF-HRV after stress induction phase and allocation to MExp, PExp, MCon, or PCon groups (i.e., Hypothesis 2, 3, and 4 – Stress Recovery), a 2 × 2 × 2 × 3 repeated measures analysis of variance (ANCOVA) was conducted with intervention (mindfulness meditation vs. listening to a prayer passage), condition (experimental vs. control), and sex (male vs. female) as between-subjects factors, phase (stress-induction, 1–5

min post-stress, 6–10 min post-stress) as the within-subjects factor, and mean HF-HRV at baseline as the covariate. Statistically significant main effects or interactions will then be followed by the analyses of simple main effects using pairwise post-hoc comparisons.

Finally, to evaluate changes in mean HF-HRV in response to MExp and PExp compared to their respective control conditions in participants with low ATQ scores (< 60) and high ATQ scores (≥ 60; i.e., Hypothesis 5 – Stress Recovery), a 2 × 2 × 2 × 3 repeated measures analysis of covariance (ANCOVA) was conducted with intervention (mindfulness meditation vs. listening to prayer), condition (experimental vs. control), and ATQ score (ATQ scores ≥ 60 vs. ATQ scores ≥ 60) as between-subjects factors, and phase (stress-induction, 1–5 min post-stress, 6–10 min post-stress) as the within-subjects factor. Given the low number of male participants when ATQ scores were stratified within study groups, evaluation of hypothesis 5 was limited to only female participants. For this analysis, ATQ scores of the participants were divided into two groups (i.e., ATQ scores < 60 vs. ATQ scores ≥ 60) according to available norms for dysphoric mood in young adults (Ingram, Johnson, Bernet, & Dombeck, 1992; Lightsey, 1994; Lightsey & Christopher, 1997).

4.0 Results

4.1 Outline of Results Section

The presentation of the results will begin with descriptions of the participation recruitment and flow, then baseline group similarities/differences are stated. These results are followed by a breakdown of the results based on each hypothesis stated in section 3.

4.2 Participant Recruitment and Flow

Figure 3 outlines participant flow diagram according to CONSORT statement (Schulz, Altman & Moher, 2010). Of the 154 potential participants (63.6% female), 28 did

not meet the inclusion criteria (i.e., 12 were not dedicated Islamic practitioners, 12 had a history of MM or minimal practice exposure over 60 minutes, 2 had a history of cardiovascular disease, and 2 had been diagnosed with depression). In addition, 5 individuals did not complete the study protocol due to technical (n = 4) or health-related issues (n = 1), leading to a total of 121 participants, randomized to one of the four study groups. Of these 121 subjects who completed the full protocol, an additional 7 individuals were excluded due to unanalyzable ECG data (e.g., insufficient analyzable beats recorded or signal noise), bringing the final sample to a total of 114 individuals available for analysis. Following randomization, participants were allocated to 4 study groups: meditation experimental (MExp = 30; 70% female), prayer experimental (PExp = 27; 66.7% female), meditation control (MCon = 29; 62.1% female), or prayer control (PCon = 28; 60.7% female) condition.

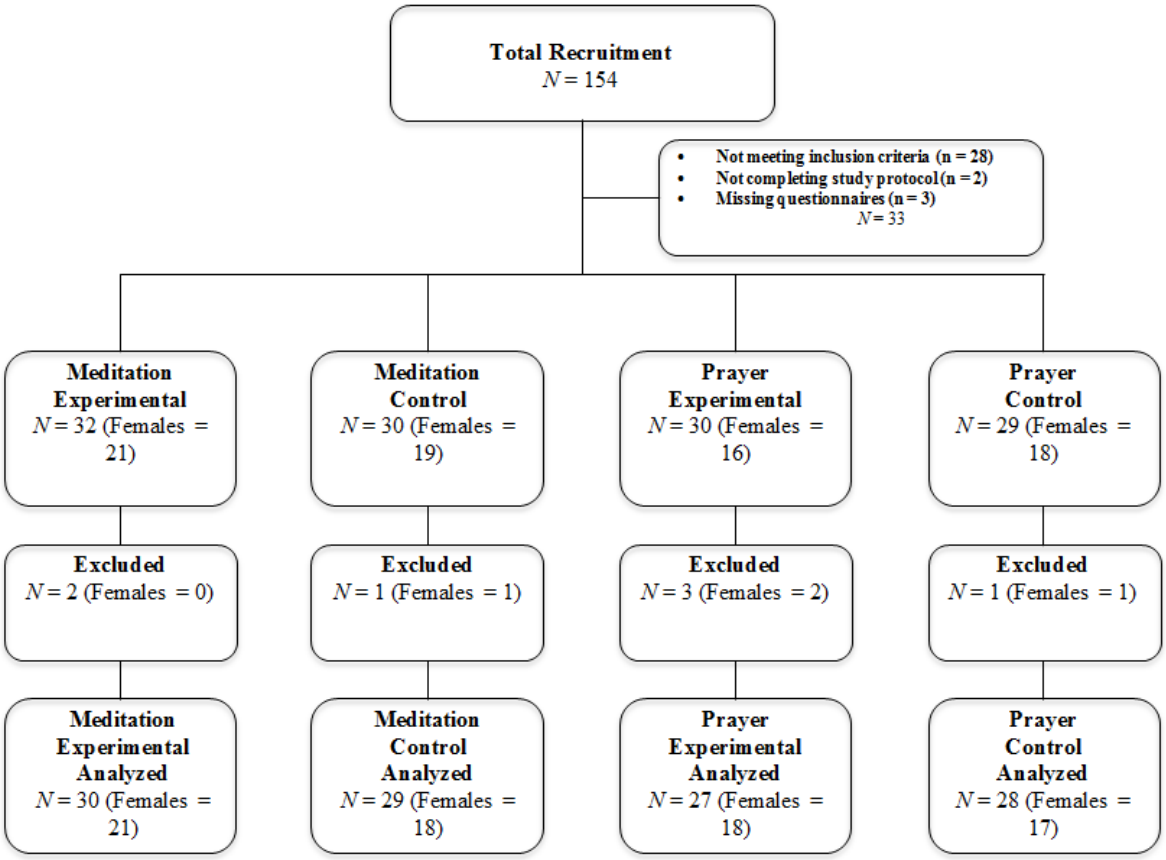

Figure 3. Participant flow through study

4.3 Group characteristics

Demographic characteristics. Participants were 114 Muslim (64.9% female) undergraduate York University students with a mean age of 19.5 (*SD* = 2.5) years. They were mainly first (64.0%) and second year (20.2%) students attending programs in Psychology (24.6%), Kinesiology (16.7%), Biomedical science (9.6%), or Business Management (17.5%). Ethnically, they were from South Asian (54.4%), West Asian (24.6%), Black African (14.0%), and Indo-Caribbean, South East Asian, White (Caucasian) and mixed (7.0%) ethnic backgrounds. As seen in Table 1, there were no statistically significant differences between groups in mean age ($p = 0.81$), year of study ($\chi^2(12) = 14.2$, $p = 0.60$), choice of major ($\chi^2(12) = 10.3$, $p = 0.59$), and ethnic background ($\chi^2(9) = 3.9$, $p = 0.91$). Participants came primarily from the Sunni (71.1%) or Shi'a (21.1%) Islamic sects, with the majority (58.8%) indicating high levels of religious involvement (i.e., "I consciously make an effort to follow Islam"). While the majority of participants did not speak Arabic as their first or second language (82.5%), many reported low (53.5%) or moderate (17.5%) levels of understanding of the Quran. In terms of engagement in prayer rituals, on average, most participants reported listening to the Quran sometimes (50.0%) or often (28.1%), with an estimated 7.0% reporting never having listened to the Quran (see Table 2).

Comprehension of the meanings and theme verses of Surah Rahman in the PExp group ranged from 0–64% (*M* = 14.6%, *SD* = 19.24), and overall participants reported listening to Surah Rahman sometimes (54.4%) or often (12.3%), however, about 25.4% of students reported to have never previously listened to it. Similarly, most participants reported on average, praying salat (i.e., an obligatory Islamic prayer) a couple times a week (24.6%) to five times a day (39.5%). As seen in Table 2, there were no statistically significant

differences between all the groups in terms of Islamic sect ($\chi^2(6) = 8.60$, $p = 0.20$), level of Quran understanding ($\chi^2(9) = 6.92$, $p = 0.65$), frequency of Quran listening ($\chi^2(9) = 8.75$, $p = 0.46$), frequency of Surah Rahman listening ($\chi^2(9) = 13.956$, $p = 0.12$) and salat frequency ($\chi^2(12) = 6.744$, $p = 0.874$), as these proportions were largely similar between groups. Finally, given that previous research has highlighted the influence of physical activity levels, irregular menstrual cycles, caffeine intake, nicotine and alcohol consumption on autonomic activity (Coote, & Townend, 2002; Fagius & Berne, 1994; Nugent et al., 2011; Routledge, Chowdhary; Sjoberg & Saint, 2011; Thayer et al., 2009) we examined potential differences between groups on these variables. There were no statistically significant differences between groups in weekly exercise ($\chi^2(6) = 9.66$, $p = 0.14$), irregular menstrual cycles ($\chi^2(9) = 15.68$, $p = 0.74$), caffeine intake ($\chi^2(9) = 8.18$, $p = 0.516$), smoking ($\chi^2(12) = 15.190$, $p = 0.23$) or alcohol consumption ($\chi^2(9) = 4.50$, $p = 0.88$; See Table 3).

Table 1. Demographic Characteristics at Baseline across all Groups

Demographics Characteristics		Mindfulness Meditation		Listening to Prayer		Tests of Significance
		Experi-mental (*N* = 30)	Control (*N* = 29)	Experi-mental (*N* = 27)	Control (*N* = 28)	
Age (years) (*SD*)		19.8 (2.6)	19.4 (2.7)	19.6 (2.6)	19.2 (1.9)	$p = 0.81$
Sex, *n* (% female)		21 (70)	18 (62.1)	18 (66.7)	17 (60.7)	$\chi^2(3) = 0.697$, $p = 0.87$
Ethnicity, *n* (%)						
	West Asian	6 (20.0)	6 (20.7)	8 (29.6)	8 (28.6)	$\chi^2(9) = 3.958$, $p = 0.91$
	South Asian	19 (63.3)	14 (48.3)	15 (55.6)	14 (50.0)	
	Black – African	3 (10.0)	6 (20.7)	3 (11.1)	4 (14.3)	
	Other	2 (6.7)	3 (10.3)	1 (3.7)	2 (7.1)	
Study Major, *n* (%)						
	Psychology	9 (30)	9 (31.0)	4 (14.8)	(21.4)	$\chi^2(12) = 10.273$, $p = 0.59$
	Kinesiology & Health Sci.	4 (13.3)	3 (10.3)	7 (25.9)	(17.9)	
	Biomedical Science	1 (3.3)	4 (13.8)	3 (11.1)	(10.7)	
	Business Management	8 (26.7)	5 (17.2)	2 (7.4)	(17.9)	
	Other	8 (26.7)	8 (27.6)	11 (40.7)	(32.1)	
Family History of Mental Illness, *n* (%)						
	Yes	3 (10.0)	2 (6.9)	1 (3.7)	2 (7.1)	$\chi^2(3) = 0.865$, $p = 0.83$
	No	27 (90.0)	27 (93.1)	26 (96.3)	26 (92.9)	

Note. *SD* = standard deviation

MExp: Meditation Experimental; MCon: Meditation Control; PExp: Prayer Experimental; PCon: Prayer Control

West Asian: Black – African (e.g., African, Somali etc.); South Asian: South Asian (e.g., Indian, Pakistani, Bangladeshi, Sri Lankan etc.); Black: African (e.g., African, Somali etc.); Other: Indo – Caribbean (e.g., Guyanese, Trinidadian etc.); White (Caucasian – European/American); South East Asian (e.g., Filipino, Thai, Cambodian, Malaysian, Indonesian etc.); Mixed ancestry

Business Management (e.g., Human Resources/Management, Administrative Studies/Business Administration,

Finance/Financial and Business Economics, Business, Accounting)

Table 2. Religion Characteristics at Baseline across all Groups

	Mindfulness Meditation		Listening to a Prayer Passage		
Religion Characteristics	**Experi-mental (*N* = 30)**	**Control (*N* = 29)**	**Experi-mental (*N* = 27)**	**Control (*N* = 28)**	**Tests of Significance**
Islamic Sect, *n* (%)					
Sunni	23 (76.7)	23 (79.3)	17 (63.0)	18 (64.3)	$\chi^2(6) = 8.600$, $p = 0.20$
Shi'a	6 (20.0)	4 (13.8)	9 (33.3)	5 (17.9)	
Ahmadiyya	1 (3.3)	2 (6.9)	1 (3.7)	5 (17.9)	
Religious Involvement, *n* (%)					
Plan for greater future religious involvement	5 (16.7)	2 (6.9)	5 (18.5)	6 (21.4)	$\chi^2(9) = 3.69$, $p = 0.93$
Attempt to increase religious involvement	6 (20.0)	8 (27.6)	6 (22.2)	6 (21.4)	
Participation in religious activities	18 (60.0)	18 (62.1)	15 (55.6)	16 (57.1)	
Active involvement in religious education	1 (3.3)	1 (3.4)	1 (3.7)	0 (0.0)	
Quranic Understanding, *n* (%)					
All of it	1 (3.3)	1 (3.4)	1 (3.7)	0 (0.0)	$\chi^2(9) = 6.92$, $p = 0.65$
Most of it	3 (10.0)	7 (24.1)	6 (22.2)	4 (14.3)	
Some of it	15 (50.0)	13 (44.8)	14 (51.9)	19 (67.9)	
None of it	11 (36.7)	8 (27.6)	6 (22.2)	5 (17.9)	
Quran Listening Frequency, *n* (%)					
Very often	5 (16.7)	4 (13.8)	2 (7.4)	6 (21.4)	$\chi^2(9) = 8.75$, $p = 0.46$
Often	6 (20.0)	9 (31.0)	9 (33.3)	8 (28.6)	
Sometimes	15 (50.0)	15 (51.7)	16 (59.3)	11 (39.3)	
Never	4 (13.3)	1 (3.4)	0 (0.0)	3 (10.7)	
Salat Frequency, *n* (%)					
More than 5 times a day	1 (3.3)	0 (0.0)	1 (3.7)	1 (3.6)	$\chi^2(12) = 6.744$, $p = 0.87$
5 times a day	12 (40.0)	11 (37.9)	9 (33.3)	13 (46.4)	
A couple times a day	8 (26.7)	9 (31.0)	4 (14.8)	4 (14.3)	
A couple times a week	6 (20.0)	7 (24.1)	8 (29.6)	7 (25.0)	

	Never	3 (10.0)	2 (6.9)	5 (18.5)	3 (10.7)	
Arabic Speaking, *n* (%)						
	Yes	2 (6.7)	5 (17.2)	3 (11.1)	3 (10.7)	$\chi^2(6) = 15.103$, $p = 0.02$
	No	22 (73.3)	24 (82.8)	23 (85.2)	25 (89.3)	
	Somewhat	6 (20.0)	0 (0.0)	1 (3.7)	0 (0.0)	
Surah Rahman Listening, *n* (%)						
	Very often	2 (6.7)	6 (20.7)	0 (0.0)	1 (3.6)	$\chi^2(9) = 13.956$, $p = 0.12$
	Often	4 (13.3)	3 (10.3)	2 (7.4)	5 (17.9)	
	Sometimes	15 (50.0)	12 (41.4)	20 (74.1)	15 (53.6)	
	Never	9 (30.0)	8 (27.6)	5 (18.5)	7 (25.0)	
Prayer Burden, *n* (%)						
	Strongly agree	1 (3.3)	0 (0.0)	0 (0.0)	0 (0.0)	$\chi^2(12) = 13.872$, $p = 0.31$
	Moderately agree	1 (3.3)	3 (10.3)	2 (7.4)	0 (0.0)	
	Neutral	5 (16.7)	1 (3.4)	5 (18.5)	3 (10.7)	
	Moderately disagree	6 (20.0)	9 (31.0)	2 (7.4)	6 (21.4)	
	Strongly disagree	17 (56.7)	16 (55.2)	18 (66.7)	19 (67.9)	

Note. MExp: Meditation Experimental; MCon: Meditation Control; PExp: Prayer Experimental; PCon: Prayer Control

Table 3. Other Characteristics at Baseline across all Groups

Other Characteristics	**MExp (*N* = 30)**	**MCon (*N* = 29)**	**PExp (*N* = 27)**	**PCon (*N* = 28)**	**Tests of Sig-nificance**
Weekly Exercise, *n* (%)					
Often	3 (10.0)	11 (37.9)	9 (33.3)	7 (25.0)	$\chi^2(6) = 9.656$, $p = 0.140$
Sometimes	16 (53.3)	10 (34.5)	14 (51.9)	11 (39.3)	
Rarely/Never	11 (36.7)	8 (27.6)	4 (14.8)	10 (35.7)	
Caffeine, *n* (%)					
Many times a day	3 (10.0)	5 (17.2)	1 (3.7)	3 (10.7)	$\chi^2(9) = 8.180$, $p = 0.516$
Once a day	8 (26.7)	9 (31.0)	10 (37.0)	13 (46.4)	
Once a week	12 (40.0)	6 (20.7)	7 (25.9)	5 (17.9)	
Rarely/Never	7 (23.3)	9 (31.0)	9 (33.3)	7 (25.0)	
Alcohol, *n* (%)					
Often	1 (3.3)	0 (0.0)	0 (0.0)	1 (3.6)	$\chi^2(9) = 4.498$, $p = 0.876$
Sometimes	1 (3.3)	0 (0.0)	1 (3.7)	1 (3.6)	
Rarely	2 (6.7)	5 (17.2)	4 (14.8)	4 (14.3)	
Never	26 (86.7)	24 (82.8)	22 (81.5)	22 (78.6)	
Smoking, *n* (%)					
Very often	0 (0.0)	0 (0.0)	0 (0.0)	1 (3.6)	$\chi^2(12) = 15.190$, $p = 0.231$
Often	1 (3.3)	0 (0.0)	2 (7.4)	1 (3.6)	
Sometimes	0 (0.0)	1 (3.4)	3 (11.1)	0 (0.00)	
Rarely	2 (6.7)	6 (20.7)	4 (14.8)	3 (10.7)	
Never	27 (90.0)	22 (75.9)	18 (66.7)	23 (82.1)	
Irregular Menstrual Cycle, *n* (%)					
Often	1 (3.3)	4 (13.8)	5 (18.5)	3 (10.7)	$\chi^2(9) = 15.684$, $p = 0.74$
Sometimes	12 (40.0)	3 (10.3)	2 (7.4)	4 (14.3)	
Rarely	7 (23.3)	10 (34.5)	11 (40.7)	9 (32.1)	
Not applicable	10 (33.3)	12 (41.4)	9 (10.2)	12 (42.9)	

Note. MExp: Meditation Experimental; MCon: Meditation Control; PExp: Prayer Experimental; PCon: Prayer Control

Measures of Automatic Negative Thoughts, Religiosity and Self-Reported Stress. In relation to psychological characteristics (see Table 4), no statistically significant differences were found in mean ATQ ($p = 0.19$), CRS-15 ($p = 0.29$), and the PRT perceived stress difficulty ($p = 0.69$), or performance rating ($p = 0.75$) scores between groups. The majority of participants perceived the PRT to be moderately stressful (36.8%) and difficult (61.4%), while indicating that they subjectively judged their performance to be below expectations (55.3%) or of poor quality (39.5%).

Table 4. Measures of Automatic Negative Thoughts, Religiosity and Self-Reported Stress at Baseline across All Groups

Psychological Characteristics		Mindfulness Meditation		Listening to Prayer		Test of Significance
		Experimental (*N* = 30)	Control (*N* = 29)	Experimental (*N* = 27)	Control (*N* = 28)	
Scales, mean (*SD*)						
	ATQ	60.0 (27.1)	48.2 (15.7)	58.7 (22.0)	55.8 (22.8)	$p = 0.19$
	CRS-15	4.06 (0.5)	4.17 (0.4)	3.9 (0.5)	4.1 (0.5)	$p = 0.29$
PRT Perceived Stress, *n* (%)						
	Not stressed	3 (10.0)	4 (13.8)	3 (11.1)	1 (3.6)	$\chi^2(12) = 7.061$, $p = 0.85$
	A little stressed	7 (23.3)	3 (10.3)	5 (18.5)	6 (21.4)	
	Moderately stressed	13 (43.3)	9 (31.0)	8 (29.6)	12 (42.9)	
	Stressed	5 (16.7)	10 (34.5)	8 (29.6)	6 (21.4)	
	Extremely stressed	2 (6.7)	3 (10.3)	3 (11.1)	3 (10.7)	
PRT Difficulty, *n* (%)						
	Easy	0 (0.0)	0 (0.0)	1 (3.7)	1 (3.6)	$\chi^2(9) = 6.472$, $p = 0.69$
	Average	10 (33.3)	9 (31.0)	9 (33.3)	4 (14.3)	
	Difficult	18 (60.0)	17 (58.6)	14 (51.9)	21 (75.0)	
	Extremely difficult	2 (6.7)	3 (10.3)	3 (11.1)	2 (7.1)	
PRT Performance, *n* (%)						
	Exceptional	1 (3.3)	0 (0.0)	1 (3.7)	0 (0.0)	$\chi^2(9) = 5.855$, $p = 0.75$
	Met expectations	0 (0.0	2 (6.9)	1 (3.7)	1 (3.6)	
	Below expectations	14 (46.7)	17 (58.6)	16 (59.3)	16 (57.1)	
	Poor	15 (50.0)	10 (34.5)	9 (33.3)	11 (39.3)	

Note. *SD* = standard deviation

MExp: Meditation Experimental; MCon: Meditation Control; PExp: Prayer Experimental; PCon: Prayer Control

ATQ: Automatic Thoughts Questionnaire; CRS-15: Centrality of Religiosity Scale

Trust-based beliefs. In relation to prayer-related trust-based beliefs (Possel et al., 2014), all participants believed that prayers get answered always (78.9%) or sometimes (21.1%). In relation to the expectation of prayer fulfillment (i.e., when) the majority of participants (86.0%) also believed that prayers were answered 'when God believed it is the right time', while the remaining believed prayers to be answered when you are in great need (8.8%) or right away (5.3%). In relation to the nature of prayer fulfillment (i.e., how) the large majority believe that 'you get what God believes is best for you' (93.9%), while only a small proportion believed that 'you get exactly what you prayed for' (5.3%) or 'you get something close to what you prayed for' (0.9%). There were no statistically significant differences between the MExp, MCon, PExp and PCon groups in terms of trust-based beliefs of whether, when and how prayers get answered ($\chi^2(3) = 8.97$, $p = 0.03$; $\chi^2(6) = 1.94$, $p = 0.92$; $\chi^2(6) = 6.32$, $p = 0.39$, respectively), as the proportions remained fundamentally similar between groups (see Table 5).

Table 5. Trust-based Beliefs at Baseline across all Groups

Trust-based belief questions		Mindfulness Meditation		Listening to Prayer		Test of Significance
		Experi-mental (*N* = 30)	Control (*N* = 29)	Experi-mental (*N* = 27)	Control (*N* = 28)	
Prayers get answered, *n* (%)						
	Yes	25 (83.3)	23 (79.3)	25 (92.6)	17 (60.7)	$\chi^2(3) = 8.975$, $p = 0.030$
	No	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)	
	Sometimes	5 (16.7)	6 (20.7)	2 (7.4)	11 (39.3)	
When do prayers get answered, *n* (%)						
	Right away	1 (3.3)	1 (3.4)	2 (7.4)	2 (7.1)	$\chi^2(6) = 1.938$, $p = 0.925$
	When you are in great need of them	3 (10.0)	3 (10.3)	1 (3.7)	3 (10.7)	
	When God believes it is the right time	26 (86.7)	25 (86.2)	24 (88.9)	23 (82.1)	
	Prayers do not get answered	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)	
How do prayers get answered, *n* (%)						
	You get exactly what you prayed for	1 (3.3)	3 (10.3)	2 (7.4)	0 (0.0)	$\chi^2(6) = 6.317$, $p = 0.389$
	You get something close to what you prayed for	1 (3.3)	0 (0.0)	0 (0.0)	0 (0.0)	
	You get what God believes is best for you	28 (93.3)	26 (89.7)	25 (92.6)	28 (100)	
	Prayers do not get answered	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)	

Note. MExp: Meditation Experimental; MCon: Meditation Control; PExp: Prayer Experimental; PCon: Prayer Control

4.4 Hypothesis Testing

4.4.1 Stress Reactivity.

Hypothesis 1 – Stress Reactivity. Results of the 2 × 2 repeated measures analysis of variance (ANOVA) aimed at evaluating changes in mean HF-HRV from the baseline phase (Phase 1) to the stress-induction phase (Phase 2) revealed a statistically significant main effect of phase ($\wedge$ = 0.94, $F(1,112) = 7.49$, $p = 0.007$, $\eta p^2 = 0.07$). The phase × sex interaction, however, did not reach statistical significance ($\wedge$ = 1.00, $F(1,112) = 0.007$, $p = 0.94$, $\eta p^2 = 0.001$). Evaluation of the simple main effects for phase revealed that as hypothesized, mean HF-HRV was lower during the stress-induction phase ($M = 2.72$, $SEM = 0.04$, $p = 0.007$), compared to mean HF-HRV at the baseline phase ($M = 2.82$, $SEM = 0.04$).

4.4.2 Stress Recovery

Overall Results. In the 2 × 2 × 2 × 3 repeated measures analysis of variance (ANCOVA), aimed at evaluating changes in mean HF-HRV in response to mindfulness meditation (MM), listening to a prayer passage, or their respective control conditions, Mauchly's test of sphericity ($\chi^2(5) = 0.56$, $p = 0.0001$) was found to be statistically significant, necessitating use of a MANOVA approach to evaluate results. The MANOVA revealed a statistically significant main effect of phase ($\wedge$ = 0.92, $F(2, 104) = 4.50$, $p = 0.01$, $\eta p^2 = 0.08$), 2) a nonsignificant phase × intervention interaction ($\wedge$ = 0.97, $F(2, 104) = 1.58$, $p = 0.21$, $\eta p^2 = 0.03$), a statistically significant phase × condition interaction ($\wedge$ = 0.93, $F(2, 104) = 4.04$, $p = 0.02$, $\eta p^2 = 0.07$), a nonsignificant phase × sex interaction ($\wedge$ = 0.99, $F(2, 104) = 0.05$, $p = 0.95$, $\eta p^2 = 0.001$), a nonsignificant phase × intervention × condition interaction ($\wedge$ = 0.99, $F(2, 104) = 0.53$, $p = 0.59$, $\eta p^2 = 0.01$), a nonsignificant phase ×

intervention × sex interaction ($\wedge$ = 0.98, $F(2, 104) = 1.19$, $p = 0.31$, $\eta p^2 = 0.02$), a nonsignificant phase × condition × sex interaction ($\wedge$ = 0.96, $F(2, 104) = 2.17$, $p = 0.12$, $\eta p^2 = 0.04$), and a statistically significant phase × intervention × condition × sex interaction ($\wedge$ = 0.92, $F(2, 104) = 4.25$, $p = 0.02$, $\eta p^2 = 0.08$).

Hypothesis 2 – Stress Recovery during Mindfulness Meditation. The statistically significant intervention × condition × phase × sex interaction was followed with the analysis of the simple main effects to evaluate differences in mean HF-HRV in response to MExp and MCon at the stress-induction, 1–5 min post-stress, 6–10 min post-stress phases separately for each sex. Results of male participants revealed no statistically significant differences in mean HF-HRV between MExp and MCon at the stress-induction phase ($MD_{MExp\text{-}MCon} = 0.18$, $p = 0.22$). There were statistically significant differences between MExp and MCon at the 1–5 min post-stress phase ($MD_{MExp\text{-}MCon} = 0.30$, $p = 0.004$) and at the 6–10 min post-stress phase ($MD_{MExp\text{-}MCon} = 0.23$, $p = 0.03$) with higher mean HF-HRV values in the MExp group compared to the MCon group (See Table 6 and Figure 4). Similarly, in female participants, there were no statistically significant differences at the stress-induction phase between MExp and MCon ($MD_{MExp\text{-}MCon} = 0.05$, $p = 0.65$). There was a statistically significant difference in mean HF-HRV between MExp and MCon at the 1–5 min post-stress ($MD_{MExp\text{-}MCon} = 0.15$, $p = 0.049$) with higher mean HF-HRV values in the MExp group compared to the MCon group. However, mean differences between MExp and MCon did not reach statistical significance at the 6–10 min post-stress phase ($MD_{MExp\text{-}MCon} = 0.04$, $p = 0.64$); See Table 7 and Figure 5).

Table 6. Means and standard deviations of mean HF-HRV during the stress-induction (Phase 2) and post-stress (Phase 3a and 3b) phases in male participants during mindfulness meditation

Phases	**Mindfulness Meditation**		
	Experimental (*N* = 9)	**Control (*N* = 11)**	***p***
Stress-induction, *M* (*SD*)	2.92 (0.33)	2.72 (0.48)	0.22
1–5 min post-stress, *M* (*SD*)	3.03 (0.30)	2.71 (0.56)	0.004*
6–10 min post-stress, *M* (*SD*)	3.01 (0.30)	2.76 (0.64)	0.03*

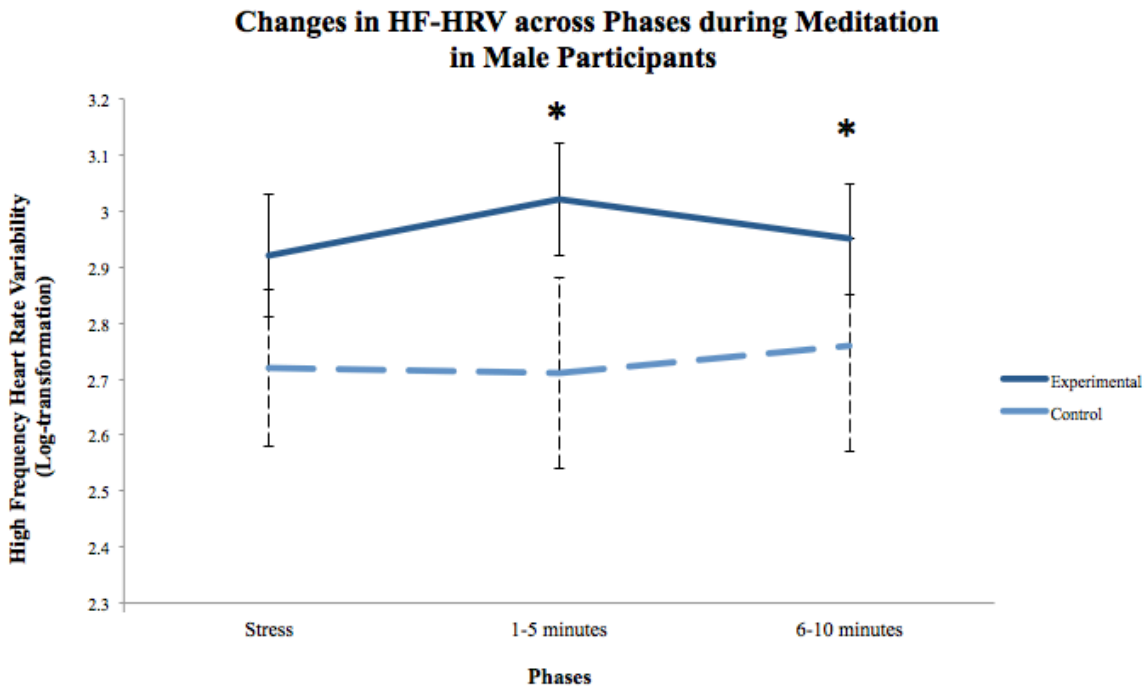

Figure 4. Log-transformed high frequency mean (± SEM) heart rate variability (HF-HRV; ms^2) in male Muslim undergraduate students during baseline, stress-induction, post-stress phases (1–5 minutes and 6–10 minutes) during meditation. Following the stress-induction phase, male participants were randomized into one of the following groups: Meditation Experimental (MExp; N = 9), Meditation Control (MCon; N = 11), Prayer Experimental (PExp; N = 9) and Prayer Control (PCon; N = 11). This graph only shows results of males randomized to MExp and MCon. Males assigned to the MExp group had significantly greater mean HF-HRV than males assigned to the MCon group, at the 1–5 min (p = 0. 004) and 6–10 min (p = 0.03) post-stress phases.

Table 7. Means and standard deviations of mean HF-HRV during the stress-induction (Phase 2) and post-stress (Phase 3a and 3b) phases in female participants during mindfulness meditation

Phases	**Mindfulness Meditation**		
	Experimental (*N* = 21)	**Control (*N* = 18)**	***p***
Stress-induction, *M* (*SD*)	2.70 (0.42)	2.59 (0.34)	0.66
1–5 min post-stress, *M* (*SD*)	2.84 (0.36)	2.62 (0.50)	0.04*
6–10 min post-stress, *M* (*SD*)	2.80 (0.38)	2.76 (0.48)	0.64

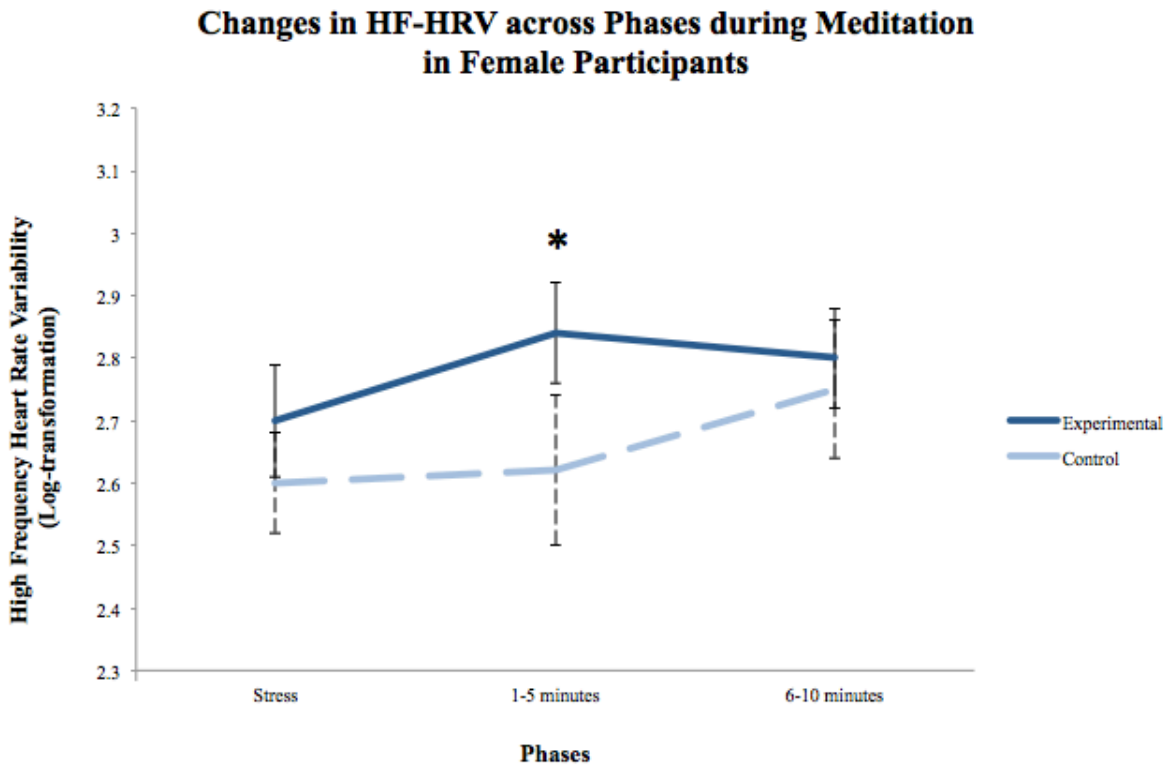

Figure 5. Log-transformed high frequency mean (± SEM) heart rate variability (HF-HRV; ms^2) in female Muslim undergraduate students during baseline, stress-induction, post-stress phases (1–5 minutes and 6–10 minutes) during meditation. Following the stress-induction phase, female participants were randomized into one of the following groups: Meditation Experimental (MExp; N = 21), Meditation Control (MCon; N = 18), Prayer Experimental (PExp; N = 18) and Prayer Control (PCon; N = 17). This graph only shows results of females randomized to MExp and MCon. Females assigned to the MExp group had significantly greater mean HF-HRV than females assigned to the MCon group, at the 1–5 min post-stress phase (p = 0.04).

Hypothesis 3 – Stress Recovery during Listening to Prayer. The statistically significant intervention × condition × phase × sex interaction was followed with the analysis of the simple main effects to evaluate changes in mean HF-HRV in response to PExp or MCon at the stress-induction, 1–5 min post-stress, 6–10 min post-stress phases separately for each sex. Results of male participants revealed no statistically significant differences in mean HF-HRV between PExp and PCon at stress-induction phase ($MD_{PExp\text{-}PCon}$ = -0.15, p = 0.31), at the 1–5 min post-stress phase ($MD_{PExp\text{-}PCon}$ = 0.10, p = 0.32), and at the 6–10 min post-stress phase ($MD_{PExp\text{-}PCon}$ = -0.08, p = 0.45; See Table 8 and Figure 6). Similarly in females, except for a statistically significant difference in mean HF-HRV at the stress-induction phase ($MD_{PExp\text{-}PCon}$ = 0.26, p = 0.03), there were no statistically significant differences in mean HF-HRV at the 1–5 min post-stress phase ($MD_{PExp\text{-}PCon}$ = 0.04, p = 0.58), and at the 6–10 min post-stress phase ($MD_{PExp\text{-}PCon}$ = -0.08, p = 0.45; (See Table 9 and Figure 7).

Table 8. Means and standard deviations of mean HF-HRV during the stress-induction (Phase 2) and post-stress (Phase 3a and 3b) phases in male participants while listening to a prayer passage

Phases	**Listening to a Prayer Passage**		
	Experimental (*N* = 9)	**Control (*N* = 11)**	***p***
Stress-induction, *M* (*SD*)	2.71 (0.62)	2.75 (0.40)	0.31
1–5 min post-stress, *M* (*SD*)	2.89 (0.54)	2.64 (0.56)	0.32
6–10 min post-stress, *M* (*SD*)	2.81 (0.62)	2.74 (0.52)	0.45

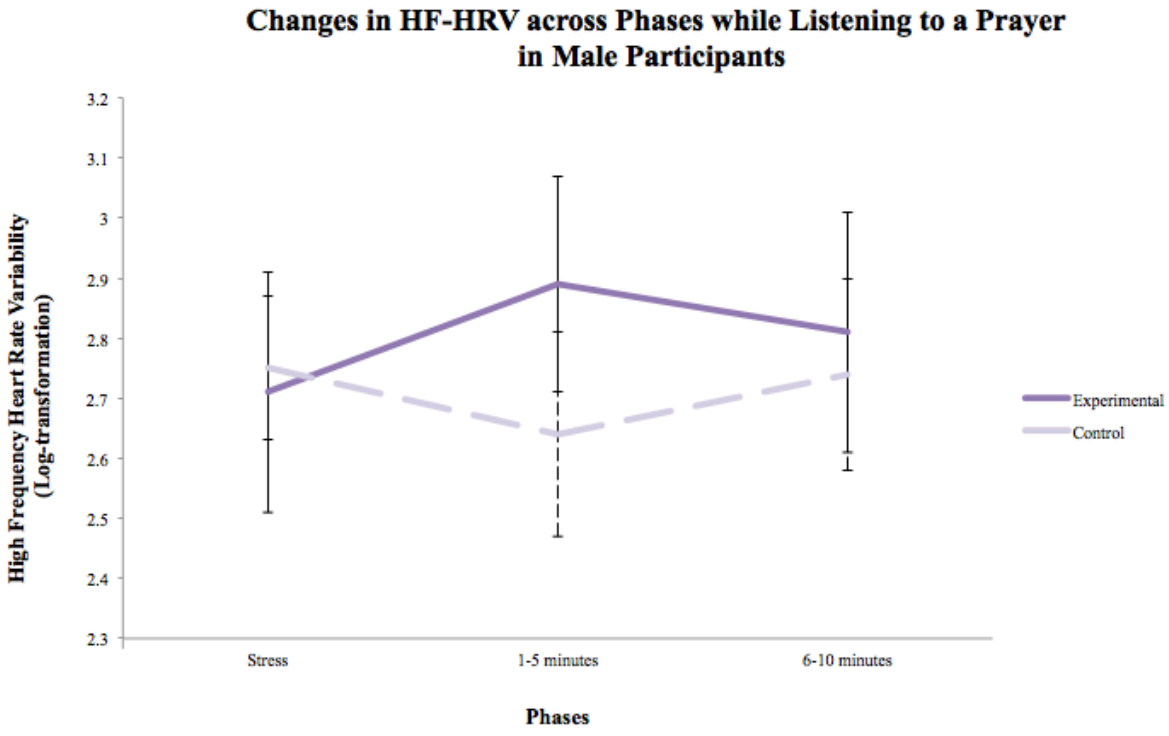

Figure 6. Log-transformed high frequency mean (± SEM) heart rate variability (HF-HRV; ms^2) in male Muslim undergraduate students during baseline, stress-induction, post-stress phases (1–5 minutes and 6–10 minutes) while listening to a prayer passage. Following the stress-induction phase, male participants were randomized into one of the following groups: Meditation Experimental (MExp; N = 9), Meditation Control (MCon; N = 11), Prayer Experimental (PExp; N = 9) and Prayer Control (PCon; N = 11). This graph only shows results of males randomized to PExp and PCon.

Table 9. Means and standard deviations of mean HF-HRV during the stress-induction (Phase 2) and post-stress (Phase 3a and 3b) phases in female participants while listening to a prayer passage

Phases	**Listening to a Prayer Passage**		
	Experimental (*N* = 18)	**Control (*N* = 17)**	***p***
Stress-induction, *M* (*SD*)	2.83(0.49)	2.57 (0.61)	0.03*
1–5 min post-stress, *M* (*SD*)	2.69 (0.58)	2.68 (0.45)	0.98
6–10 min post-stress, *M* (*SD*)	2.67 (0.55)	2.62 (0.46)	0.58

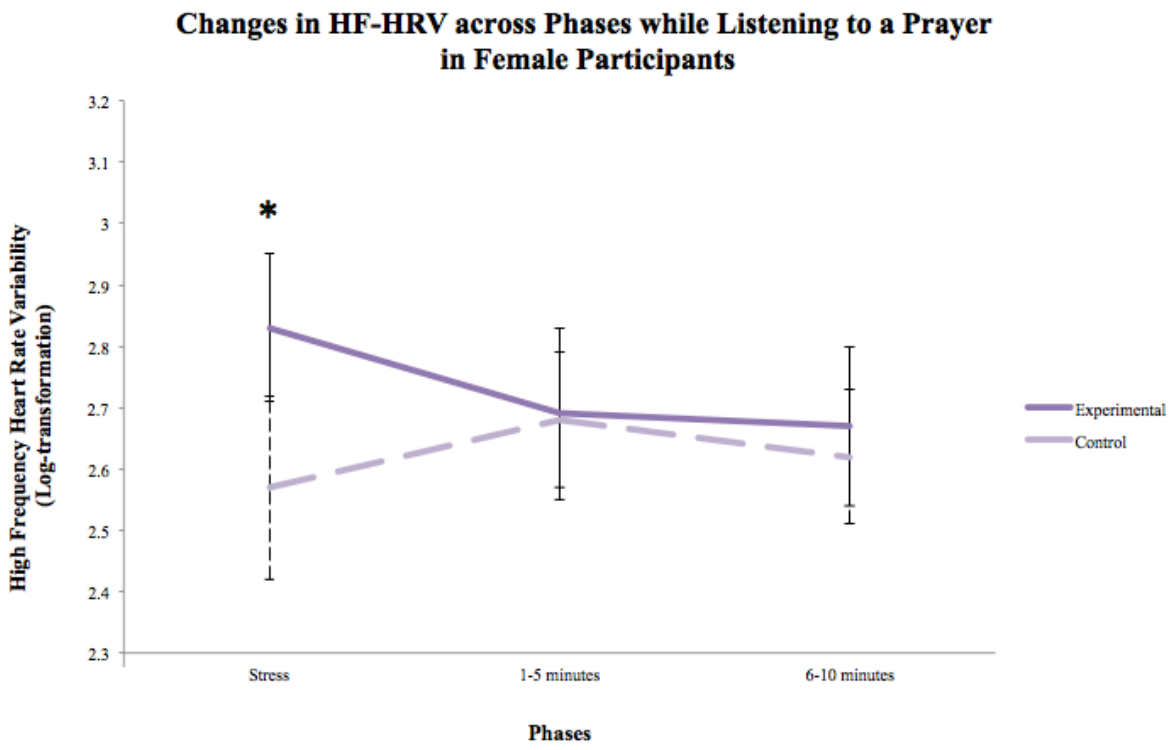

Figure 7. Log-transformed high frequency mean (± SEM) heart rate variability (HF-HRV; ms^2) in female Muslim undergraduate students during baseline, stress-induction, post-stress phases (1–5 minutes and 6–10 minutes) while listening to a prayer passage. Following the stress-induction phase, female participants were randomized into one of the following groups: Meditation Experimental (MExp; N = 21), Meditation Control (MCon; N = 18), Prayer Experimental (PExp; N = 18) and Prayer Control (PCon; N = 17). This graph only shows results of females randomized to PExp and PCon. Females assigned to the MExp group had significantly greater mean HF-HRV than females assigned to the MCon group, at the stress-induction phase (p = 0.03).

Hypothesis 4 – Stress Recovery during Mindfulness Meditation vs. Listening to Prayer. The statistically significant intervention × condition × phase × sex interaction was followed with the analysis of the simple main effects to evaluate changes in mean HF-HRV in response to MExp and PExp at the stress-induction, 1–5 min post-stress, 6–10 min post-stress phases separately for each sex. Results of male participants revealed no statistically significant differences in mean HF-HRV between MExp and PExp at stress-induction phase ($MD_{MExp\text{-}PExp}$ = 0.26, p = 0.10). However at the 1–5 min post-stress phase the difference between MExp and PExp approached significance ($MD_{MExp\text{-}PExp}$ = 0.20, p = 0.06), with higher mean HF-HRV values in MExp group compared to PExp. There were statistically significant differences between MExp and PExp at the at the 6–10 min post-stress phase ($MD_{MExp\text{-}PExp}$ = 0.27, p = 0.02), with higher mean HF-HRV values in the MExp group compared to the PExp group (See Table 10 and Figure 8). Similarly, in female participants, there were no statistically significant differences at the stress-induction phase between MExp and PExp ($MD_{MExp\text{-}PExp}$ = -0.16, p = 0.14), and at the 1–5 min post-stress phase ($MD_{MExp\text{-}PExp}$ = 0.12, p = 0.09). However, mean differences between the MExp and PExp groups did not reach statistical significance at the 6–10 min post-stress phase ($MD_{MExp\text{-}PExp}$ = 0.10, p = 0.18; See Table 11 and Figure 9).

Table 10. Means and standard deviations of mean HF-HRV during the stress-induction (Phase 2) and post-stress (Phase 3a and 3b) phases in male participants during mindfulness meditation and while listening to a prayer passage

Phases	**Meditation**	**Listening to a Prayer**	***p***
	Experimental (*N* = 9)	**Experimental (*N* = 9)**	
Stress-induction, *M* (*SD*)	2.87 (0.33)	2.61 (0.33)	0.10
1–5 min post-stress, *M* (*SD*)	2.97 (0.24)	2.76 (0.24)	0.06
6–10 min post-stress, *M* (*SD*)	2.95 (0.24)	2.68 (0.24)	0.02*

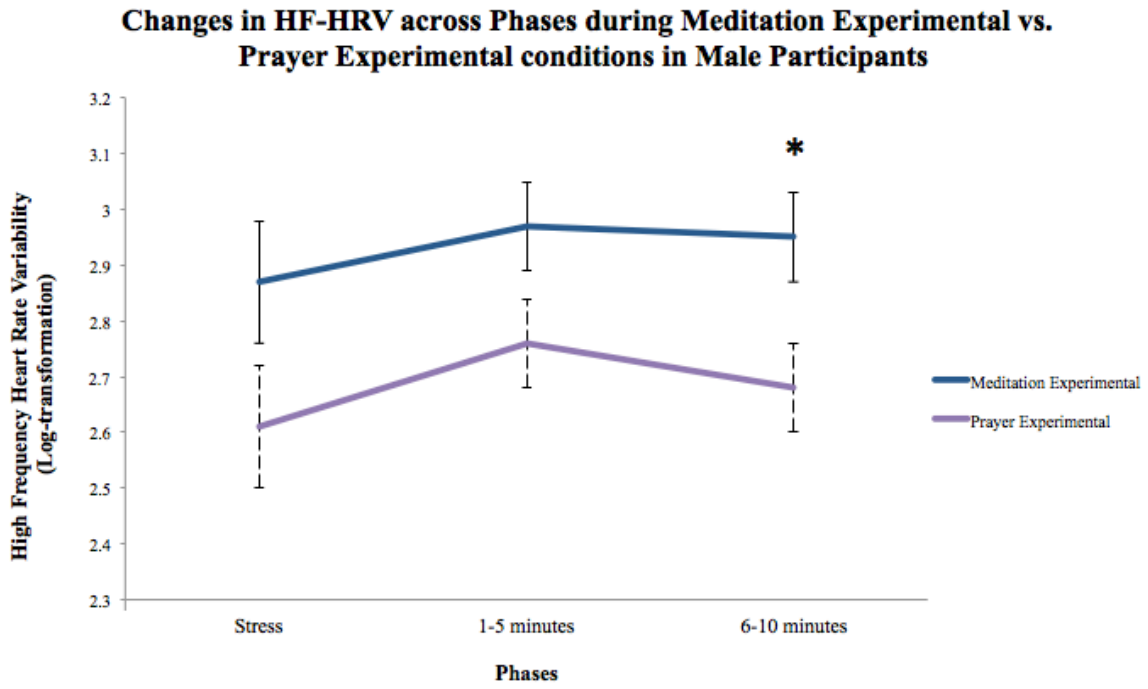

Figure 8. Log-transformed high frequency mean (± SEM) heart rate variability (HF-HRV; ms^2) in male Muslim undergraduate students during baseline, stress-induction, post-stress phases (1–5 minutes and 6–10 minutes) while listening to a prayer passage. Following the stress-induction phase, male participants were randomized into one of the following groups: Meditation Experimental (MExp; N = 9), Meditation Control (MCon; N = 11), Prayer Experimental (PExp; N = 9) and Prayer Control (PCon; N = 11). This graph only shows results of males randomized to PExp and MExp. Males assigned to the MExp group had significantly greater mean HF-HRV than males assigned to the PExp group, at the 6–10 min post-stress phase (p = 0.02).

Table 11. Means and standard deviations of mean HF-HRV during the stress-induction (Phase 2) and post-stress (Phase 3a and 3b) phases in female participants during mindfulness meditation and while listening to a prayer passage

Phases	**Meditation**	**Listening to a Prayer**	***p***
	Experimental (*N* = 21)	**Experimental (*N* = 18)**	
Stress-induction, *M* (*SD*)	2.69 (0.32)	2.85 (0.34)	0.14
1–5 min post-stress, *M* (*SD*)	2.84 (0.23)	2.71 (0.21)	0.09
6–10 min post-stress, *M* (*SD*)	2.79 (0.23)	2.69 (0.25)	0.18

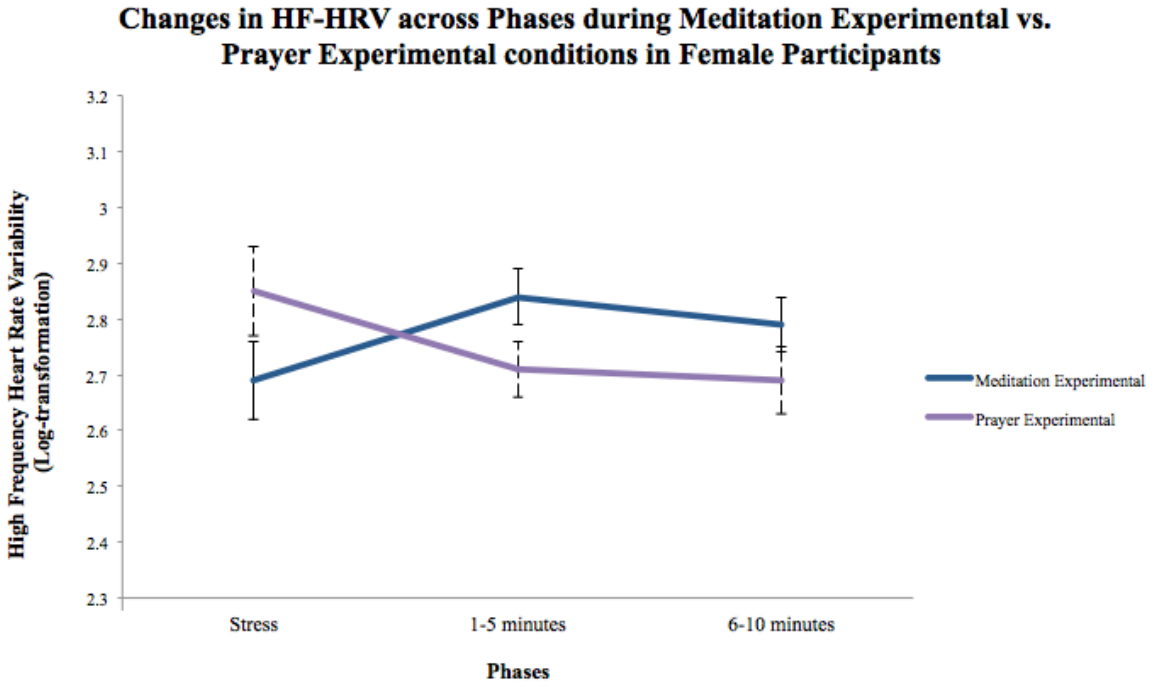

Figure 9. Log-transformed high frequency mean (± SEM) heart rate variability (HF-HRV; ms^2) in female Muslim undergraduate students during baseline, stress-induction, post-stress phases (1–5 minutes and 6–10 minutes) while listening to a prayer passage. Following the stress-induction phase, female participants were randomized into one of the following groups: Meditation Experimental (MExp; N = 21), Meditation Control (MCon; N = 18), Prayer Experimental (PExp; N = 18) and Prayer Control (PCon; N = 17). This graph only shows results of females randomized to MExp and PExp.

Hypothesis 5 – Stress Recovery and Negative Automatic Thoughts. Given the low number of males within each study group when ATQ scores were stratified according to ATQ scores < 60 vs. ATQ scores ≥ 60, hypothesis 5 was evaluated only in female participants. A 2 (mindfulness meditation vs. listening to a prayer passage) × 2 (experimental vs. control) × 2 (ATQ scores ≥ 60 vs. ATQ scores ≥ 60) × 3 (stress-induction, 1–5 min post-stress, 6–10 min post-stress) ANCOVA was conducted. Given the statistical significance of the Mauchly's test of sphericity ($\chi^2(5) = 0.37$, $p = 0.0001$) a MANOVA was conducted, leading to a significant intervention × condition × phase × ATQ interaction ($\wedge = 0.75$, $F(2, 64) = 10.22$, $p = 0.0001$, $\eta p^2 = 0.07$) in female participants. Subsequently, this interaction was followed by the evaluation of mean HF-HRV differences between the MExp and MCon groups, and between the PExp and PCon groups at each phase (i.e., stress-induction, 1–5 min post-stress, 6–10 min post-stress), separately in female participants with ATQ scores < 60 and female participants with ATQ scores of ≥ 60.

The statistically significant intervention × condition × phase × ATQ interaction was followed with the analysis of the simple main effects to evaluate differences in mean HF-HRV in response to MExp and MCon at the stress-induction, 1–5 min post-stress, 6–10 min post-stress phases in female participants with ATQ scores < 60. Results of female participants with ATQ scores < 60 revealed no statistically significant differences in mean HF-HRV between MExp and MCon at the stress-induction phase ($MD_{MExp\text{-}MCon} = 0.007$, $p = 0.96$), at the 1–5 min post-stress phase ($MD_{MExp\text{-}MCon} = 0.08$, $p = 0.32$), and at the 6–10 min post-stress phase ($MD_{MExp\text{-}MCon} = -0.04$, $p = 0.63$); See Table 12 and Figure 10).

The statistically significant intervention × condition × phase × ATQ interaction was followed with the analysis of the simple main effects to evaluate differences in mean HF-

HRV in response to PExp and PCon at the stress-induction, 1–5 min post-stress, 6–10 min post-stress phases in female participants with ATQ scores < 60. Results of female participants with ATQ scores < 60 revealed no statistically significant differences in mean HF-HRV between PExp and PCon at the stress-induction phase ($MD_{PExp\text{-}PCon}$ = 0.20, p = 0.23), at the 1–5 min post-stress phase ($MD_{PExp\text{-}PCon}$ = 0.02, p = 0.87), and at the 6–10 min post-stress phase ($MD_{PExp\text{-}PCon}$ = -0.13, p = 0.15; See Table 13 and Figure 11).

Table 12. Means and standard deviation of mean HF-HRV during the stress-induction (Phase 2) and post-stress (Phase 3a and 3b) phases in female participants who scored less than 60 during mindfulness meditation.

Phases	**Mindfulness Meditation**		
	Experimental (*N* = 15)	**Control (*N* = 13)**	***p***
Stress-induction, *M* (*SD*)	2.65 (0.10)	2.64 (0.10)	0.96
1–5 min post-stress, *M* (*SD*)	2.73 (0.05)	2.66 (0.06)	0.32
6–10 min post-stress, *M* (*SD*)	2.76 (0.05)	2.80 (0.06)	0.63

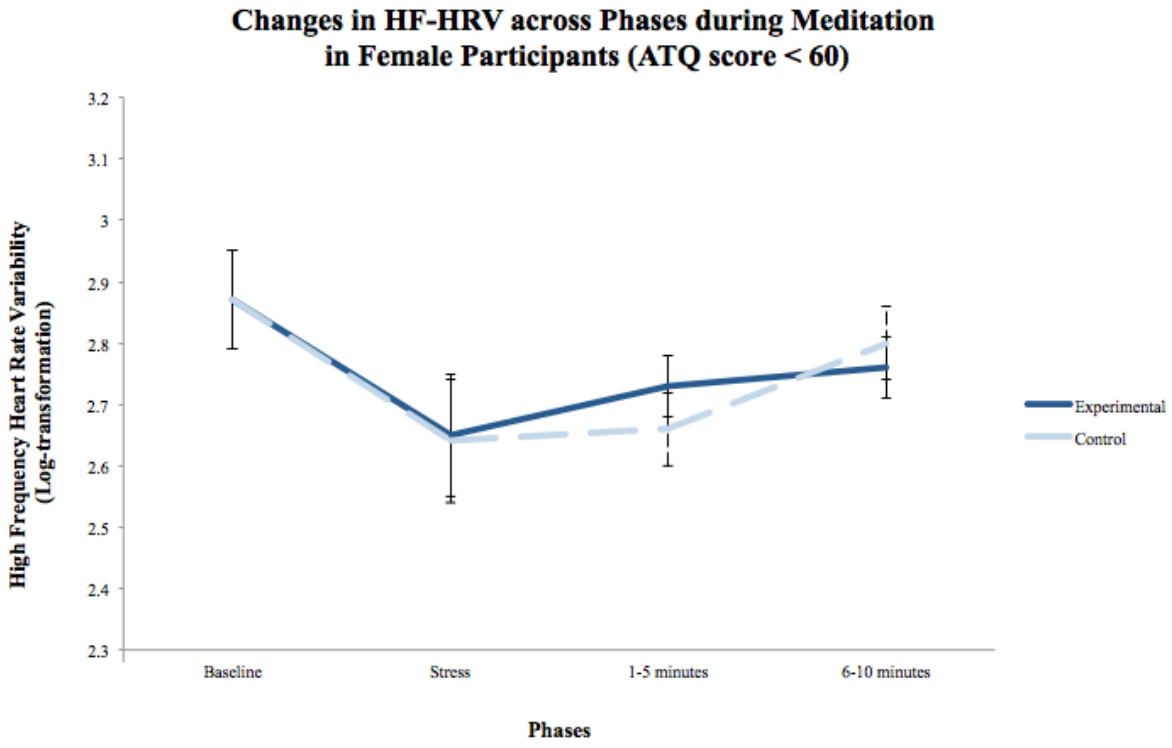

Figure 10. Log-transformed high frequency mean (± SEM) heart rate variability (HF-HRV; ms^2) in female Muslim undergraduate students during baseline, stress-induction, post-stress phases (1–5 minutes and 6–10 minutes) while listening to a prayer passage. Following the stress-induction phase, female participants were randomized into one of the following groups: Meditation Experimental (MExp; N = 21), Meditation Control (MCon; N = 18), Prayer Experimental (PExp; N = 18) and Prayer Control (PCon; N = 17). This graph only shows results of females participants who scored below 60 on automatic negative thoughts questionnaire (ATQ) who were randomized to MExp (N = 15) and MCon (N = 13).

Table 13. Means and standard deviation of HF-HRV during the stress-induction (Phase 2) and post-stress (Phase 3a and 3b) phases in female participants who scored less than 60 while listening to a prayer passage

Phases	**Listening to a Prayer Passage**		
	Experimental (*N* = 10)	**Control (*N* = 10)**	***p***
Stress-induction, *M* (*SD*)	2.81 (0.12)	2.61 (0.12)	0.23
1–5 min post-stress, *M* (*SD*)	2.72 (0.07)	2.70 (0.07)	0.87
6–10 min post-stress, *M* (*SD*)	2.59 (0.06)	2.72 (0.06)	0.15

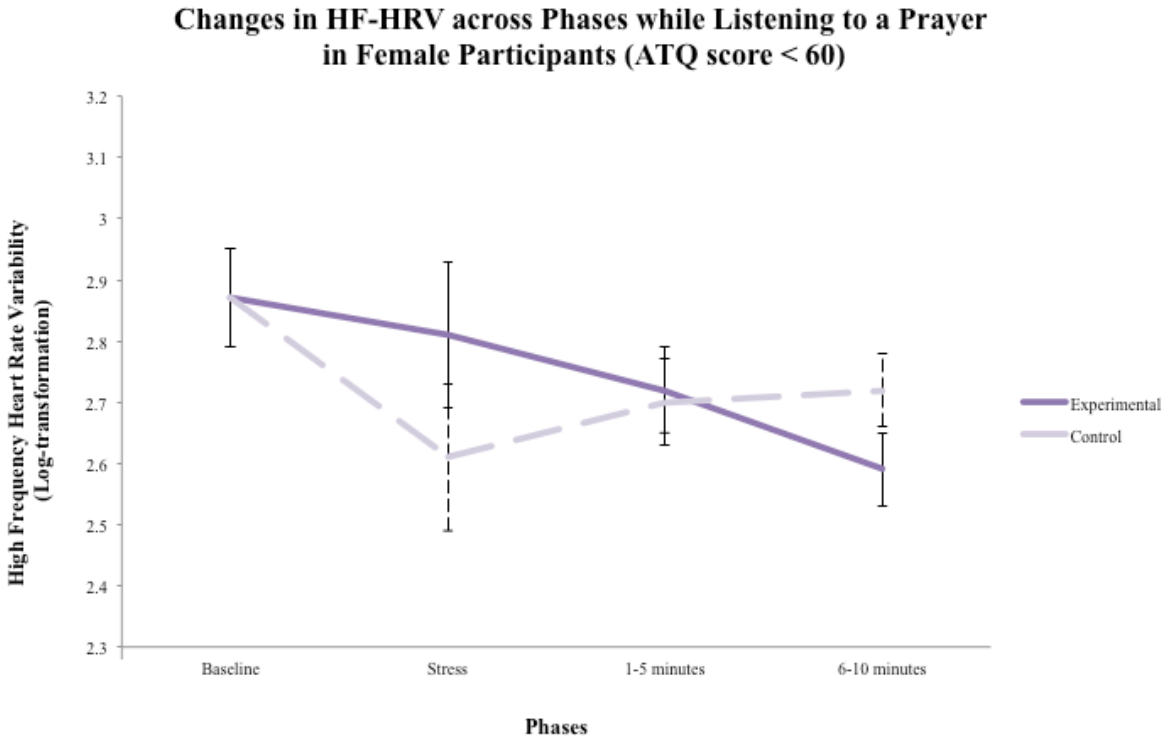

Figure 11. Log-transformed high frequency mean (± SEM) heart rate variability (HF-HRV; ms^2) in female Muslim undergraduate students during baseline, stress-induction, post-stress phases (1–5 minutes and 6–10 minutes) while listening to a prayer passage. Following the stress-induction phase, female participants were randomized into one of the following groups: Meditation Experimental (MExp; N = 21), Meditation Control (MCon; N = 18), Prayer Experimental (PExp; N = 18) and Prayer Control (PCon; N = 17). This graph only shows results of females participants who scored below 60 on automatic negative thoughts questionnaire (ATQ) who were randomized to PExp (N = 10) and PCon (N = 10).

The statistically significant intervention × condition × phase × ATQ interaction was followed with the analysis of the simple main effects to evaluate differences in mean HF-HRV in response to MExp and MCon at the stress-induction, 1–5 min post-stress, 6–10 min post-stress phases in female participants with ATQ scores > 60. Results of female participants with ATQ scores ≥ 60 revealed no statistically significant differences in mean HF-HRV between MExp and MCon at the stress-induction phase ($MD_{MExp\text{-}MCon}$ = 0.16, p = 0.47). There were statistically significant differences between MExp and MCon at the 1–5 min post-stress phase ($MD_{MExp\text{-}MCon}$ = 0.32, p = 0.01), with higher mean HF-HRV values in the MExp group compared to the MCon group. However there were no statistically significant differences between MExp and MCon at the 6–10 min post-stress phase ($MD_{MExp\text{-}MCon}$ = -0.02, p = 0.86; See Table 14 and Figure 12).

The statistically significant intervention × condition × phase × ATQ interaction was followed with the analysis of the simple main effects to evaluate differences in mean HF-HRV in response to PExp and PCon at the stress-induction, 1–5 min post-stress, 6–10 min post-stress phases in female participants with ATQ scores > 60. Results of female participants with ATQ scores ≥ 60 revealed no statistically significant differences in mean HF-HRV between PExp and PCon at the stress-induction phase ($MD_{PExp\text{-}PCon}$ = 0.34, p = 0.08) and at the 1–5 min post-stress phase ($MD_{PExp\text{-}PCon}$ = -0.01, p = 0.91). There were statistically significant differences between PExp and PCon at the 6–10 min post-stress phase ($MD_{PExp\text{-}PCon}$ = 0.28, p = 0.009), with higher mean HF-HRV values in the PExp group compared to the PCon group (See Table 15 and Figure 13).

Table 14. Means and standard deviation of HF-HRV during the stress-induction (Phase 2) and post-stress (Phase 3a and 3b) phases in female participants who scored greater than 60 on automatic negative thoughts questionnaire (ATQ) during mindfulness meditation.

Phases	**Mindfulness Meditation**		
	Experimental (*N* = 6)	**Control (*N* = 5)**	***p***
Stress-induction, *M* (*SD*)	2.73 (0.15)	2.57 (0.17)	0.47
1–5 min post-stress, *M* (*SD*)	3.00 (0.08)	2.68 (0.09)	0.01*
6–10 min post-stress, *M* (*SD*)	2.77 (0.08)	2.80 (0.09)	0.86

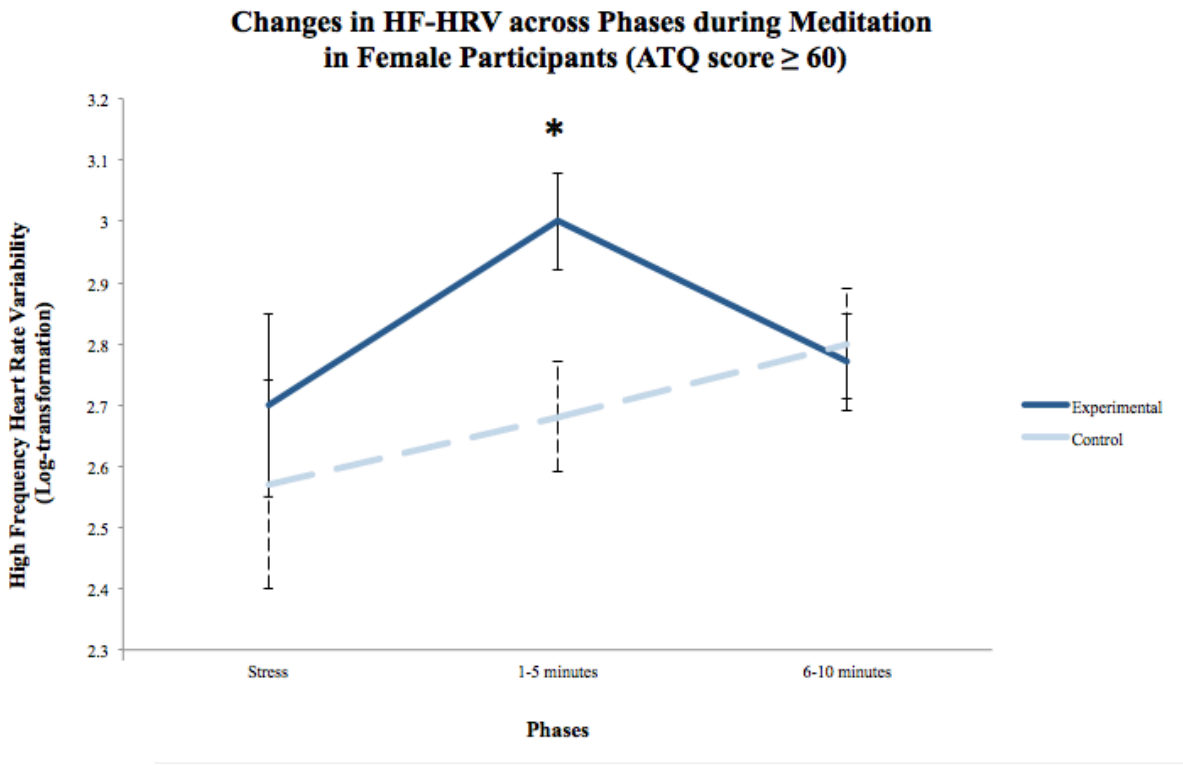

Figure 12. Log-transformed high frequency mean (± SEM) heart rate variability (HF-HRV; ms^2) in female Muslim undergraduate students during baseline, stress-induction, post-stress phases (1–5 minutes and 6–10 minutes) while listening to a prayer passage. Following the stress-induction phase, female participants were randomized into one of the following groups: Meditation Experimental (MExp; N = 21), Meditation Control (MCon; N = 18), Prayer Experimental (PExp; N = 18) and Prayer Control (PCon; N = 17). This graph only shows results of females participants who scored equal to or above 60 on automatic negative thoughts questionnaire (ATQ) who were randomized to MExp (N = 6) and MCon (N = 5). Females in the MExp group had significantly greater mean HF-HRV than females in the MCon group, during the 1–5 min post-stress phase (p = 0.01).

Table 15. Means and standard deviation of HF-HRV during the stress-induction (Phase 2) and post-stress (Phase 3a and 3b) phases in female participants who scored greater than 60 on automatic negative thoughts questionnaire (ATQ) while listening to a prayer passage.

Phases	**Listening to a Prayer Passage**		
	Experimental (*N* = 8)	**Control (*N* = 7)**	***p***
Stress-induction, *M* (*SD*)	2.86 (0.13)	2.52 (0.14)	0.08
1–5 min post-stress, *M* (*SD*)	2.64 (0.07)	2.66 (0.08)	0.91
6–10 min post-stress, *M* (*SD*)	2.76 (0.07)	2.48 (0.08)	0.009*

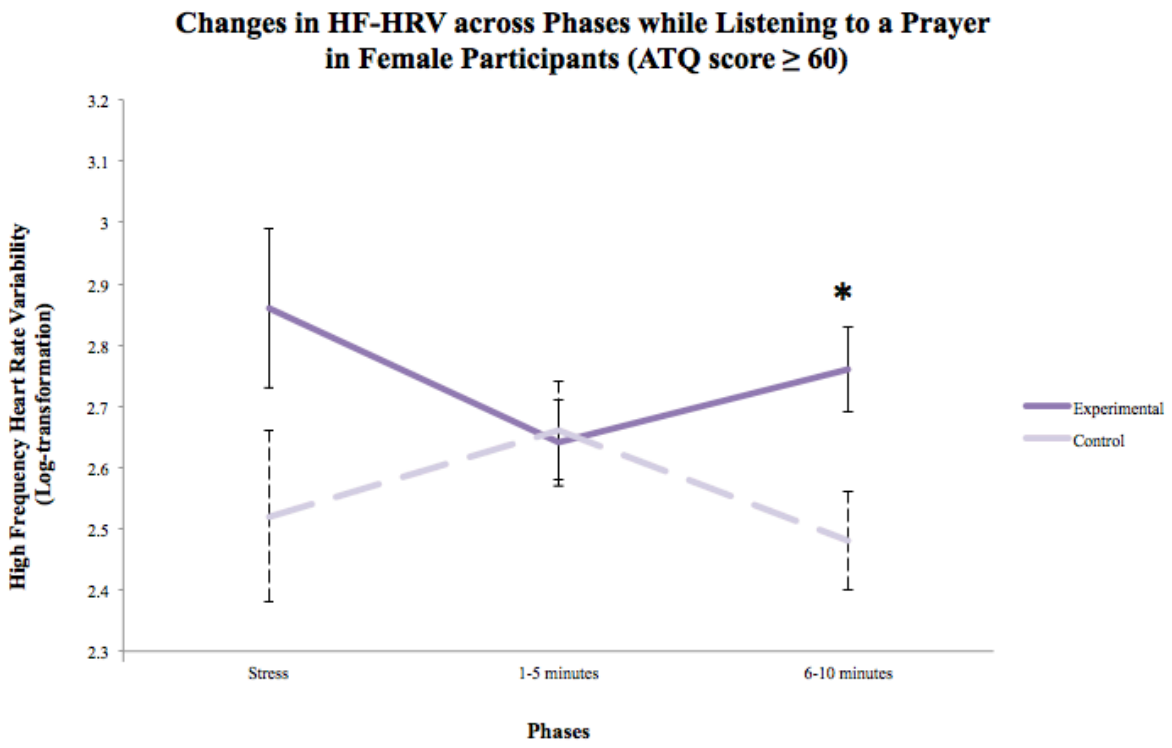

Figure 13. Log-transformed high frequency mean (± SEM) heart rate variability (HF-HRV; ms^2) in female Muslim undergraduate students during baseline, stress-induction, post-stress phases (1–5 minutes and 6–10 minutes) while listening to a prayer passage. Following the stress-induction phase, female participants were randomized into one of the following groups: Meditation Experimental (MExp; N = 21), Meditation Control (MCon; N = 18), Prayer Experimental (PExp; N = 18) and Prayer Control (PCon; N = 17). This graph only shows results of females participants who scored equal to or above 60 on automatic negative thoughts questionnaire (ATQ) who were randomized to PExp (N = 8) and PCon (N = 7). Females in the PExp group had significantly greater mean HF-HRV than females in the PCon group, during the 6–10 min post-stress phase (p = 0.009).

5.0 Discussion

5.1 Summary of Findings and Measures

Given that a significant proportion of Canadians report high stress levels (Statistics Canada, 2014), a physiological evaluation of the stress reduction effects of mindfulness meditation (MM) or other related modalities seems prudent. From a public health standpoint, efforts aimed at identifying effective stress-reduction methods are urgently needed to prevent the negative physical and mental health outcomes that result from inadequate relaxation or prolonged stress reactivity.

The present study aimed to compare the effects of different contemplative practices on high-frequency heart rate variability (HF-HRV), given that lab-based HRV measurement has been a valid predictor of mental and physical health (Allen, Chambers, & Towers, 2007; Cacioppo et al., 2007; Force, 1996; Grossman & Taylor, 2007; Karim, Hasan, & Ali, 2011; Porges & Byrne, 1992; Thayer & Brosschot, 2005; Thayer et al., 2012; Thayer, Yamamoto, & Brosschot, 2009). To this end, we evaluated the effect of two contemporary contemplative practices (i.e., MM and listening to a prayer passage from the Quran) on mean HF-HRV, with both intervention groups being additionally compared to respective control conditions (see methods section for a detailed description). HRV reactivity to a stressor stimulus and recovery during exposure to guided MM instructions (MExp) or listening to a prayer passage (PExp) was examined. Changes from the baseline phase (Phase 1) to the stress-induction phase (Phase 2) and changes from the stress-induction (Phase 2) to post-stress phases (Phase 3a and 3b) were intended to represent stress reactivity and stress recovery, respectively. All participants were undergraduate students who were self-reported followers of Islamic faith and believed in a Higher Power.

Given our reliance on HF-HRV as an outcome measure, it is important to briefly review its relevance to the study comparisons. HRV appears to be a useful tool in investigating the sympathetic and parasympathetic function of the ANS (Karim, Hasan, & Ali, 2011). During resting conditions, the parasympathetic (vagal) tone dominates and HRV is mainly dependent on vagal modulations (Task Force of the European Society of Cardiology, 1996). Increased vagal-mediated HRV has been observed in individuals displaying psychological resilience (Low, Stanton, & Bower, 2008; Segerstrom & Nes, 2007) and during attention regulation (Burg & Wolff, 2012; Hovland et al., 2012) and meditative states (Azam et al., 2015; Krygier et al., 2013; Lumma et al., 2015; Wu & Lo, 2008). Neuroimaging and pharmacological blockade studies support HRV as an index of vagal activity resulting from prefrontal inhibitory control of attention regulation processes (Cacioppo et al., 2007; Hovland et al., 2012; Thayer, Hansen, Saus-Rose, & Johnsen, 2009; Thayer & Lane, 2000). More specifically HF-HRV, the primary measure used in this study, is used extensively as an index of parasympathetic (vagal) control of the heart and is widely accepted as an appropriate measure of parasympathetic function (Allen et al., 2007; Berntson et al., 1997; Cacioppo et al., 2007; Force, 1996; Pittig, Arch, Lam, & Craske, 2013).

As a vagal nerve-mediated marker of cardiac function, HRV is used to investigate attention-regulation processes such as meditation. For instance, HRV was measured in 36 participants enrolled in a 10-day intensive meditation course at the Vipassana Meditation Centre (VMC; Krygier et al., 2013). Measures were taken at rest and during meditation before and after the completion of the course. There was no significant effect of time (i.e., pre- and post-VMC course measures) for HF-HRV. However, results indicated that a

significant increase (p = 0.006) in HF-HRV from the resting to meditation measure, with a large effect size (Cohen's f = 0.710), indicative of relaxation effects.

5.2 Discussion of Results

5.2.1 Hypothesis 1 – Stress Reactivity. Decrease in HF-HRV from baseline (Phase 1) to stress-induction phase (Phase 2). Methodologically, it is important to note that this is the third study in which we have used the identical cognitive stress-induction procedure, called the Pattern Recognition Task (PRT; Azam et al., 2015; Azam et al., 2016 (submitted)). The PRT previously elicited a stress response in maladaptive perfectionists (Azam et al., 2015) and individuals with tension and migraine headache (Azam et al., 2016) to evaluate HF-HRV stress recovery responses. Our study also demonstrated that the PRT elicited a stress response, as there were significant decreases in mean HF-HRV from the baseline phase (Phase 1) to the stress-induction phase (Phase 2), thus, supporting our first hypothesis.

5.2.2 Hypothesis 2 – Stress Recovery during Mindfulness Meditation: Greater mean HF-HRV in response to the MExp than MCon. In support of hypothesis 2, male participants assigned to the MExp group showed greater mean HF-HRV than the MCon group at both post-stress phases (Phase 3a and 3b) and similarly in female participants at only the 1-5 min post-stress phase (Phase 3a). These results aligned with previous findings that examined mean HF-HRV recovery in perfectionists and non-perfectionists (Azam, et al., 2015) and headache and headache-free groups (Azam, et al., 2016). Specifically, in those studies, non-perfectionists, headache and headache-free groups, all demonstrated statistically

significant increases in mean HF-HRV levels from the stress-induction phase to the post-stress phases (Phase 3a and 3b) in comparison to the MCon group.

Not only can MM be beneficial for healthy control participants, but results from the previous study indicated that mindfulness-based interventions could be beneficial as adjunct or alternatives to pharmacological treatment for headache-affected individuals. This is particularly important given previous evidence of ANS dysregulation in headache disorders (Koenig et al., 2015; Matei et al., 2015). The increased vagal-mediated HF-HRV response of headache and headache-free groups to the mindfulness condition, is consistent with previous research (Azam et al., 2015; Krygier et al., 2013; Lumma et al., 2015; Wu & Lo, 2008), and suggests mindfulness practice can help headache sufferers alleviate stress vulnerabilities by preventing, or mitigating, their contribution to the onset of headache episodes.

The present study extends this area of research by examining the relaxation effect following MM and listening to a prayer passage in the aftermath of a stress-induction. To this date, no previous study has used HF-HRV to investigate the effects of MM and listening to a prayer passage. This current study replicates the previous results in self-identified Muslim undergraduate students who responded to guided MM instructions (MExp) with higher levels of HF-HRV compared to a description of mindfulness practice (MCon). The guided MM instructions requested participants to focus attention on breathing sensations, which may have achieved two important stress regulating functions: (i) it generated a relaxation effect via awareness of breath; and (ii) it shifted attention away from the elevated arousal and cognitive features of the prior elicited stress response. These results provide additional physiological evidence suggesting that listening to guided MM instructions increased parasympathetic/vagal tone and countered the typical cognitive-stress response. Thus, MM is

beneficial to recover from conditions where sympathovagal balance is shifted towards sympathetic activity due to stress. Together, previous findings and our results depict that MM instructions can be used across a variety subsample of groups to increase the vagal-mediated HF-HRV response, thereby promoting relaxation.

However in the current study, the difference in HF-HRV between MExp and MCon did not remain significant during the 6–10 min phase in female participants. Accordingly, one reason could be that MM responses are relatively temporary in this population. Only an additional study with a longer period of post-stress evaluation can ascertain whether the MM responses observed are temporary or if they resume after certain additional durations. Another reason could be that the description of MM benefits presented to participants assigned to the MCon group, either from the first half (e.g., "*mindfulness evokes awareness by using breathing sensations for attentional anchoring*") or the second half of the control audio (e.g., "*one can feel a calming process where there is often an increasing clarity of perception and insight*" etc.), may have motivated students to attempt MM practice. Only an additional study with variations in the control instructions can ascertain why females assigned to the MExp group did not see a greater mean HF-HRV compared to females assigned to the MCon group at the 6–10 min post-stress phase (Phase 3b).

5.2.3 Hypothesis 3 – Stress Recovery during Listening to Prayer. Greater mean HF-HRV in response to the PExp than the PCon group. This study explored the effect of engaging in contemplative prayer through listening to a prayer passage from the Quran (PExp) or listening to a description of the benefits of prayer (PCon). There are meditative elements to most spiritual practices and particularly to prayer, which typically focus on words that express and support intentions to engage in positively transcendent activities. The

stress-buffer hypothesis suggests that under high stress conditions, religiousness (i.e., prayer frequency, religious orientation, secure attachment to God, spiritual life integration, service attendance) reduces the negative effects of stress. For example, cardiac patients who used prayer to cope with the stress of their heart surgery had higher levels of self reported hope and optimism (Possel et al., 2014).

Contrary to hypothesis 3, male and female participants assigned to the MExp group did not show greater mean HF-HRV than the PCon group at either post-stress phases (Phase 3a and 3b).

There are multiple reasons to explain the absence of the relaxation effect while listening to the prayer (PExp group) in the overall results. Individuals may be vulnerable to self pejorative tendencies while engaged in prayer practice, a finding supported by Bradshaw, Ellison and Marcum (2010)'s national panel survey of 1041 elders and active members of the Presbyterian Church (U.S.). The key study findings indicated that secure attachment to God (i.e., perceiving God as warm and responsive) was inversely associated with psychological distress, whereas insecure/anxious attachment (i.e., perceiving God as impersonal, distant or inconsistent) to God was positively related to distress. Insecure attachment to God likely includes more self pejorative cognitions, either derived from a projective process whereby negative cognitions could be seen as emanating from the Higher Power, or in a unidirectional manner where negative cognitions are directed *to* the Higher Power due to disappointment with the lack of response to inherent requests accompanying prayer. Thus negative cognitions and associated stress or distress experiences could, theoretically speaking, be highly correlated with lower HRV.

In addition, since the subjects were all individuals of Muslim background, for whom the prayer passage (presented to the PExp group) was ethnically more compatible than the MM (presented to the MExp group), it is possible participants assigned to the PExp group experienced more self-pejorative tendencies and/or performance anxiety when exposed to the prayer passage. As performance anxiety is present when a task like listening to a prayer is perceived relevant, but mastery or effective performance is uncertain, performing specific tasks can evoke anxiety about the potential failure consequences. Experiencing symptoms of anxiety can explain the lack of increase in HF-HRV in the participants assigned to the PExp group, as many studies have revealed that patients with anxiety disorders have lower tonic HF-HRV at rest and in response to anxiety stressors, in comparison to healthy controls (Friedman and Thayer, 1998a, 1998b; Klein et al., 1995). Patients with anxiety have an over-reactive and maladaptive response in HRV to certain anxiety stressors (Pittig, Arch, Lam, & Craske, 2013). Pittig, Arch, Lam, & Craske (2013) examined HF-HRV in patients with anxiety during rest and during a relaxation task (i.e., silently and passively repeating "ah-nam"). Compared to matched healthy controls, patients showed reduced HRV after controlling for age, sex, respiratory cycle time and the use of psychotropic medication, which was maintained during the relaxation task. According to the neurovisceral model (Thayer & Lane, 2000), patients with anxiety disorders have deficits in inhibitory processes in the prefrontal cortical areas, resulting in reduced HRV. The underlying symptoms of anxiety disorders revolve around preservative cognitions (e.g., excessive worrying) that link thoughts to stress as it has been defined as, "the repeated or chronic activation of the cognitive representation of one or more psychological stressors" (Brosschot, Gerin, & Thayer, 2006). Though mobilization does not partake per se, it is theorized that individuals who participate

in excessive worrying suffer from a prolonged states of psychophysiological "action preparation" (Brosschot, Gerin, & Thayer, 2006). The participants in the PExp group may not have been clinically diagnosed with anxiety but they may have experienced symptoms of anxiety like excessive worrying. It is possible that the Muslim participants felt pressured to perform a certain way while listening to the prayer in the PExp group, and/or were worried if their HRV readings would be indicative of their level of religiosity.

Differences in HF-HRV in response to study conditions was examined separately for males and females. All analyses were examined separately for males and females, in light of research demonstrating sex differences in the autonomic nervous system (ANS) reactivity (Kajantie & Phillips, 2006) and recovery (Earle, Linden & Weinberg, 1999; Kudielka et al., 2004) to acute psychosocial stress. Variations in the ANS response in females have been associated with the phase of the menstrual cycle, menopausal status and pregnancy.

In support of hypothesis 2, male participants assigned to the MExp group showed greater mean HF-HRV than the MCon group at both post-stress phases (Phase 3a and 3b) and only at the 1–5 min post-stress phase (Phase 3a) for female participants. In this study, since all females were between puberty and menopause stages and none were pregnant, it is possible that the sex differences may have been due to their menstrual cycle phase. Sato and Miyake (2004) demonstrated that females had lower HF-HRV during the luteal phase than the follicular phase of the menstrual cycle. It had been suggested that these differences are due changes in hormone levels and their association with the ANS: the high levels of estrogen during the follicular phase activates the parasympathetic nervous system, while high levels of progesterone during the luteal phase activates the sympathetic nervous system

(SNS). Thus it is possible that the female participants did not benefit from the 6–10 min post-stress phase (Phase 3b) due to the phase of the menstrual cycle they were in during testing (e.g., majority could have been in the luteal phase with increased activation of SNS and lower HF-HRV). However, this prediction cannot be verified with our sample, as we did not collect data on what stage of their menstrual cycle they were in. Future studies can take phases of menstrual cycles into account in order to verify this prediction.

5.2.4 Hypothesis 4 – Stress Recovery during Mindfulness Meditation vs. Listening to Prayer: no significant difference in mean HF-HRV between MExp and PExp. Contrary to hypothesis 4, male participants assigned to the MExp group had significantly greater mean HF-HRV than male participants assigned to the PExp group at the 6–10 min post-stress phase. These results suggest that listening to the prayer may be a different form of meditation than MM. One difference between Buddhist meditation and contemplative prayer is that prayer revolves around connecting with a Higher Power (i.e., God) via cognitions and behaviours believed transcendent (Ferguson et al., 2010), whereas MM follows the Buddhist principle of non-theism where individual engagement in practices do not require beliefs in external intervention. These comparative findings, although specific to the type of Muslim prayer utilized and to the type of mindfulness of breathing instruction utilized, perhaps represent the differential physiological effects of mindfulness vs. prayer, which are, in turn, linked to varied purposes. Whereas MM (per the instruction of mindfulness of breath) is aimed at a conscious regulation of breath and a release of attachments to particular cognitions and to relaxing the body, listening to the prayer is aimed at strengthening attachments to particular cognitions (which are associated with *praying* to a perceived Higher Power, who represents moral-ethical and religious obligations).

While MM involves conscious and deliberate regulations of the breath, the participated assigned to the PExp group did not receive specific instructions on how to sustain attention during the practice. A domain of HRV called respiratory sinus arrhythmia (RSA) involves HRV being synchronized with respiration, where there is a decrease and an increase in HRV during inspiration and expiration, respectively (Allen et al., 2007; Force, 1996; Yasuma & Hayano, 2004). This synchronization can help understand how deliberately elongating the out-breath during MM practice (e.g., "*Emphasize longer, slower and more complete breathes; focus on breathing out thoroughly, emptying the air in your lungs; feel your breath moving outwards as you breath out and see if you can feel the outward breath linked to other flows of sensation in your body; when you breath out, you are stimulating a nerve called the vagus nerve that naturally relaxes your heart and the rest of your body; allow the exhaling breath and the action of the vagus nerve to take place*"), can in turn, increase HRV. In contrast, while listening to the prayer passaged (presented to the PExp group), individuals were not told to attend to their in- and out-breathe nor reminded to focus attention on the present moment. Due to the lack of continuous on-going instructions, it is possible that the participants assigned to the PExp group and both control groups (MCon and PCon) allowed distractions to draw attention back to the past or future concerns.

While meditation is commonly associated with a relaxed hypo-metabolic state, recent research has taken both the relaxing and arousing effects of meditation into consideration (Lumma, Kok & Singer, 2015). The psychophysiological effect of meditation may depend on the type of meditation, as each type differs with respect to the complexity of attentional, cognitive and affective processes involved. For instance, Lumma et al. (2015) examined changes in HF-HRV during MM, loving-kindness meditation and observing-thoughts

meditation throughout a 13-week training program in a healthy population (N = 156; 60% females). Measures were taken during week 3 and 13 of the training sessions for each type of meditation exercise. There were no significant differences in HF-HRV across exercises at the first time point. However, contrary to the hypothesis proposed, HF-HRV significantly decreased from week 3 to 13 for loving-kindness and observing-thoughts meditation, although the participants reported these meditation types to be more enjoyable and less effortful over time. The decrease in HF-HRV over time suggests an increase in sympathetic arousal over training, and it was proposed that these results are due to the complex nature of the types of meditation assessed. Loving-kindness and observing-thoughts meditations are depicted as more demanding exercises that make use of attentional and cognitive resources (e.g., visual imagery, positive affect, focusing on thoughts and emotions, meta-cognitive awareness etc.), leading to an arousing effect instead of a relaxing effect. Amihai and Kozhevnikov (2014) demonstrated that meditation types that involved the use of active processes (e.g., generating mental imagery) lead to increased SNS responses compared to meditation types that involved sustained attention (e.g., focus on breath). Thus the decreased HF-HRV over training for loving-kindness and observing-thoughts meditation may be indicative of physiological arousal due to increased mental alertness. In addition, despite the increase in sympathetic arousal, participants still reported these types of meditations as more enjoyable and less effortful with additional training, suggesting that participants were able to achieve a state of flow, wakefulness and/or alertness while partaking in these demanding exercises (Britton et al., 2014; Lumma et al., 2015). In this current study, male participants assigned to the MExp group had greater mean HF-HRV than male participants assigned to the PExp group at 6–10 min post-stress, which could be explained by the differences between

MM (in the MExp group) and listening to a prayer passage (in the PExp group) with respects to the complexity of attentional, cognitive and affective processes involved. MM involves sustained attention as individuals are instructed to maintain their focus on the breath. In contrast, listening to a prayer passage may be considered a more demanding exercise, which requires complex attentional and cognitive resources, such as generating mental imagery of God and God's creations, positive affect towards the Higher Power and thoughts and emotions stimulated by the prayer.

It is important to clarify here that these results are not evaluative with respect to which contemplative procedure (MM or listening to a prayer passage) might have superior health effects. We have used one measure of health-related reactivity (HF-HRV) and for only a 10-minute time span, after a specifically cognitively oriented stressor exposure. These are highly specific results that were aimed at demonstrating one method of comparing different contemplative procedures. Nonetheless, we have intended to initiate exploration of how these procedures might differ in physiological effects related to stress exposures. Both MM and prayer are arguably widely used to cope with stressful situations and it is a worthy experimental goal to better understand how stress recovery is impacted as it is an important health-related goal.

5.2.5 Hypothesis 5 – Stress Recovery and Negative Automatic Thoughts: Greater mean HF-HRV in MExp and PExp compared to respective control groups in participants with elevated negative thoughts. We further explored HF-HRV recovery in relation to negative automatic thoughts (ATQ). To evaluate effects of negative cognitions on changes in HF-HRV across groups, scores on ATQ were dichotomized according to available

norms for dysphoric mood in young adults (Ingram, Johnson, Bernet, & Dombeck, 1992; Lightsey, 1994; Lightsey & Christopher, 1997).

Results indicated that females with dysphoric mood (e.g., ATQ ≥ 60) that were assigned to the MExp group had greater mean HF-HRV than females assigned to the MCon group at the 1–5 min post-stress phase (Phase 3a), however this difference did not remain significant during 6–10 min post-stress phase (Phase 3b). MM practice involves observing and not reacting to thoughts as they capture your attention, and moreover, it involves flexible awareness of automatic negative thoughts (Frewen, Evans, Maraj, Dozois, & Partridge, 2008). For example, Broderick (2005) induced dysphoric mood in participants using the Velten induction procedure (i.e., listening to statements with depressing content, concentrating on their sadness, and thinking about depressing life experiences). These participants were then randomized into the rumination condition (i.e., reflect on self-focused statements; e.g., why they reacted a certain way), distraction condition (i.e., reflect on non-self-focused statements; e.g., a freshly painted door), or a MM condition. Participants in the MM condition reported significantly lower levels of negative mood compared to the other two conditions. Thus it is possible that females with dysphoric mood in this current study were able to 'let go' of their negative cognitions, therefore benefiting from HF-HRV stress recovery effects at the 1–5 min post-stress phase. In contrast, females with dysphoric mood assigned to the MExp group did not show greater mean HF-HRV compared to females assigned to the MCon group at the 6–10 min post-stress phase. It is possible that females with dysphoric mood need longer exposure to MM in order to see consistent HF-HRV stress recovery effects. For example, Frewen et al. (2008) demonstrated that participants of the MM-based clinical intervention (eight weekly 120-150 min sessions of guided meditation,

yoga and psychoeducation) had a lower frequency in automatic negative thoughts, while experiencing an increase in ability to "let go" of the negative cognitions. In addition, females with dysphoric mood may also need psychoeducation to help teach them how to positively experience, or cultivate a decentered awareness of their negative cognitions.

In addition, results indicated that females with dysphoric mood (e.g., ATQ ≥ 60) that were assigned to the PExp group had greater mean HF-HRV than females assigned to the PCon group at the 6–10 min post-stress phase (Phase 3b), however this difference was not significant during 1–5 min post-stress phase (Phase 3a). It is worth highlighting that while non-perfectionist participants exhibited significantly elevated HF-HRV during the two consecutive 5-minute phases of the post-stress mindfulness instruction ($p < .001$), maladaptive perfectionist subsample did not exhibit HF-HRV responses to MM instruction (Azam, et al., 2015). It was speculated that cognitive factors associated with maladaptive perfectionism (e.g., harsh self-evaluation, attention bias to failure) hindered the perfectionists from engaging in mindfulness practice and prevented parasympathetic stress recovery. Thus, it is possible that these females assigned to the PExp group were focusing more on their negative thoughts and were not able to "let go" at the 1–5 min post-stress phase, akin to maladaptive perfectionists, but with time they were able to obtain parasympathetic stress recovery.

Differences in HF-HRV recovery between the MExp and PExp groups suggests that both practices can lead to HF-HRV recovery in the aftermath of a stress-induction task; however, both practices may involve different processes as previously mentioned in section 5.2.4. These results suggest that both practices can help increase HF-HRV for females with dysphoric mood; however, the effects of MM are faster. While MM (per the instruction of

mindfulness of breath) is aimed at relaxing attachments to particular cognitions and to relaxing the body, listening to a prayer is aimed at strengthening attachments to particular cognitions (which are associated with *praying* to a perceived Higher Power, who represents moral-ethical and religious obligations). Since listening to a prayer passage was shown to have a relaxing effect in the latter half of the post-stress phase, we speculate that moral-ethical commitments can resolve conflicts and situational ambiguities with time.

These results seen in females with dysphoric mood, were not seen in females who had low ATQ scores (< 60). It is possible that female participants with dysphoric mood were more motivated to overcome their negative automatic thoughts through MM or listening to a prayer passage, than females without dysphoric mood. Furthermore, since we had a smaller sample size of male participants, it was difficult to make conclusions on how males with and without dysphoric mood behaved in this study.

5.3 Implications

Male Muslim participants assigned to the MExp group showed greater mean HF-HRV than the MCon group at both post-stress phases (Phase 3a and 3b) and similarly in female participants at the 1–5 min post-stress phase (Phase 3a). Thus MM is a suitable practice for meditation novices to promote relaxation after experiencing cognitive stress, however more exposure to MM in addition to psychoeducation could possibly help individuals gain the most benefit. More specifically, females with dysphoric mood can benefit from MM to possibly lower the amount of negative automatic thoughts and/or help them learn how to deal with negative cognitions as they arise.

In contrast, prayer is a common practice completed by many individuals from a range of different religious backgrounds. Muslim females with dysphoric mood (e.g., ATQ ≥ 60)

that were assigned to the PExp group had greater mean HF-HRV than females assigned to the PCon group at the 6–10 min post-stress phase (Phase 3b), however this difference was not significant during 1–5 min post-stress phase (Phase 3a). Thus listening to a prayer is also a suitable practice for individuals to promote relaxation after experiencing cognitive stress. However more exposure to listening to prayers in addition to psychoeducation on how to deal more immediately with automatic negative thoughts could help counter the delay in the relaxation.

Since male participants assigned to the MExp group had significantly greater mean HF-HRV than male participants assigned to the PExp group at the 6–10 min post-stress phase, it may be beneficial for individuals to perform MM before their prayer or to adapt elements of MM into their prayers, when stress reduction is a specific goal. For instance, while praying, practitioners could be instructed to focus on their in- and out-breath. This practice can be easily adapted into the prayer by deliberately synchronizing each in- and out-breath with each consecutive prayer verse. Similar to meditation, prayer also involves focusing attention on the present moment, while additionally focusing on transcendent actions. Through practice with meditative techniques, individuals can learn to focus on transcendence in the present moment so that they are less likely to allow distractions to draw their attention back to past or future concerns. Through this 'mindful prayer' practice, individuals could return their focus to transcendent actions after non-avoidantly accepting thoughts, emotions and external stimuli as distractors.

In this current study only participants with lower and higher levels of dysphoric mood were examined. However, it is possible that unhealthy individuals (e.g., chronic illnesses or

psychiatric conditions) might benefit from improved ANS regulation, which could be accomplished via MM and/or listening to a prayer passage.

5.4 Strengths and Limitations

This present study adapted a stress-induction task prior to randomization to the study groups, as suggested by Zeidan et al. (2010), in order to examine the benefits of brief mindfulness training after the experience of stress. In addition, our protocol overcame the criticism of there being a lack of adequate control conditions in meditation research (Toneatto & Nguyen, 2007). Our control conditions were designed to be structurally identical to the experimental conditions in non-specific factors of eyes closed, seated position and audio being played of equal duration. This corresponds to the approach taken in studies of MBSR, wherein an active control condition involved health education (e.g., nutrition, chronic disease) but did not feature any specific mindfulness training (MacCoon et al., 2012; Rosenkranz et al., 2013). In our meditation and prayer control conditions, participants listened to historical information about the benefits of meditation and prayer, respectively, without hearing any guided meditation instructions or prayer passages from the Quran.

Participants were stratified based on sex (male-female) and the Centrality of Religiosity Scale-15 (CRS-15; non-religious, religious or highly-religious) scores (Huber & Huber, 2012). Stratification by sex and religiosity was aimed at obtaining an identical number of religious and highly females and males per condition. In this study, there was a scarce recruitment of Muslim male participants, thus it was difficult to make conclusions about how males with dysphoric mood were performing in both the MExp and PExp groups. While this study had a large sample of female participants, females in both the luteal or

follicular phases of their menstrual cycle were included in the analysis. Sato and Miyake (2004) demonstrated that females had lower HF-HRV during the luteal phase than the follicular phase of the menstrual cycle, which could have impacted the results of this study. Future studies should inquire about what stage of their menstrual cycle the females were in, in order to control for these possible variations in HF-HRV.

Furthermore, there may have been a social desirability bias where participants over-reported their religious behaviour in line with what is deemed as a favourable response by others. Thus it was difficult to firmly conclude that there were identical numbers of highly religious and moderately religious participants in each condition.

This current study limited its sample to only Muslim undergraduate students in attempts to minimize additional confounding variables (e.g., familiarity and experience with passage from the Quran, belief in the benefits of listening to the Quran etc.). Thus our findings must be conservatively interpreted, as they are only generalizable to Muslim undergraduate populations.

5.5 Future Research Directions

This study gave participants, who had little or no previous meditative experience, a brief 10-minute dose of MM instruction or listening to a prayer passage in the aftermath of a cognitive stressor. Future research with HRV assessment protocols should consider using stress-inductions more relevant to daily stressors with stronger ecological validity.

In the current study, unlike previous studies (Azam et al., 2015; Azam et al., 2016), the difference in mean HF-HRV in female participants assigned to the MExp and MCon groups did not remain significant during the 6–10 min post-stress phase. Only an additional

study with a longer period of post-stress evaluation can ascertain whether the MM responses observed are temporary or if they resume after certain additional durations. In addition, we did not investigate the optimal length of meditation and prayer time required to achieve MM- and prayer-related benefits. The optimal length of meditation and time listening to a prayer passage required to achieve MM- and possible prayer-related benefits using protocols that assess a dose-response curve can be examined. In addition, it would be interesting to examine whether MM- and possible prayer-related benefits last for long periods of time or if continuous practice is necessary. This could lead to a study that adapts a longitudinal design examining the benefits for extensive MM and prayer practice over a lengthier time frame.

It is interesting to note that Muslims female participants with dysphoric mood assigned to the MExp group, had greater mean HF-HRV than the females assigned to the MCon group at only the 1–5 min post-stress phase. In contrast, Muslims female participants with dysphoric mood assigned to the PExp group, had greater mean HF-HRV than the females assigned to the PCon group at only the 6–10 min post-stress phase. Future studies could include an audio stimulus that begins with 5-minutes of MM and then ends with 5-minutes of a passage from the Quran. This additional arm of the randomized controlled trial will help depict whether or not the combination of MM and listening to a prayer is most optimal. In addition, features of the MM instructions can be provided to individuals assigned to the PExp group to investigate if focusing on the in- and out- breath is an important element in achieving an increased HF-HRV. Studies may use these findings to further explore the comparison between other types of MM and prayer as alterative forms of stress-reduction. Overall, future studies can actively recruit more male participants in order to get an equal

sample size of each sex in order to explore how males with dysphoric mood were performing in both the MExp and PExp groups, compared to respective control groups.

In addition, future studies can compare the effects of MM and prayer between: Muslims and non-Muslims; advanced meditators, highly religious individuals (e.g., imams) and novices; and between healthy and unhealthy individuals. In this study, a particular reciter presented the prayer in a specific Quranic scale, however in the future, it would be interesting to examine whether different Quranic scales would elicit a different HF-HRV. Finally, there are multiple forms of prayer, such as *salat*, which is Muslims could be more familiar with than the study stimuli used (listening to the recitation of a specific passage from the Quran), that could be used in future studies. Futhermore, future studies can compare other forms of prayer to meditation (e.g., repeating an Islamic phrase/one of God's names versus mantra meditation).

6.0 Conclusion

This study's primary objective was to investigate stress reactivity in Muslim undergraduate students under conditions of stress, MM and while listening to a prayer. There is a lack of understanding of how prayer can impact psycho/physiological health and how it compares to MM. The results for male participants revealed greater mean HF-HRV for participants in the MExp group than the MCon group at the 1–5 min and 6–10 min post-stress phases and results for female participants revealed greater mean HF-HRV for the MExp group than the MCon group only at the 1–5 min phase. Further analyses of females with self-reported dysphoric mood revealed greater mean HF-HRV for participants in the MExp group than the MCon group at the 1–5 min post-stress phase and it revealed greater mean HF-HRV for participants in the PExp group than the PCon group at the 6–10 min post-

stress phase. Overall, these results suggest that MM and listening to a prayer passage can both promote stress recovery in females with dysphoric mood and these findings promote further exploration of alternative methods of stress reduction to support preventive mental health initiatives.

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Appendix A – Systematic Review

Effectiveness of Spiritually-based Psychoeducational Interventions in Improving Mental Health and Quality of Life Outcomes: A Systematic Review of Randomized Controlled Trials

2.10.1 Introduction

In the twenty-first century, there has been an increasing interest in spiritually-based interventions within the fields of mental health and disease management (Buck, 2006; Miller & Thoresen, 2003; Puchalski, 2001; Salsman, Fitchett, Merluzzi, Sherman, & Park, 2015). While religious and spiritual themes were previously considered outside the scope of medicine and psychiatry (Hill et al., 2000; Koenig, 2009; Puchalski, 2001) spirituality is increasingly viewed as an important component of medical and psychiatric practice (Post & Wade, 2009; Puchalski, 2001).

Although spirituality has been traditionally viewed in terms of organized religious practice (George, Larson, Koenig, & McCullough, 2000; Koenig, 2009), interventions oriented around spirituality and religious belief are now viewed as applicable in secular contexts (Hodge & Chen McGrew, 2005; Marler & Hadaway, 2002). Given these developments, most current spirituality-themed interventions draw from religious *and* secular traditions, emphasizing: (a) meaning and purpose in life; and (b) increased appreciations of the interconnections between values, community, nature, and/or a higher being in ways that define personal paths for transcendence and transformation (Buck, 2006; Chandler, Miner Holden, & Kolander, 1992; Piedmont, 1999; Tanyi, 2002).

Across numerous evaluations, spirituality, whether religiously or secularly conceived, is linked to a range of mental health benefits (Bonelli & Koenig, 2013; Clayton-Jones & Haglund, 2015; Fangauf, 2014; Jim et al., 2015; Nichols & Hunt, 2011), prompting efforts to

identify and utilize these effects in mental health interventions (Elkonin, Brown, & Naicker, 2014; Sperry, 2012; Wade, Post, Cornish, Vogel, & Runyon-Weaver, 2014). With increasing evidence of positive benefit, these programs have generally taken the form of: (a) psychoeducation, exploring spiritual themes in a skill-based teaching framework without reliance on specific psychotherapeutic formats (Koszycki, Bilodeau, Raab-Mayo, & Bradwejn, 2014; Koszycki, Raab, Alsosary, & Bradwejn, 2010); and/or (b) spiritually-integrated psychotherapies (e.g., behavioural activation of religious behaviours, spiritually-based cognitive-behavioural therapy; Armento et al., 2012; Pearce et al., 2015; Rosmarin, Auerbach, Bigda-Peyton, Björgvinsson, & Levendusky, 2011).

In recent years, specific spiritually-based psychoeducational interventions (SBPIs) have received attention as promising mental health-improving approaches. While sharing many similarities with standard psychotherapies, these programs highlight spiritual themes using psychoeducational frameworks, emphasizing goal setting, self-directed learning, and skill development (Authier, 1977; Lukens & McFarlane, 2004). Given that previous reviews on the effectiveness of spiritually-based interventions have largely focused on spiritually-integrated psychotherapies (Gonçalves, Lucchetti, Menezes, & Vallada, 2015; Viftrup, Hvidt, & Buus, 2013), our primary objective was to evaluate the effectiveness of spiritually-based *psychoeducational* interventions in improving mood (e.g., depression and anxiety symptoms) or disease-specific outcomes (e.g., quality of life) in clinically and non-clinically defined populations.

2.10.2 Method

Literature Search

A systematic keyword search of MEDLINE, EBSCO, PsycINFO, PubMed, and Web of Science databases was conducted to identify spiritually-based interventions in the English language for the period of January 2005 to April 2016. Search terms included are presented in Table 11. To identify additional citations, we further investigated the reference sections of selected trials and performed online web searches.

Inclusion and Exclusion Criteria

Inclusion was limited to randomized controlled trials (RCTs), from January 2005 to April 2016 that evaluated the effectiveness of SBPIs in improving psychological and quality of life status in healthy, emotionally-distressed or clinical samples. Given these goals, inclusion was limited to RCTs that integrated spiritual teachings within a psychoeducational framework. We excluded studies evaluating the effectiveness of spiritually-integrated psychotherapies, primarily relaxation and meditation-based programs, and off-site retreats.

Abstraction, Synthesis, and Ratings of Study Quality

Three reviewers (IA, MP, and KC) extracted relevant study information, including participant characteristics, study characteristics and findings, using a pre-specified format. The Cochrane tool for bias assessment (Higgins et al., 2011) was used to evaluate methodological rigour and potential bias sources (e.g., selection bias, performance bias, attrition bias, reporting bias, etc.) across studies (see Table 12). Ratings were performed separately by two reviewers (IA & MP), with disagreements resolved by consultation with a third reviewer (PR).

Table 11. Search terms Example (Medline)

Step	Search term(s)
1	randomized controlled trial.mp. or Randomized Controlled Trial/
2	randomised controlled trial.mp.
3	clinical trial.mp. or Clinical Trial/
4	1 or 2 or 3
5	"Religion and Medicine"/ or prayer*.mp. or Complementary Therapies/
6	spiritual*.mp. or Spirituality/ or Spiritual Therapies/
7	(prayer and health*).mp. [mp=title, abstract, original title, name of substance word, subject heading word, keyword heading word, protocol supplementary concept word, rare disease supplementary concept word, unique identifier]
8	(prayer and well being*).mp. [mp=title, abstract, original title, name of substance word, subject heading word, keyword heading word, protocol supplementary concept word, rare disease supplementary concept word, unique identifier]
9	(prayer and well-being*).mp. [mp=title, abstract, original title, name of substance word, subject heading word, keyword heading word, protocol supplementary concept word, rare disease supplementary concept word, unique identifier]
10	Personal prayer.mp.
11	private prayer.mp.
12	religious activity.mp.
13	5 or 6 or 7 or 8 or 9 or 10 or 11 or 12
14	Multiple Sclerosis/ or Cardiovascular Diseases/ or Chronic Disease/ or chronic disease*.mp. or Diabetes Mellitus, Type 2/ or Neoplasms/

Table 12. Risk of Bias Assessment using Cochrane Risk of Bias Tool

Reference	Selection Bias		Performance Bias	Attrition Bias	Reporting Bias	Other bias
	Random sequence generation	Allocation concealment	Blinding[a]	Incomplete outcome data	Selective reporting	
Jafari et al., 2013	Low	Unclear	High	Low	Low	High
Koszycki et al., 2010	Unclear	Unclear	High	Low	Low	High
Koszycki et al., 2014	Low	Low	High[a]	Low	Low	High
McCauley et al., 2011	Low	Low	Low[b]	Low	Low	High
Mortiz et al., 2006	Low	Low	High	Low	Low	High
Richards et al., 2006	Unclear	Unclear	High	Low	Low	High
Rickhi et al., 2011	Low	Low	High[a,b]	Low	Low	High

Note. Unclear, low, and high indicate the risk of bias with in each domain as outlined by the Cochrane organization (Higgins et al., 2011).

[a] Given the nature of interventions, blinding of therapists or participants may not have been possible. However, some studies took precautionary measures, including non-disclosure of intervention type.

[b] personnel blinded to participant group assignment.

2.10.3 Results

Database Search and Selection Process

Database searches led to a total of 433 citations across MEDLINE (*n* = 160), EBSCO (*n* = 9), PsycINFO (*n* = 207), PubMed (*n* = 20), and Web of Science (*n* = 37) along with 5 additional citations identified using manual internet search (Jafari et al., 2013; Miller, Forcehimes, O'Leary, & LaNoue, 2008; Moritz et al., 2006; Musarezaie, Ghasemipoor, Momeni- Ghaleghasemi, Khodaee, & Taleghani, 2015; Warber et al., 2011). After the removal of duplicate citations, of the 356 remaining citations, 205 were eliminated in the first stage (review of title and abstract), and another 144 were removed at subsequent stages, leading to a total of seven RCTs selected for inclusion. Figure 9 depicts the search and selection process flow diagram according to PRISMA (Preferred Reporting Items for Systematic Reviews and Meta-Analyses) guidelines (Liberati et al., 2009).

Ratings of Study Quality

Table 12 presents ratings of study quality according to the Cochrane criteria. Overall, of the seven studies selected, all explicitly stated their inclusion and exclusion criteria and randomly assigned participants to either the SBPI or a comparison control group. However, only five (71%) trials elaborated on their exact method of randomization and only four (57%) described whether a concealed allocation schedule was employed. While participant or therapist blinding may not have been possible or relevant given the nature of SBPIs, there were efforts at minimizing bias, notably by creating neutral program recruitment notices (Koszycki et al., 2014; Rickhi et al., 2011) or blinding program assessors as to participants' group assignment (McCauley et al., 2011; Rickhi et al., 2011).

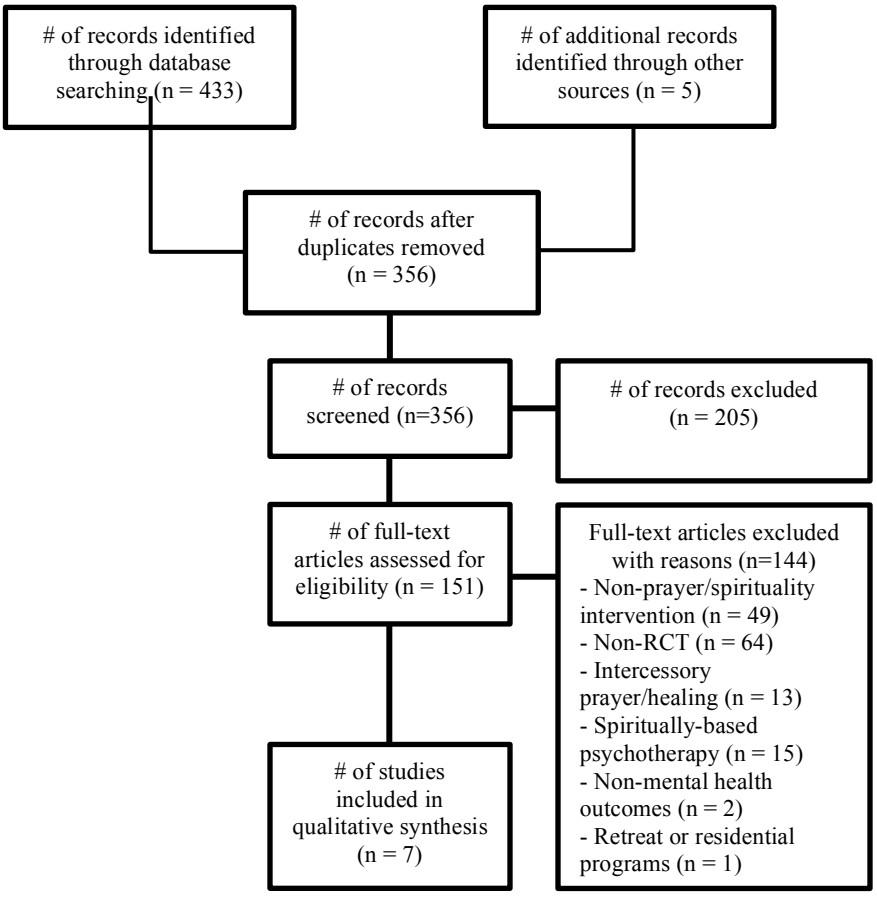

Figure 9. PRISMA Diagram for the search and selection process

Program Characteristics

The RCTs identified (n = 7) evaluated the effectiveness of SBPIs in emotionally-distressed individuals (Moritz et al., 2006) diagnosed with psychiatric conditions (Koszycki et al., 2010; Koszycki et al., 2014; Richards et al., 2006; Rickhi et al., 2011), or in those with chronic disorders (Jafari et al., 2013; McCauley et al., 2011). Of the seven selected RCTs (see Table 13 for detailed study summaries), five employed a parallel group design, evaluating the effectiveness of SBPIs compared to a waitlist control group (WC) (Rickhi et al., 2011), usual care control group (UC; Jafari et al., 2013), or contrasting psychotherapeutic approaches (Koszycki et al., 2010; Koszycki et al., 2014; McCauley et al., 2011). However, two studies employed a three-armed design, in which the SBPI was compared against a cognitive- and emotionally-focused support group (Richards et al., 2006) or compared against a mindfulness- based stress reduction and a WC comparison condition (Moritz et al., 2006). Across the SBPI, program length ranged between 4 (McCauley et al., 2011) to 12 weeks (Koszycki et al., 2010; Koszycki et al., 2014), with a mean of 8.5 weeks across trials. Although specific program content varied across trials, all interventions employed nondenominational spiritual teachings, aligned with common conceptualizations of spirituality (Buck, 2006; Chandler, Miner Holden, & Kolander, 1992; Piedmont, 1999; Tanyi, 2002) that were compatible with religious and cultural backgrounds.

Programs included the use of home-based audiovisual materials (McCauley et al., 2011; Moritz et al., 2006; Rickhi et al., 2011) in-person one-on-one meetings (Koszycki et al., 2010; Koszycki et al., 2014) or group sessions (Jafari et al., 2013; Richards et al., 2006). In addition, SBPIs were delivered by various individuals, including a spiritual care counsellor (Koszycki et al., 2010), spiritual educators (Jafari et al., 2013), Ph.D. level psychologists

Table 13. Characteristics of Included Trials

Study	Sample Characteristics	Religious Affiliation	SBPI Intervention and Spiritual Themes Explored	Comp-arison	Results[c]
Jafari et al. (2013)	*N* = 68 breast cancer patients (without other comorbid diagnoses); 100% female[b]; *M* age = 47.9 yr intervention, 48.1 yr control; 95% completion rate.	Not indicated (possibly Muslim).	6 weeks, weekly group sessions (120–180 mins); Topics include: meditation and relaxation, personal control, self-compassion, personal and interpersonal relationships, and prayer to God.	Usual medical care.	Increased mean global health and cancer quality of life scores on EORTC QLQ-C30 in intervention versus usual care (p = 0.001, d = 2.1)
Koszycki et al. (2010)	*N* = 22 adults with GAD; 59% female[a]; *M* age = 38.5 yr intervention, 48.4 yr control; 82% completion rate.	63.6% Christian, 4.5% Jewish, 31.8% no religious affiliation.	12 weeks, weekly individual sessions (12–50 mins); activities and discussions centre on themes from the book *Essential Spirituality* (e.g., meditation techniques, mindfulness, forgiveness, gratitude, attachment, suffering, generosity, and self-acceptance).	12 weeks, weekly individual sessions (12–50 mins); CBT	Reduced mean HAM-A (d = 1.87), BAI (d = 1.24), CGI-S (d = 1.72), & BDI (d = 1.10) in intervention; no statistically significant difference between intervention and CBT.
Koszycki et al. (2014)	*N* = 23 adults with GAD; 65% female[a]; *M* age = 39.8 yr intervention, 44.7 yr control; 87% completion rate.	69.6% Christian, 13.0% Other, 17.4% no religious affiliation.	12 weeks, weekly individual sessions (12–50 mins); activities and discussions centred on themes from the book *Essential Spirituality* (e.g., meditation techniques, mindfulness, forgiveness, gratitude, attachment, suffering, generosity, and self-	12 weeks, weekly individual sessions (12–50 mins); Supportive psychot	Reduced mean HAM-A ($p \leq$ 0.001, d = 1.50), CGI-S ($p \leq 0.001$, d = 1.64), in intervention versus supportive psychotherapy.

			acceptance).	herapy.	
McCauley et al. (2011)	*N* = 100 adults with at least one chronic illness; 62% female[a]; *M* age = 66.1 yr intervention, 65.7 yr control; 85% completion rate.	93.9% Christian, 1.3% Jewish, 1.3% Muslim, 3.6% No religious affiliation.	4 weeks, home-based program; weekly activities include completion of video (*Plans to Prosper*) and workbook tasks.	General cardiac risk reduction information (video called *Straight from the Heart*).	Increased mean MOS *energy levels* in intervention versus general cardiac risk reduction (p = 0.01, d = 0.20).
Mortiz et al. (2006)	*N* = 165 adults with emotional distress; 84% female[a]; *M* age = 44.6 yr intervention, 43.6 yr meditation, 43.9 control; 89% completion rate.	50.3% Christian, 8.5% Other, 39.4%; no religious affiliation, 1.8% not specified.	8 weeks, home-based program; weekly home-based audio program (90 mins); daily progressive visualization practice (45 mins); Themes include: recognizing behavioural tendencies that separate us from the divine and life's purpose, self-transcendence, forgiveness, and unconditional love.	Meditation group: 8 weekly sessions of meditation (MBSR) or wait list control group	Reduced POMS total score in intervention compared to both the MBSR (p = 0.03) and WC (p = 0.005); Reductions in POMS Tension (p = 0.007) and depression (p = 0.01) subscales compared to MBSR. Improvements on SF-36 in intervention compared to MBSR (p = 0.03) and WC (p < 0.001)

Richards et al. (2006)	*N* = 122 adults with eating disorders; 100% female[b]; *M* age = 21.2 yr intervention and control; 100% completion rate.	81.1% Christian, 1.6% Jewish, 7.4% no religious affiliation, 7.4% not specified.	9[d] weeks, weekly spiritual support group sessions (60 mins); activities and discussions centred on themes from the book *Spiritual Renewal: A Journey of Faith and Healing* (e.g., spiritual identity, grace, forgiveness, repentance, faith, prayer, and meditation).	Weekly group sessions (60 mins); CBT or emotional open-topic support group	Reduced eating disorder symptoms (p = 0.013), OQ-45's symptom (depression-anxiety) distress (p = 0.026), relationship distress (p = 0.006), and social role conflict (p = 0.004); in intervention versus CSG or ESG.
Rickhi et al., 2011	*N* = 84 adults mild to moderate unipolar depression; 77% female[a]; *M* age = 44.1 yr intervention, 44.0 yr control; 67% completion rate.	56.0% Christian, 35.7% no religious affiliation, 8.3% other religion.	8 weeks, weekly home-based audio program (90 mins); daily progressive relaxation practice (15 mins); Themes include: self-transcendence, connectedness (personal, interpersonal, God), self-acceptance, compassion, and gratitude.	WC	Reduced mean HAM-D (p = 0.0001) and greater depression response (p < 0.001) and remission rates (p < 0.001) in intervention versus waitlist control.

[a] = Percentage determined from those enrolled.
[b] = Percentage determined from those completing the intervention.
[c] = Statistically significant findings at post-intervention, for subsequent follow ups refer to narrative.
[d] = Average length of stay in the program

BDI: Beck Depression Inventory; CBT: Cognitive-Behavioural Therapy; CGI-S: Clinical Global Impression; CSG: Cognitive Support Groups; EORTC QLQ-C30: European Organization for Research and Treatment of Cancer quality of life questionnaire; ESG: Emotional Support Groups; GAD: Generalized anxiety disorder; HAMA-A: Hamilton Anxiety and Depression score; HAM-D: Hamilton Depression Rating Scale; MBSR: Mindfulness-based Stress Reduction; OQ-45: Outcome Questionnaire; POMS: Profile of Mood States; SF-36: Short form 36; WC: Waitlist control

(Koszycki et al., 2014; Richards et al., 2006), psychiatrists (Moritz et al., 2006; Rickhi et al., 2011), and physicians (McCauley et al., 2011).

In alignment with psychoeducational principles, all programs integrated self-directed learning by requiring participants to watch videos (McCauley et al., 2011), listen to audiotapes (Moritz et al., 2006; Rickhi et al., 2011), or complete relevant readings and exercises (Jafari et al., 2013; Koszycki et al., 2010; Koszycki et al., 2014; McCauley et al., 2011; Richards et al., 2006). Moreover, four programs supplemented self-directed activities with weekly counsellor-supportive meetings (Jafari et al., 2013; Koszycki et al., 2010; Koszycki et al., 2014; Richards et al., 2006).

Participant Characteristics

Study participants ranged in age from 21.2 years (Richards et al., 2006) to 65.8 years (McCauley et al., 2011) with a mean age of 51.0 years across studies. The majority of participants came from multiple Abrahamic religions or spiritual backgrounds, but 3.5% (McCauley et al., 2011) to 39% (Moritz et al., 2006) indicated no religious affiliation. Participants were recruited via local media and community advertisements (Koszycki et al., 2010; Koszycki et al., 2014; Rickhi et al., 2011), through primary care physician practices (Koszycki et al., 2010; Koszycki et al., 2014; McCauley et al., 2011; Rickhi et al., 2011) and at a rehabilitation centre (Richards et al., 2006) and at a hospital (Jafari et al., 2013).

Psychological status or diagnosis was determined through psychologist assessments (Richards et al., 2006; Koszycki et al., 2010; Koszycki et al., 2014), elevated scores on validated psychometric self report scales (Moritz et al., 2006; Rickhi et al., 2011), or their combination (Koszycki et al., 2010; Koszycki et al. 2014) except in RCTs where inclusion criteria was based on a chronic disease diagnosis (Jafari et al., 2013; McCauley et al., 2011).

Finally, amongst the six studies where self report data were statistically compared (Jafari et al., 2013; Koszycki et al., 2010; Koszycki et al., 2014; McCauley et al., 2011; Moritz et al., 2006; Rickhi et al., 2011), there were no statistically significant differences at baseline between intervention and comparison conditions with respect to age, religious affiliations, medications, or diagnostic status. A detailed overview of relevant program and participant characteristics is presented at Table 1.

Program Outcomes

Spiritually-based Psychoeducational Programs in Psychiatric Samples. Four of the RCTs evaluated the effectiveness of SBPIs in improving mood (e.g., anxiety or depressive symptoms) in clinically diagnosed populations (Koszycki et al., 2010; Koszycki et al., 2014; Richards et al., 2006; Rickhi et al., 2011). For example, Koszycki et al. (2010) evaluated the effectiveness of a 12-week SBPI in adults with generalized anxiety disorder (GAD). Participation in the program (n = 11) entailed 12 individual sessions of 50-minutes in duration that focused on better understanding GAD, cultivating mindfulness and emotional awareness, forgiveness, ethical living, and generosity. The control group attended 12 individual cognitive-behavioural therapy (CBT) sessions of similar length that focused on relaxation training, cognitive restructuring, worry exposure, time management, goal setting and problem solving. At 12-weeks post-treatment, participants in both the SBPI and CBT experienced reductions of similar magnitude in anxiety symptoms on the Hamilton Anxiety Rating Scale (HAM-A: -13.5 in the SBPI; d = 1.87 vs. -14.5 in CBT; d = 1.84), and Beck Anxiety Inventory (BAI: -12.0 in the SBPI; d = 1.24 vs. -9.5 in CBT; d = 0.73); Participants in both groups further experienced additionally significant reductions in depressive symptoms on the Beck Depression Inventory (BDI: -10.9 in the SBPI; d = 1.10 vs. -13.6 in

CBT; d = 1.26), and in clinician-ratings of GAD severity (CGI-S: -2.2 in the SBPI; d = 1.72 vs. -2.4 in CBT; d = 2.22). In addition, these improvements were maintained at subsequent 3- and 6-months follow-ups, with no statistically significant differences between the SBPI and the CBT conditions. Both the SBPI and the CBT condition also showed comparable response and remission rates at post-intervention (63.6% in the SBPI vs. 72.7% in CBT) and subsequent follow-ups, with no statistically significant between-group differences.

In a follow-up study, Koszycki et al. (2014) examined the effectiveness of the same SBPI approach relative to supportive psychotherapy (SP), based on a format that focuses on nonspecific therapeutic factors (e.g., empathy, reflective listening, and therapeutic optimism).

SBPI participants (n = 11) attended 12 weekly 50-minute individual sessions and SP participants attended unstructured sessions with similar length and duration built around therapist facilitation of reflective listening, empathy, affect elicitation, and patient acknowledgement. At 12-weeks post-treatment, compared to SP, SBPI participants showed statistically significant reductions in anxiety symptoms on the HAM-A (-15.3 in SBPI vs. -8.7 in SP, $p \leq 0.001$; d = 1.50) and on the Clinical Global Impression-Severity Scale (CGI-S: -2.5 in the SBPI vs. -1.2 in SP, $p \leq 0.001$; d = 1.64), but not on anxiety and depressive symptoms as assessed on the BAI (-8.2 in the SBPI vs. - 5.6 in SP, $p > 0.05$; d = 0.40) and the BDI-II (-12.2 in the SBPI, $p \geq 0.05$ vs. -9.4 in SP, $p \geq 0.05$; d = 0.44), respectively. At 3-months follow-up, compared to SP, SBPI participants demonstrated statistically significant improvements on the BAI (-10.8 in the SBPI vs. -5.6 in SP, $p > 0.05$; d = 1.18), while continuing to show further improvements on the HAM-A (-14.8 in the SBPI vs. -9.7 in SP, $p \leq 0.05$; d = 0.98) and the CGI-S (-2.6 in the SBPI vs. -1.6 in SP, $p \leq 0.05$; d = 0.86). Moreover, at study conclusion, a decidedly greater percentage (82% in the SBPI vs. 25% in

SP, $p = 0.012$) achieved HAM-A scores in the normal (non-symptomatic) ranges (HAM-A $\leq$ 7).

Within a group-based setting, Richards et al. (2006) evaluated the effectiveness of a SBPI program relative to cognitive support groups (CSG) or emotional support groups (ESG) in 122 women (mean age = 21.2 years) with eating disorders (e.g., anorexia nervosa, bulimia nervosa, or eating disorder not otherwise specified) within an inpatient facility. SBPI participants ($n = 44$) completed readings and attended psychologist-led weekly 60-minute group discussions on spiritual themes (e.g., identity, forgiveness, faith, prayer, meditation). Similarly, CSG participants completed readings and attended weekly discussions on cognitive-behavioural techniques, and participants in ESG attended open-ended group discussions. At post-treatment (average length of stay in the program = 9 weeks), compared to CSG, SBPI participants demonstrated statistically significant reductions on the Eating Attitudes Test (EAT: -49.7 in the SBPI vs. -42.0 in CSG, $p = 0.013$; $d = 0.68$). However, there were no statistically significant differences between the SBPI and ESG on EAT (-49.7 in the SBPI vs. -47.5 in ESG, $p > 0.05$). SBPI participants also showed statistically significant reductions on the symptom distress subscales of the Outcome Questionnaire (OQ-45; i.e., anxiety, depression and substance abuse) compared to both CSG and ECG (-28.3 in the SBPI vs. -22.7 in CSG vs. -22.6 in ESG, $p = 0.026$; d(SBPI-CSG) = 0.53; d(SBPI-ESG) = 0.54), on the relationship distress subscales of OQ- 45 compared to CSG and ECG (-7.6 in the SBPI vs. -4.6 in CSG vs. -4.2 in ESG, $p = 0.006$; d(SBPI-CSG) = 0.59; d(SBPI-ESG) = 0.67), and on the social role conflict subscales compared to CSG only (-7.6 in the SBPI vs. -4.7 in CSG, $p = 0.004$; d(SBPI-CSG) = 0.79).

Finally, Rikhi et al. (2011) evaluated the effectiveness of an 8-week SBPI in improving depressive symptoms and related parameters in 84 moderately depressed individuals (HAM-D score = 18–22; mean age = 44.0 years). Primarily home-based, SBPI participants listened to pre- recorded: (a) 90-minute psychiatrist-led workshops, weekly, organized around spiritual themes (e.g., self-transcendence, connectedness, self-acceptance, forgiveness, and gratitude); coupled with (b) daily 15-minute progressive relaxation exercise. Overall, compared to the waitlist control (WC) condition (n = 39), SBPI participants experienced statistically significant reductions in mean HAM-D scores (-8.5 in the SBPI vs. -2.3 in WC, $p < 0.0001$), along with significantly depression response (35.9% in the SBPI vs. 4.4% in WC, $p < 0.001$) and remission (30.7% in the SBPI vs. 2.2% in WC, $p < 0.001$) at 8-weeks post-treatment (criteria for remission not specified).

Spiritually-based Psychoeducational Programs in Emotionally-Distressed Adults. In evaluating the effectiveness of a SBPI in non-clinical settings, Moritz et al. (2006) evaluated the effectiveness of an 8-week home-based SBPI in improving mood in emotionally- distressed adults (mean age = 44.6 years). Participants were randomly assigned to either: (a) an 8-week home study-based spirituality program (n = 56); (b) an 8-week mindfulness meditation- based stress reduction (MBSR) program (n = 54); or (c) a 12-week WC group (n = 55). The spirituality program consisted of weekly 90-minute workshops on cultivating spirituality in daily life. Specifically, the SBPI focused on: (a) developing a self-transcendent understanding through recognizing behavioural tendencies that separate us from the divine and life's purpose (e.g., materialistic life orientation, power struggles, failure to face fears, and being judgemental, forgiveness, and unconditional love); along with (b) daily 45-minute breathing and visualization techniques to foster self-awareness, gratitude, and

living without expectations. The MBSR program involved attending 8 weekly mindfulness meditation sessions and practicing daily mindfulness meditation at home via audiotapes, and participants assigned to WC were instructed to continue their routine daily activities. In addition, all three groups also received minimal weekly phone calls to encourage adherence with the intervention. At 8-weeks post-treatment, the SBPI experienced statistically significant reductions on total Profile of Mood States (POMS) scores compared to both the MBSR (-43.1 in the SBPI vs. -22.7 in MBSR, $p = 0.034$) and WC control condition (-43.1 in the SBPI vs. -10.3 in WC, $p < 0.001$). In terms of specific subscale scores, compared to MBSR, participants in the SBPI experienced statistically significant reductions on POMS tension (-9.1 in the SBPI vs. -4.2 in MBSR, $p = 0.007$) and depression (-14.3 in the SBPI vs. -7.1 in MBSR, $p = 0.013$) subscales, and all POMS subscales (i.e., tension, depression, anger, vigor, fatigue, confusion) relative to WC, which were largely maintained at 12-weeks follow-up. A similar pattern of results was observed in the Short Form Health Survey (SF-36) assessments as well, with the SBPI demonstrating significantly greater improvements on SF-36 mental health component compared to both the MBSR (14.4 in the SBPI vs. 7.1 in MBSR,$p = 0.029$) and WC control condition (14.4 in the SBPI vs. 4.7 in WC, $p < 0.001$).

Spiritually-based Psychoeducational Programs in Chronic Disease Samples. Two of the selected programs evaluated the effectiveness of the SBPI in improving quality of life in cancer patients (Jafari et al., 2013) and in a mixed sample of individuals with chronic conditions (McCauley et al., 2011). First, Jafari et al. (2013) examined the effectiveness of a 6-week SBPI in improving mental health and quality of life in 68 women (mean age = 48.0 years) with breast cancer. Participants in the SBPI ($n = 37$) attended weekly group sessions (two- three hours/session) organized around themes of personal control (e.g., identifying and

letting go of matters beyond their control), identity (e.g., identifying barriers to self-compassion), and relationships (e.g., relationships with self and others, and their impact on coping with cancer), coupled with prayer and relaxation practice. At 6-weeks post-intervention, compared to usual care (UC), participants in the SBPI showed statistically significant increases in global health quality of life scores on the cancer quality of life questionnaire (QLQ-C30: +24.3 in the SBPI vs. +1.4 in UC, $p = 0.001$; d intervention(pre-post)= 2.16). Participants in the SBPI also showed statistically significant within group improvements on physical functioning (+8.2 in the SBPI, $p < 0.001$ vs. -0.6 in UC, $p = 0.88$), role functioning (+15.9 in the SBPI, $p < 0.001$ vs. -5.4 in UC, $p = 0.27$), emotional functioning (+21.3 in the SBPI, $p < 0.001$ vs. -5.9 in UC, $p = 0.16$), and cognitive functioning (+15.0 in the SBPI, $p < 0.001$ vs. -2.7 in UC, $p = 0.57$). In addition, only participants in the SBPI showed statistically significant within group reductions in mean fatigue (-21.9, $p = 0.001$), sleep disturbance (-9.7, $p = 0.03$), and pain (-16.1, $p = 0.001$) scores on the QLQ-C30.

In contrast, McCauley et al. (2011) evaluated the home-based delivery of a 4-week SBPI in improving mental health and chronic illness in 100 older adults (mean age = 65.8 years). Participants were randomly assigned to either: (a) a SBPI ($n = 51$) to promote coping with chronic disease within a spiritual framework; or (b) an educational cardiovascular reduction program (EDUC). The SBPI consisted of a 60-minute video on the role of spirituality in coping with chronic illness and weekly workbook exercises centered on the role of spirituality (e.g., meaning of life, gratitude, social support, etc.) in chronic disease management, and the EDUC program included videos and workbook exercises on lifestyle-based management of cardiovascular disease. At 4-weeks post-intervention, while SBPI

participants experienced improvements in self-efficacy (+0.2 in the SBPI vs. 0.0 in EDUC, p = 0.72), depression (-0.7 in the SBPI vs. 0.0 in EDUC, p = 0.50), and pain scores (-0.4 in the SBPI vs. 0.0 in EDUC, p = 0.28), but only improvements in fatigue-energy levels (+0.2 in the SBPI vs. 0.0 in EDUC, p = 0.019) on the medical outcome questionnaire (MOS) reached statistical significance between groups.

2.10.4 Discussion

Religion and spirituality have involved discourses and activities aimed at improving mood and reducing anxiety for millennia. Until recently, however, this context was largely viewed as incompatible with medical and scientific inquiry (Miller & Thoresen, 2003). As this review reflects, spirituality is increasingly viewed as an important component of mental and physical health promotion. Accordingly, this systematic review is timely, aimed at better understanding the effectiveness of SBPIs for clinical samples, as well as non-diagnosed, distressed individuals. Altogether, the RCTs reviewed provide preliminary support for the effectiveness of SBPIs in improving mood and quality of life in clinically-diagnosed and distressed individuals, demonstrating effect sizes equivalent to or larger than those achieved with conventional psychotherapy (Koszycki et al., 2010; Koszycki et al., 2014; Richards et al., 2006).

Our review specifically focused on methodologically sound studies that evaluated SBPI effectiveness versus established psychotherapeutic modalities. These include Koszycki et al. (2010), who demonstrated that an SBPI achieved largely equivalent reductions in anxiety and depression symptomatology to CBT. Koszycki et al. (2014) further demonstrated that their SBPI protocol was significantly better than an SP intervention. These findings

provide initial indications that non-denominational SBPIs are powerful, and perhaps as powerful as standard psychotherapeutic formats.

In relation to the less intensive home-based approaches, Rikhi et al. (2011) demonstrated that an SBPI intervention, centering on non-denominational spiritual teachings, improved depressive symptoms in moderately-depressed individuals. Moritz et al. (2006) showed an SBPI to be more effective than MBSR, a widely disseminated stress reduction protocol, in improving mood and specific depressive symptoms. It is notable that the lower adherence observed in the MBSR group, as compared to the SBPI group, was a factor in this study. It may be that a more articulate and specific approach to spiritual issues, implemented in the particular SBPI tested, was linked to the better adherence observed. In summary, despite more modest effect sizes in home-based programs compared to in-person and therapist-supported programs, this review supports home-based delivery of SBPIs as a potentially cost-effective alternative to individual and group psychotherapy.

SBPIs also demonstrated effectiveness for individuals with chronic diseases, particularly cancer patients, who demonstrated improved quality of life. While findings in relation to quality of life were less robust in the study conducted by McCauley et al. (2011), the more intensive counsellor supported program undertaken by Jafari et al. (2013) produced robust findings with large pre-post effects.

Strengthens and Limitations

Despite variations in content, all programs featured core themes aligned with frequently shared spiritual concepts (Buck, 2006; Chandler, Miner Holden, & Kolander, 1992; Piedmont, 1999; Tanyi, 2002). Nevertheless, the further standardization of intervention practices is an important priority for spirituality-based research. Standardization would allow

for better evaluations of program elements versus non-program elements. For example, the levels of religiosity, use of formal prayer, and concurrent engagement in religious ritual by participants may be influential in combination with other factors that are not specific to the SBPI used.

Although spirituality as a psychological construct has been criticized for its apparent lack of conceptual clarity (Buck, 2006; Piedmont, 2014), spirituality, as defined in SBPIs represents multiple dimensions embodying universal concerns for meaning and purpose, connectedness to the community and/or the divine, and self-transcendence (Piedmont, 1999). Similar to other psychological constructs, it combines cognitive and affective elements. From a cognitive perspective, spiritual and religious beliefs can serve as mental frameworks (i.e., schema) that influence emotional and coping responses (Hoffman, Lent, & Raque-Bogdan, 2013; James & Wells, 2003). From an affective viewpoint, spirituality can be viewed as a comparatively understudied *sixth factor* on a par with the other more intensively studied factors in the five- factor model of personality (Piedmont, 1999). While few of the reviewed RCTs included an assessment of trait spirituality, the availability of formal measures that quantify spirituality as a psychological construct (e.g., Spiritual Transcendence Scale and Spiritual Wellbeing Scale; Bufford, Paloutzian, & Ellison, 1990; Piedmont, 1999) permit inclusions of spirituality-related measures in assessing changes in spirituality and spiritual development, which may function as mediators of positive intervention effects.

Although the RCTs reviewed included efforts at reducing the probability of the self-selection of more religious and spiritually-oriented subjects, the potential for self-selection remains a research limitation. Alternatively, it may also be an unintended advantage, providing developmental steps towards tailored psycho-spiritual interventions for the

religiously-oriented, and, by doing so, coverage and discussion of themes not typically addressed in traditional psychotherapies. Patient expectations are an important factor in therapeutic alliance and ultimate effectiveness (DeFife & Hilsenroth, 2011; Swift & Derthick, 2013). Accordingly, responsiveness to religiously and spiritually-oriented treatments may be even greater in religiously inclined clients (Koenig et al., 2015).

Finally, our results are relevant to another recent systematic review of spiritually-based therapies (Gonçalves et al. 2015). Notably, the Gonçalves et al. (2015) review differs from ours in broadly focusing on multiple types of spiritually-based interventions (e.g., meditation-based programs, spiritually-oriented psychotherapy, pastoral care). We specifically focused on spiritually-based interventions of a *psychoeducational* nature, with the view that focusing only on SBPIs (including 3 RCTs never previously reviewed) adds an important degree of theoretical and practical specificity. In other words, meditation-based programs, spiritually-oriented psychotherapy and pastoral care each represent distinct interventions, following varying theoretical orientations and likely engaging differing mechanisms. Limiting this review to SBPIs provides a more focal evaluation of psychoeducational formats and the specific spiritual elements used, all minimally influenced by pre-existing psychotherapy techniques (e.g., spiritually-integrated CBT).

2.10.5 Conclusions and Future Directions

Given rising interests in exploring spirituality and spiritually-based programs in promoting mental health and improved quality of life, we will likely witness a sizeable increase in spiritually-related research. The RCTs reviewed provide encouraging evidence re: SBPI effectiveness in reducing anxiety and depression, and improving quality of life. The RCTs assessed included clinical and non-clinical populations with effect sizes comparable to

conventional cognitively-based and nonspecific psychotherapies (Koszycki et al., 2010; Koszycki et al., 2014; Richards et al., 2006).

With spirituality likely a universal human capacity (Piedmont & Leach, 2002), many people are naturally predisposed to reflect on spiritual concerns during experiences of adversity, distress and resilience. Accordingly, inserting spirituality as a component of anti-anxiety and anti-depressant programs can strengthen them, with the resulting combination more closely representing how people *naturalistically* adapt to stress. Second, we are witnessing what has been termed in the media as a 'mindfulness movement' where meditation formats, previously considered religious or spiritual in nature, are disseminated in secular contexts for psychosocial support. It is possible that the effectiveness experienced by individuals who take an MBSR course, for example, or similarly structured mindfulness programs, is partly due to the implicit integration of a spiritual perspective into everyday life concerns. Mindfulness meditation neither requires a spiritual commitment, nor limits individuals from considering spiritual issues and ideas, and related emotions. Spiritually-based programming, within *psychoeducational* formats, may promote both broader and more specific assistance with spiritual issues and practices.

Appendix B – Randomization Sheet

Purpose: To randomly allocation participants into study conditions based on sex and Centrality of Religiosity Scale-15 (CRS-15) score

Legend:
F = Female; *M* = Male

CRS-15 Scores:
0–2.0: non-religious
2.1–3.9: religious
4.0–5.0: highly-religious

Instructions:

1) Calculate CRS-15 scores to determine if participants are non-religious, religious or highly religious
2) Based on the sex of the participant and the CRS-15 score, find the corresponding column with the **lowest** cell number that has not yet been assigned
3) The cell number will determine which condition the participant will be assigned to

Example of Randomization:

1) Participant #1 - Sex: Female; CRS-15 Score: 2.2 → Cell: #5
2) Participant #2 - Sex: Female; CRS-15 score: 3.8 → Cell: #6
3) Participant #3 - Sex: Male; CRS-15 score: 4.8 → Cell: #21
4) Participant #4 - Sex: Male; CRS-15 score: 1.5 → Cell: #13
5) Participant #5 - Sex: Female; CRS-15 score: 2.3 → Cell: #7
6) Participant #6 - Sex: Female; CRS-15 score: 3.5 → Cell: #8
7) Participant #7 - Sex: Female; CRS-15 score: 3.4 → Cell: #29

Sex	**Meditation (Experimental)**	**Meditation (Control)**	**Prayer (Experimental)**	**Prayer (Control)**
F	Cell 1	Cell 2	Cell 3	Cell 4
F	Cell 5	Cell 6	Cell 7	Cell 8
F	Cell 9	Cell 10	Cell 11	Cell 12
M	Cell 13	Cell 14	Cell 15	Cell 16
M	Cell 17	Cell 18	Cell 19	Cell 20
M	Cell 21	Cell 22	Cell 23	Cell 24
F	Cell 25	Cell 26	Cell 27	Cell 28
F	Cell 29	Cell 30	Cell 31	Cell 32
F	Cell 33	Cell 34	Cell 35	Cell 36
M	Cell 37	Cell 38	Cell 39	Cell 40
M	Cell 41	Cell 42	Cell 43	Cell 44
M	Cell 45	Cell 46	Cell 47	Cell 48

Appendix C – Problem Sets for Pattern Recognition Task (PRT)

14 48 88 140 400
AB AZ AC AX AY
F1 D3 C5 E7 B9
90 09 19 96 69
AG NA CL OH CO
18 56 72 27 63
A1 91 B1 81 C1
26 66 36 96 16
SH CH ST TH SC
US CA RU UK VU
12 21 32 45 59
44 2 56 8 22 4
AT AN AM AD AH
54 78 96 12 62
UI UO UA UI UE
3e 4A 1b 6U 7i
PI IP OP PE AP
13 26 49 82 116
T2 F5 N9 S7 E8
OR OP OS OW OX
31 24 53 46 75
4T T6 7T T8 9T
MU NU PI XI OM
10 25 50 75 0
CT CH CK CL CR
11 3 13 6 15 9

Appendix D – Questionnaires

Automatic Thoughts Questionnaire (ATQ; Hollon & Kendall, 1987)

Instructions: Listed below are a variety of thoughts that pop into people's heads. Please read each thought and indicate how frequently, if at all, the thought occurred to you over the last week. Please read each item carefully and fill in the appropriate answer in the following fashion:

Scoring
1 – Not at all
2 – Sometimes
3 – Moderately often
4 – Often
5 – All the time

1. I feel like I'm up against the world
2. I'm no good
3. Why can't I ever succeed?
4. No one understands me
5. I've let people down
6. I don't think I can go on
7. I wish I were a better person
8. I'm so weak
9. My life's not going the way I want it to go
10. I'm so disappointed in myself
11. Nothing feels good anymore
12. I can't stand this anymore
13. I can't get started
14. What's wrong with me?
15. I wish I were somewhere else
16. I can't get things together
17. I hate myself
18. I'm worthless
19. I wish I could just disappear
20. What's the matter with me?
21. I'm a loser
22. My life is a mess
23. I'm a failure
24. I'll never make it
25. I feel so helpless
26. Something has to change
27. There must be something wrong with me
28. My future is bleak
29. It's just not worth it
30. I can't finish anything

The Centrality of Religiosity Scale-15 (CRS-15; Huber & Huber, 2012)

SCORING

I. Score each individual question from 1 to 5
II. Add up the total score
III. Divide the total score by 15
IV. Final score determines religious category:
- 1.0 to 2.0 = not-religious
- 2.1 to 3.9 = religious
- 4.0 to 5.0 = highly-religious

1. How often do you think about religious issues?
   A) Several times a day – 5
   B) Once a day – 5
   C) More than once a week – 4
   D) Once a week – 3
   E) One or three times a month – 3
   F) A few times a year – 2
   G) Less often – 2
   H) Never – 1
   I) Prefer not to answer*

2. To what extent do you believe God or something divine exists?
   A) Very much so – 5
   B) Quite a bit – 4
   C) Moderately – 3
   D) Not very much – 2
   E) Not at all – 1
   F) Prefer not to answer*

3. How often do you take part in religious services?
   A) More than once a week – 5
   B) Once a week – 5
   C) One or three times a month – 4
   D) A few times a year – 3
   E) Less often – 2
   F) Never – 1
   G) Prefer not to answer*

4. How often do you pray?
   A) Several times a day – 5
   B) Once a day – 5
   C) More than once a week – 4
   D) Once a week – 3
   E) One or three times a month – 3

F) A few times a year – 2
G) Less often – 2
H) Never – 1
I) Prefer not to answer*

5. How often do you experience situations in which you have the feeling that God or something divine intervenes in your life?
   A) Very often – 5
   B) Often – 4
   C) Occasionally – 3
   D) Rarely – 2
   E) Never – 1
   F) Prefer not to answer*

6. How interested are you in learning more about religious topics?
   A) Very much so – 5
   B) Quite a bit – 4
   C) Moderately – 3
   D) Not very much – 2
   E) Not at all – 1
   F) Prefer not to answer*

7. To what extent do you believe in an afterlife—e.g., immortality of the soul, resurrection of the dead or reincarnation?
   A) Very much so – 5
   B) Quite a bit – 4
   C) Moderately – 3
   D) Not very much – 2
   E) Not at all – 1
   F) Prefer not to answer*

8. How important is it to take part in religious services?
   A) Very much so – 5
   B) Quite a bit – 4
   C) Moderately – 3
   D) Not very much – 2
   E) Not at all – 1
   F) Prefer not to answer*

9. How important is personal prayer for you?
   A) Very much so – 5
   B) Quite a bit – 4
   C) Moderately – 3
   D) Not very much – 2
   E) Not at all – 1
   F) Prefer not to answer*

10. How often do you experience situations in which you have the feeling that God or something divine wants to communicate or to reveal something to you?
    A) Very often – 5
    B) Often – 4
    C) Occasionally – 3
    D) Rarely – 2
    E) Never – 1
    F) Prefer not to answer*

11. How often do you keep yourself informed about religious questions through radio, television, internet, newspaper, or books?
    A) Very often – 5
    B) Often – 4
    C) Occasionally – 3
    D) Rarely – 2
    E) Never – 1
    F) Prefer not to answer*

12. In your opinion, how probable is it that a Higher Power really exists?
    A) Very much so – 5
    B) Quite a bit – 4
    C) Moderately – 3
    D) Not very much – 2
    E) Not at all – 1
    F) Prefer not to answer*

13. How important is it for you to be connected to a religious community?
    A) Very much so – 5
    B) Quite a bit – 4
    C) Moderately – 3
    D) Not very much – 2
    E) Not at all – 1
    F) Prefer not to answer*

14. How often do you pray spontaneously when inspired by daily situations?
    A) Very often – 5
    B) Often – 4
    C) Occasionally – 3
    D) Rarely – 2
    E) Never – 1
    F) Prefer not to answer*

15. How often do you experience situations in which you have the feeling that God or something divine is present?
    A) Very often – 5

B) Often – 4
C) Occasionally – 3
D) Rarely – 2
E) Never – 1
F) Prefer not to answer*

Supplementary Questionnaire

1. Participant ID: _____

2. What is your sex?
   a) Female
   b) Male

3. Year of Birth (YYYY): _____

4. What is your current age? (in years): _____

5. Study Major: _____

6. Year of Study
   a) First Year
   b) Second Year
   c) Third Year
   d) Fourth Year
   e) Fifth Year
   f) Other (please specify):_____

7. What is your ethnicity? (Please select all that apply.)
   a) Aboriginal (Inuit, Metis, North American Indian)
   b) West Asian (e.g., Armenian, Egyptian, Iranian, Iraqi, Lebanese, Moroccan)
   c) Black—African (e.g., African, Somali etc.)
   d) Black—Caribbean (e.g., Haitian, Jamaican etc.)
   e) Indo—Caribbean (e.g., Guyanese, Trinidadian etc.)
   f) White (Caucasian—European/American)
   g) Hispanic
   h) Latin American
   i) Chinese
   j) Japanese
   k) Korean
   l) South Asian (e.g., Indian, Pakistani, Bangladeshi, Sri Lankan etc.)
   m) South East Asian (e.g., Filipino, Thai, Cambodian, Malaysian, Indonesian etc.)

8. Do you ever use glasses for reading?
   a) Yes
   b) No

9. Do you ever use contact lens for readings?
   a) Yes
   b) No

10. I am predominately…
    a) Right-handed
    b) Left-handed
    c) Both

11. Have you ever been clinically diagnosed with a mental disorder?
a) Depression Disorder
b) Anxiety Disorder
c) Bipolar I/II
d) Schizophrenia/Schizoaffective
e) Substance Abuse
f) Eating Disorder
g) Not Applicable
h) Other (please specify): _____

12. Do you have a history of mental illnesses in your family (i.e., first degree relatives)?
    a) Yes
    b) No

13. What medication are you currently taking? (Name, reason, dose, how often, time on medication, any change in dose). If you are not taking any medications, please type N/A for not applicable.

    _____

    _____

14. Have you ever had a heart attack in the past?
a) Yes
b) No

15. Do you have a history of any of the following (please select all that apply):
    - ☐ Cardiovascular disease
    - ☐ Pulmonary disease
    - ☐ Hypertension
    - ☐ Diabetes
    - ☐ Thyroid disease
    - ☐ Abnormal heart rhythm or arrhythmias
    - ☐ Not applicable
    - ☐ Other (please specify): _____

16. How often do you smoke (e.g., cigarettes, cigars, hookah/sheesha)?
    a) Very often
    b) Often
    c) Sometimes
    d) Rarely
    e) Never

17. How often do you consume caffeine?
    a) Many times a day
    b) Once a day
    c) Once a week
    d) Rarely/Never

18. Did you have any caffeine today? (If so, please specify the source, amount time)
    _____
    _____

19. How often do you consume alcohol?
    a) Very often
    b) Often
    c) Sometimes
    d) Rarely
    e) Never

20. Are you pregnant?
    a) Yes
    b) No
    c) Potentially
    d) Not applicable

21. How often do you have irregular menstrual cycles?
    a) Very often
    b) Often
    c) Sometimes
    d) Rarely/Never
    e) Not applicable

22. What sect of Islam do you follow?
    a) Sunni
    b) Shi'a
    c) Ahmadiyyah
    d) I do not follow Islam
    e) Other (please specify): _____

23. Do you believe in a God or supernatural power?
    a) Yes
    b) No
    c) Unsure

24. Choose the following statement that best describes you:
    a) I do not follow Islam
    b) I hope to follow Islam more in the future

c) I try to make an effort to follow Islam
d) I am a hafiz, scholar and/or imam and I consciously make an effort to follow Islam

25. Do you speak Arabic fluently?
    a) Yes
    b) No
    c) Somewhat

26. Do you understand Arabic well?
    a) Yes
    b) No
    c) Only some words

27. How much of the Arabic used in the Quran (i.e., Islamic religious text) do you understand?
    a) All of it
    b) Most of it
    c) Some of it
    d) None of it

28. During a typical 7-day period (a week), in your leisure time, how often do you engage in any regular activity long enough to work up a sweat (heart beats rapidly)?
    a) Often
    b) Sometimes
    c) Rarely/Never

29. Do you think it is necessary to pray?
    a) Yes
    b) No
    c) Sometimes

30. Do you enjoy praying?
    a) Always
    b) Most of the time
    c) Sometimes
    d) No
    e) I do not pray

31. Do you believe prayers get answered?
    a) Yes
    b) No
    c) Sometimes

32. When do you believe prayers get answered?
    a) Right away

b) When you are in great need of them
c) What God believes it is the right time
d) Prayers do not get answered

33. How do prayers get answered?
a) You get exactly what you prayed for
b) You get something close to what you prayed for
c) You get what God believes is best for you
d) Prayers do not get answered

34. How much do you agree/disagree with the following statement: "Prayer is a burden on me"
a) Strongly agree
b) Moderately agree
c) Neutral
d) Moderately disagree
e) Strongly disagree

35. How do you react when your prayers are not answered right away? (Please select all that apply.)
- ☐ I feel mad/frustrated
- ☐ I feel sad/depressed
- ☐ I feel anxious
- ☐ I feel confused
- ☐ I feel doubtful
- ☐ I feel neutral
- ☐ I do not pray

36. On average, how often do you listen to/recite the Quran?
a) Very often
b) Often
c) Sometimes
d) Never

37. How many years have you been listening to/reciting the Quran for? (If never, enter 0; if half-a-year enter 0.5 etc.) _____

38. During a typical 7-day period (a week), how many hours do you spend listening to/reciting the Quran? _____

Surah Rahman is chapter 55 of the Quran. Below are the first 13 verses from this chapter. If you would like to see all 78 verses of the surah, please ask the experimenter for the full version.

Bismillaahir Rahmaanir Raheem

1. Ar Rahmaan

2. 'Allamal Quran
3. Khalaqal insaan
4. 'Allamalhul bayaan
5. Ashshamsu walqamaru bihusbaan
6. Wannajmu washshajaru yasjudan
7. Wassamaaa'a rafa'ahaa wa wada'al Meezan
8. Allaa tatghaw fil meezaan
9. Wa aqeemul wazna bilqisti wa laa tukhsirul meezaan
10. Wal arda wada'ahaa lilanaame
11. Feehaa faakihatunw wan nakhlu zaatul akmaam
12. Walhabbu zul 'asfi war Raihaanu
13. Fabi ayyi aalaaa'i Rabbikumaa tukazzibaan

39. On average, how often do you listen to/recite Surah Rahman?
    a) Very often
    b) Often
    c) Sometimes
    d) Never

40. How many years have you been listening to/reciting Surah Rahman for? (If never, enter 0; if half-a-year enter 0.5 etc.) _____

41. During a typical 7-day period (a week), how many hours do you spend listening to/reciting Surah Rahman? _____

42. Have you memorized Surah Rahman?
    a) Yes all of it
    b) Most of it
    c) Some of it
    d) No I do not have Surah Rahman memorized

43. On average, how often do you perform salat/namaz?
    a) More than 5 times a day
    b) 5 times a day
    c) A couple times a day
    d) A couple times a week
    e) Never

44. How many years have you been praying salat/namaz? (If never, enter 0; if half-a-year enter 0.5 etc.) _____

45. When I pray salat, I usually feel…
a) Connected to a Higher Power
b) Disconnected to a Higher Power
c) I do not feel anything

d) I do not perform salat

Please answer the following questions with respects to any other forms of meditation you currently engage in besides listening to/reciting the Quran or performing salat/namaz)

46. What type(s) of other meditation do you engage in? (type N/A if not applicable)
    _____
    _____
    _____

47. How often do you perform this other type(s) of meditation?
    a) Very often
    b) Often
    c) Sometimes
    d) Not applicable

48. How many years have you been meditating for? (If never, enter 0; if half-a-year enter 0.5 etc.) _____
49. During a typical 7-day period (a week), how many hours do you spend performing this other type(s) of meditation? _____

Post-Pattern Recognition Task (PRT) Questionnaire

1) Rate the level of difficulty of the Pattern Solving Task on a scale of 5:
   a) 1 - Extremely easy
   b) 2 - Easy
   c) 3 - Average
   d) 4 - Difficult
   e) 5 – Extremely difficult

2) How stressed were you while completing the Pattern Solving Task?
   a) Extremely stressed
   b) Stressed
   c) Moderately stressed
   d) A little stressed
   e) Not stressed at all

3) Rate your performance on the Pattern Solving Task on a scale of 5:
   a) 1 – Poor performance
   b) 2 – Below expectations
   c) 3 – Met expectations
   d) 4 – Above expectations
   e) 5 – Exceptional performance

Post-Listening Intervention Questionnaire: Experience

1) Rate how attentive you were, overall, while listening to the audio on a scale of 5:

a) 1 – Not attentive
b) 2 – Slightly attentive
c) 3 – Moderately attentive
d) 4 – Attentive
e) 5 – Extremely attentive

2) What was your <u>overall</u> experience like while listening to the audio?

a) Extremely Positive
b) Positive
c) Neutral
d) Negative
e) Extremely negative

Post-Listening Intervention Questionnaire: Understanding Meaning

English Translation of the Passage (Surah Rahman – chapter 55 from the Quran)

1) **Did you understand the meaning of the passage?**
   a) Yes all of it
   b) Most of it
   c) Some of it
   d) None of it

"I am going to play a couple of verses from the recording you just listened to. If you do understand the verse, please let me know what the translation is to the best of your ability. If you do not know, just say pass."

1. **Feehimaa min kulli faakihatin zawjaan** (52: In them both are all kinds of fruit in pairs).

   _____

2. **Ashshamsu walqamaru bihusbaan** (5: The sun and the moon are by an exact calculation (of the All-Merciful).

   _____

3. **Zawaataaa afnaan** (48: Having in them trees with thick, spreading branches).

   _____

4. **Yatoofoona bainahaa wa baina bameemim aan** (44: They will go round between it(s fire) and hot, boiling water).

   _____

5. **Lam yatmis hunna insun qablahum wa laa jaaann** (74: Whom no man or jinn has touched before).

   _____

6. **Muttaki'eena 'alaa rafratin khudrinw wa 'abqariyyin bisaan** (76: [The people of those Gardens] reclining on green cushions and rich, beautiful mattresses).

   _____

7. **Haazihee jahannamul latee yukazzibu bihal mujrimoon** (43: This is Hell, which the disbelieving criminals deny).

   _____

8. **Fabi ayyi aalaaa'i Rabbikumaa tukazzibaan** (73: Then, [o humankind and jinn] which of the favours of your Lord will you deny?)

   _____

9. **Wa aqeemul wazna bilqisti wa laa tukhsirul meezaan** (9: And observe the balance with full equity, and do not fall short in it).

_____

10. **Yu'raful mujrimoona biseemaahum fa'yu'khazu binna waasi wal aqdaam** (41: The disbelieving criminals will be known by their marks (especially on their faces), and seized by the forelocks and the feet.

_____

11. **Yaa ma'sharal jinni wal insi inis tata'tum an tanfuzoo min aqtaaris samaawaati wal ardi fanfuzoo; laa tanfuzoona illaa bisultaan** (33: you assembly of jinn and humankind! If you are able to pass through and beyond the spherical regions of the heavens and the earth, then pass through. You will not pass through except with an authority (spiritual or scientific).

_____

_____

_____

12. **Feehimaa 'aynaani nad daakhataan** (66: In them both are springs gushing forth).

_____

13. **Wa khalaqal jaaanna mim maarijim min naar** (15: And He has created the jinn from a smokeless [fusing flame of] fire).

_____

14. **Hoorum maqsooraatun fil khiyaam** (72: Pure maidens assigned for them in secluded pavilions).

_____

15. **Wassamaaa'a rafa'ahaa wa wada'al Meezan** (7: And the heaven – He has made it high (above the earth), and He has set up the balance).

_____

16. **Khalaqal insaana min salsaalin kalfakhkhaari** (14: He has created human from sounding clay like the potter's)

_____

17. **Feehinna qaasiratut tarfi lam yatmishunna insun qablahum wa laa jaaann** (56: In them are pure, chaste-eyed spouses [whose glances are fixed on their spouses only], whom no man or jinn has touched before).

_____

18. **Allaa tatghaw fil meezaan** (8: So that you may not go beyond [the limits with respect to the balance].

_____

19. **Wa lahul jawaaril mun sha'aatu fil bahri kal a'laam** (24: His are the ships constructed [by God's inspiration and running] through the sea [with sails unfurled], lofty like mountains)

    _____

20. **Yakhruju minhumal lu 'lu u wal marjaanu** (22: There come forth from them pearl and coral).

    _____

21. **Kullu man 'alaihaa faan** (26: All that is on the earth is perishable)

    _____

22. **Rabbul mashriqayni wa Rabbul maghribayni** (17: He is the Lord of the two easts, and the Lord of the two wests).

    _____

23. **Feehinna khairaatun bisaan** (70: In them both are maidens good in character and beautiful).

    _____

24. **'Allamalhul bayaan** (4: He has taught him speech).

    _____

25. **Wa liman khaafa maqaama rabbihee jannataan** (46: But for him who lives in awe of his Lord and of the standing before his Lord (in the Hereafter), there will be two Gardens).

    _____
    _____

Nal, A. (2006). The Qur'an with annotated interpretation in modern English. Somerset, N.J.: The Light

Percent of Passage you understood:
Total # of different lines understood =
Total # of different lines =
Percent of passage understood =

Appendix E – Debriefing Statement

Thank you for participating in our study that is examining the stress reactivity in Muslims under conditions of stressful performance, mindfulness meditation and listening to the Quran. The purpose of the rest task was to obtain a baseline HRV measurement. The sole purpose of using the Pattern Solving Task (PST) was to induce stress. All patterns have been created so that they do not have a correct solution, however feedback for the task was configured using a pre-determined random order, to provide an equal number of "Right" and "Wrong" answers. Thus your results on these five tasks were **not** indicative of your cognitive/intellectual abilities. The purpose of the post-stress phase was to assess your recovery from a stressful performance under one of four conditions: (1) listening to a guided mindfulness meditation (2) listening to a passage from the Quran (translation attached below) (3) listening to a description of mindfulness meditation (4) listening to a description of 'mindful prayer'.