Transcendental Meditation, mindfulness, and yoga : a review of the therapeutic potential of mind-body interventions on stress and cardiovascular disease

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Introduction

Accounting for 17.3 million deaths annually, cardiovascular disease (CVD) has become the world's leading cause of mortality (World Health Organization, 2012). It is estimated that the number of CVD-related deaths will grow to 23.6 million by 2030 (Smith et al., 2012). Currently, 80% of CVD-related deaths occurs in low-and middle- income countries (LMICs), usually involving people of younger ages than in higher-income countries (Smith et al., 2012; World Health Organization, 2011). In addition to causing death, CVD is also the cause of 10% of the disability-adjusted life years (DALYs) lost in LMICs and 18% of DALYs in high-income countries (World Heart Federation, 2012).

The economic cost of CVD includes the loss of productivity and income of the person with CVD and any caregiver who may have to end their employment in order to provide care for the person with CVD (Laslett et al., 2012). It has been estimated that CVD will account for $3.76 trillion in economic losses in LMICs from 2011-2025—half of the total economic losses for non-communicable diseases in those countries in the same time period (World Health Organization and World Economic Forum [WHO/WEF], 2011). Economists have forecasted a savings of $377 billion in economic losses in LMICs if CVD mortality is reduced by 10% from 2011-2025 (WHO/WEF, 2011). According to economists, not investing in CVD treatment and prevention could result in a loss of as much as $47 trillion worldwide by 2037 (Nainggolan, 2012).

Treatment for cardiovascular disease includes drug therapy, surgical intervention, and lifestyle modifications. Though drug therapy has been shown to effectively treat cardiovascular disease, only approximately 50% of patients receiving medical treatment for CVD fully adhere to the recommended treatments (Centers for Disease Control and Prevention, 2010; Haynes, Ackloo, Sahota, McDonald, & Yao, 2008). Only 50% of patients with hypertension have blood pressures within desirable ranges, often citing the adverse side effects of the blood pressure medications as the primary reason for their nonadherence with their prescribed medicinal regimen (Egan, Zhao, & Axon, 2010; Ockene, Hayman, Pasternak, Schron, & Dunbar-Jacob, 2002). This phenomenon has led to increased interest in investigating treatments that produce less negative side effects (Steffen & Larson, 2015).

The search for effective complementary and/or alternative treatments for cardiovascular disease has led to increased scrutiny of mind-body therapies. Mind-body practices originated in ancient cultures with the intention to enhance physical, mental, and spiritual well-being; and there has been a growing awareness of their therapeutic potential (Telles, Gerbarg, & Kozasa, 2015). The following literature review will address investigations that focus on three types of mind-body therapies: Transcendental Meditation, mindfulness, and yoga.

Literature Review

Hypertension and CVD

Hypertension is the most prominent risk factor for the development of premature cardiovascular disease (Chobanian et al., 2003). Hypertension that is prolonged and uncontrolled can lead to a variety of cardiovascular problems. According to Riaz & Ahmed (2014), such problems include left ventricular hypertrophy (LVH), coronary artery disease (CAD), conductive dysfunction, and systolic and diastolic dysfunction of the myocardium. Common clinical presentations of these problems include myocardial, cardiac arrhythmias, and congestive heart failure. These diseases are often collectively referred to as hypertensive heart disease (Riaz & Ahmed, 2014).

Left Ventricular Hypertrophy

A direct relationship exists between the level and duration of elevated blood pressure and left ventricular hypertrophy (Shimbo et al., 2011). Left ventricular hypertrophy (LVH) is defined as an increase in the mass of the left ventricle, and according to Riaz & Ahmed (2014), 15-20% of individuals with hypertension develop LVH. Riaz & Ahmed's pathophysiology overview also notes that LVH is a result of the myocytes' response to various stimuli that accompany elevated blood pressure. That response involves an increase in size as a way to compensate for the increased afterload caused by elevated blood pressure. Mechanical and neurohormonal stimuli accompany elevated blood pressure and can lead to activation of myocardial cell growth (Riaz & Ahmed). Also, growth of interstitium and cell matrix components result from the activation of the renin-angiotensin system (von Lueder, Atar, & Krum, 2014). Riaz and Ahmed explain that LVH initially is cardioprotective in that it compensates for the increased stress the heart wall experiences during prolonged elevation of blood pressure and maintains adequate cardiac output. However, LVH later leads to diastolic and, ultimately, systolic myocardial dysfunction.

Riaz and Ahmed (2014) further explains that hypertension can also lead to structural and functional changes of the left atrium. This occurs when chronically increased blood pressure precipitates an elevated end-diastolic pressure, which leads to the left atrium experiencing an increased afterload. This results in impaired function and increased size and thickness of the left atrium. Such changes put individuals at a higher risk of developing atrial fibrillation, which can lead to heart failure.

Heart Failure

Heart failure commonly results from chronic hypertension. Individuals with hypertension fit into one of two classifications: a) asymptomatic but at risk of heart failure or b) suffering from heart failure (Riaz & Ahmed, 2014). Diastolic dysfunction is common in chronically hypertensive patients and is often accompanied by left ventricular hypertrophy (LVH) that is due to remodeling as the heart muscle strains to compensate for the increased afterload. In addition to increased afterload, factors that may contribute to diastolic dysfunction include coronary artery disease, aging, systolic dysfunction, and structural abnormalities (e.g. fibrosis). Diastolic dysfunction is often followed by asymptomatic systolic dysfunction. Hypertension and diastolic dysfunction appear to be directly proportional (Riaz & Ahmed).

As the disease progresses, LVH is no longer able to compensate for the elevated blood pressure by increasing cardiac output, which leads to dilation of the left ventricular cavity to maintain output (Riaz & Ahmed, 2014). As an individual progresses into end stage heart failure, left ventricular systolic function continues to decrease. Riaz and Ahmed explain that this progression leads to increased activation of the neurohormonal and renin-angiotensin systems, causing increased salt and water retention and increased peripheral vasoconstriction. As the heart failure worsens, the pathologic left ventricle becomes overwhelmed, and the individual begins to show symptoms of systolic dysfunction.

Programmed cell death, known as apoptosis, is believed to be an important factor in the transition from compensated to decompensated heart failure (Riaz & Ahmed, 2014). Apoptosis is stimulated by hypertrophy of the heart muscle cells and a disturbance in the balance between the cells stimulators and inhibitors (Riaz & Ahmed). A rapid increase in blood pressure can lead to acute pulmonary edema. Development of LV dilation or dysfunction is most often a harbinger of rapid decline in a patient’s clinical status and a significant increased risk of death. In addition to the left ventricular abnormalities, hypertrophy and diastolic dysfunction of the right ventricular wall often occur.

Myocardial Ischemia

Hypertension nearly doubles the risk of developing coronary artery disease, and there is a high occurrence of hypertension in patients with angina (Riaz & Ahmed, 2014). Arteriosclerosis, the hallmark of coronary artery disease, is worsened in arteries that experience chronically elevated blood pressure. Riaz and Ahmed state that the increased sheer stress associated with hypertension leads to endothelial dysfunction. This endothelial dysfunction reduces production of nitric oxide. Without the potent vasodilatory effects of nitric oxide, arteriosclerosis is accelerated, and plaque formation is promoted. This plaque formation can lead to myocardial ischemia and angina.

Riaz & Ahmed’s (2014) pathophysiology overview notes that angina can also occur in hypertensive patients in the absence of coronary artery disease. The increased afterload associated with hypertension leads to increased left ventricular wall tension and transmural pressure. This causes dysfunctional blood flow during diastole. Additionally, hypertensive patients have been known to have dysfunction in the microvasculature beyond the epicardial coronary arteries. This microvascular may be unable to compensate for the increased metabolic and oxygen demand (Riaz & Ahmed).

Cardiac Arrythmias

Atrial fibrillation, premature ventricular contractions, and ventricular tachycardia are common arrhythmias found in hypertensive patients (Ghali, Kadakia, Cooper, & Liao, 1991). These arrhythmias increase the risk of sudden cardiac death (Jouven, Desnos, Guerot, & Ducimetiere, 1999). Altered cellular structure and metabolism, inhomogeneity of the myocardium, poor perfusion, myocardial fibrosis, and fluctuation in afterload are mechanisms thought to be contributory to arrhythmias in patients with hypertension (Riaz & Ahmed, 2014). The risk of thromboembolic complications, such as stroke, is also increased with atrial fibrillation (Riaz & Ahmed).

Stress and Its Impact on the Cardiovascular System

In recent years, the theorized relationship between stress and pathophysiological disease has been a topic of thorough investigation (Esch, 2002). In the scientific community, stress is a term that is used to refer to the effects of psychosocial and environmental factors on physical or mental well-being (Jones, Bright, & Clow, 2001). Within this conceptualization, stressors and stress responses are distinguished (Esch). It is widely accepted that stressors (challenging stimuli) induce physiological, behavioral, and psychological modifications that are meant to help an organism cope—and, ultimately, survive—in the environment that has now been altered by the presence of the stressor. These modifications are known as the stress response (McEwen, 1998). It is also referred to as the "fight-or-flight" response (Esch).

Stress becomes problematic when balance is not established. Organisms survive the presence of external and internal stressors by maintaining an equilibrium—or "homeostasis" (Esch, 2002). As a result of that balance being constantly challenged, organisms have developed mechanisms to overcome disturbances in the equilibrium. These mechanisms are essential to the survival and thriving of the organism (Chrousos & Gold, 1992). The body exhausts metabolic energy to employ mechanisms to constantly adapt to physical challenges and psychosocial threats in an effort to maintain homeostasis (Esch). These mechanisms involve a confluence of biochemical (e.g. neurotransmitter, peptides, steroids), physiological (e.g. heart rate, blood pressure) and behavioral (e.g. anxiety, depression, tension) factors (Esch).

The hypothalamic-pituitary-adrenal (HPA) axis and the sympathoadrenal medullary (SAM) systems are the two major components of the autoregulatory stress response in vertebrates (Esch, 2002). The SAM is often equated with the sympathetic nervous system. According to Esch, the HPA and SAM normally work via the stress response to maintain homeostasis in order to ensure an organism's integrity even when experiencing challenging conditions. However, the stress response is susceptible to pathophysiological factors and processes (Jones et al., 2001). When this occurs, the stress response ceases to be an ameliorative mechanism and becomes deteriorative in nature (Esch).

Mental and psychosocial stressors have shown the ability to have profound effects on the cardiovascular system (Esch, 2002). Persistent arousal of the HPA and SAM can engage a cascade of autoregulatory responses, including those that lead to endothelial dysfunction (which is a precursor to atherosclerosis), hypertension, myocardial ischemia, ventricular fibrillation, plaque rupture, and/or coronary thrombosis (Krantz, Kop, Santiago, & Gottdiener, 1996; McCarty & Gold, 1996).

Transcendental Meditation

What is Transcendental Meditation?

Transcendental Meditation® (TM) has its origin in the Vedic tradition of India and was introduced to the West in the late 1950s (Alexander, 1993). Subsequently, more than five million people worldwide have learned the technique (Travis, 2001). TM has an advantage over other forms of meditation in that it has been taught in a systematic and reliable way since its introduction, which has created a standardization in the rigorous training TM instructors have received and the manner in which it is executed during TM sessions. This feature has made widespread research on TM more feasible compared to other forms of meditation (Wallace, Benson, & Wilson, 1971).

TM involves repeating a cycle of movement of attention from the active level to more abstract or subtle levels, reaching a dormant state of the subtlest level of thinking, and then returning to the move active levels of thinking (Travis, 2001). Transcendental Meditation gets its name from the inference that the ordinary process of thinking is "transcended"—that the state of awareness gradually settles into being free of all mental content, or silently awake, and a psychophysiological state of "restful alertness" is ultimately achieved. Proponents of transcendental awareness claim that the practice allows the mind to effortlessly settle inward and reach a state that is beyond thought and eventually experience the source of thought. This point of mental existence, considered to be the most peaceful state of awareness, is referred to as pure awareness or transcendental consciousness. Transcendental consciousness is associated with increased EEG coherence and deep physiological rest (Travis, Olson, Egenes, & Gupta, 2001). It has been theorized that the benefits of those associations are carried over into the ordinary wake state, sleep, and dreaming (Mason & Orme-Johnson, 2010).

Clinical studies have shown that individuals of any age, level of education, profession, or cultural background can easily learn the TM technique (Chalmers, Clements, Schenkluhn, & Weinless, 1990; Orme-Johnson & Farrow, 1977). Participants are instructed to sit in a comfortable position with eyes closed during the TM session. TM is to be practiced for 15-20 minutes twice daily, once in the morning and once in the afternoon (Roth, 1994).

Transcendental Meditation’s Physiological Impact

TM’s impact on neurophysiology.

Transcendental Meditation produces increased alpha wave power and lower beta and gamma wave power in the frontal cortex (Dillbeck & Bronson, 1981; Travis & Arenander, 2006). It also creates increased alpha coherence between the left and right hemispheres and anterior and posterior areas of the brain (Dillbeck & Bronson; Travis & Arenander). Past research has shown that alpha EEG coherence and synchrony promote the integration of the brain areas responsible for conscious awareness, attention, semantic processing, memory, learning, and mental health (Hummel & Gerloff, 2006; Sauseng & Klimesch, 2008). This increased EEG coherence and synchrony appear to facilitate the physiological, behavioral, and clinical effects that result from TM (Travis & Shear, 2010). According to Newberg et al. (2006), neuroimaging has shown that, compared to eyes-closed rest, TM increases frontal and parietal activity, which corresponds with an enhanced inner awareness. Neuroimaging has also revealed that TM results in decreased thalamic activity, which corresponds to decreased sensory messaging as the mind settles inward (Newberg et al.). TM also seems to promote increased functional connectivity in the Default Mode Network, a network of brain regions thought to be responsible for one’s sense of self and self-efficacy (Alexander, Rainforth, & Gelderloos, 1991).

Research has revealed that increased self-actualization occurs during TM practice, a phenomenon that may be a result of the increased connectivity of the Default Mode Network (Alexander et al.).

TM's impact on cortisol levels.

Chronically elevated plasma levels of cortisol, the primary stress hormone, are associated with a greater risk of ischemic heart disease, independent of conventional risk factors (Reynolds et al., 2010). A study noted that long-term (having a history of 3-5 years of TM experience) TM practitioners' post-meditation plasma cortisol levels were 27% less than premeditation levels after 30 minutes of meditation. The same study trained the group that was previously the control group on TM meditation. That group, known as short-term practitioners, also experienced a decline in cortisol levels when compared to its non-TM control numbers, howbeit a non-significant decline (Jevning, Wilson, & Davidson, 1978). This suggests the existence of a dose-response relationship. A four-month longitudinal study showed that TM practitioners who regularly meditated twice a day had decreased basal cortisol levels after meditation but had increased cortisol responsiveness to laboratory stress compared to controls (MacLean et al., 1997). Some longer TM studies that have lasted 6-36 months have failed to show consistent changes in cortisol levels (Jayadevappa et al., 2007; Werner et al., 1986). However, a study that examined postmenopausal women found that the long-term TM practicing group had a slower rise in salivary cortisol and significantly lower salivary cortisol levels compared to the control group, which had never participated in a systematic stress reduction program (Walton et al., 2004).

TM's impact on hypertension.

Randomized controlled trial (RCT) results have suggested TM is effective in treating hypertension. One such RCT involved 127 African Americans with the mean age of 67 years (Schneider et al., 1995). Each participant was assigned to one of three groups: TM, progressive muscle relaxation (PMR), or lifestyle modification education control group (EC). Prior to intervention, multiple baselines measurements were recorded. After three months of intervention, both active intervention groups (TM and PMR) exhibited significant reductions in SBP and DBP compared to the EC group, while the TM group experienced the largest reduction. The TM group experienced a 10.7 mmHg reduction in SBP and a 6.4 mmHg reduction in DBP from baseline compared to the PMR group's 4.7 mmHg and 3.3 mmHg reduction in SBP and DBP respectively (Schneider et al., 1995).

Another RCT extended the aforementioned three-month trial design to investigate if TM could remain an effective antihypertensive remedy over the course of a year (Schneider et al., 2005; Schneider et al., 1995). After one year of intervention, the TM group experienced a significantly greater reduction in DBP than the PMR group or EC group. In addition, there was a trend for greater reduction of SBP in the TM group than the PMR group or EC group. Importantly, the TM group experienced a significant reduction in the use of antihypertensive medication compared to the control group (Schneider et al., 2005).

Nidich et al. (2009) conducted an RCT involving 298 university students, including 159 subjects at-risk for hypertension, and noted significant reductions in SBP and DBP (5.0 and 2.8 mmHg respectively) after three months for the high-risk TM group compared to increases of 1.3 and 1.2 respectively in the SBP and DBP of the control group. The TM group also displayed significant improvements in total psychological distress, anxiety, depression, anger/hostility, and coping compared to the control group. Furthermore, the reductions in psychological distress and improvement in coping significantly corresponded with reductions in SBP and DBP (Nidich et al.).

TM'S impact on angina and atherosclerosis.

A single-blind prospective study examining the effects of TM on twenty-one patients with angina pectoris showed that the 12 patients in the TM group exhibited improved exercise tolerance, increased maximum workload, and delayed onset of ST segment depression after eight months of TM practice compared to the nine members in the wait-listed control group (Zamarra, Schneider, Besseghini, Robinson, & Salerno, 1996). Castillo-Richmond et al. (2000) conducted an RCT involving 60 African Americans with hypertension to assess the effects of TM practice on carotid intima-media thickness, a de facto measure of coronary and cerebral atherosclerosis. The TM group in the study experienced a decrease in carotid artery thickness compared to an increase in the control group. This suggests that TM practice may reduce atherosclerosis (Castillo-Richmond et al., 2000). Changes of this magnitude predict an 11% reduction in risk of myocardial infarction (Salonen & Salonen, 1993) and an 8-15% reduction in risk of stroke (O'Leary et al., 1999).

TM's impact on left ventricular mass and functional capacity.

Left ventricular mass (LVM) is one of the major heralds of hypertensive heart disease and a major risk factor for cardiovascular mortality (Barnes & Orme-Johnson, 2012). A study by Salerno, Schneider, & Alexander (2004) selected 102 African Americans with hypertension and randomly assigned them to a TM group or a health education control group. The health education group was instructed on how to use proper diet and exercise to reduce the risk of hypertensive heart disease. The LVM remained stable for the TM group from baseline to the seven-month post-test. However, the health education control group experienced a significant increase in LVM of 5.6g/m^2 (Salerno, Schneider, & Alexander). In another study, twenty-three African Americans hospitalized for chronic heart failure were enrolled into a preliminary six-month RCT. The TM group in that study had a significant improvement in functional capacity on a six-minute walk test compared to the health education control group (Jayadevappa et al., 2007).

Transcendental Meditation's Impact on Medical Utilization

Efforts have been made to use health insurance statistics to analyze the effects of TM on cardiovascular morbidity. Orme-Johnson (1987) examined the medical utilization over a five-year period of the 2,119 members of the SCI Insurance Group, a health insurance group that had only one criterion for membership: that all of its enrollees and covered family members practice TM for at least six months prior to enrollment. In order to remain eligible for participation in the SCI plan, members were required to maintain regular practice of TM. SCI was one of many insurance groups belonging to a major insurance carrier in Iowa—a carrier that possessed a membership of over 600,000. SCI and the other groups had comparable policies. When compared to the other insurance groups belonging to the major carrier, the medical utilization analysis found that SCI had lower overall utilization rates, including possessing a hospitalization rate for heart and vascular disease that was 87% lower. As a control for profession, SCI was also compared to five other insurance accounts with similar professional membership. SCI also had lower utilization rates compared to those five accounts (Orme-Johnson, 1987).

Mindfulness

What is Mindfulness?

Mindfulness is most consistently defined in the psychotherapy community as “a moment-to-moment awareness of one’s experience without judgment.” (Davis & Hayes, 2011, p. 189). The word *mindfulness* is derived from *sati*, a Pali word that means having awareness, attention, and remembering (Bodhi, 2000). Mindfulness has also been described as a “state of *psychological freedom* that occurs when attention remains quiet and limber, *without attachment* to any particular point of view” (Martin, 1997, p. 291) [emphasis in original text]. According to Wallin (2007), mindfulness focuses on the temporary, subjective, and fluid nature of mental states and is thought to enhance emotional regulation and cognitive flexibility. Mindfulness trains the participant to be aware of the “reflective self” that is engaged in the mentalization while still fully experiencing the progression of mental states with acceptance and without attachment and judgment (Wallin). In recent years, mindfulness has experienced a tremendous increase in popularity in the popular press and psychotherapy literature, particularly as a component of stress reduction programs (Davis & Hayes, 2011).

Mindfulness and Emotional Regulation

Research has shown that mindfulness helps facilitate effective emotion regulation in the brain (Corcoran, Farb, Anderson, & Segal, 2010). Theories pertaining to the mechanisms behind the emotional regulation have suggested that mindfulness meditation “promotes metacognitive awareness, decreases rumination via disengagement from perseverative cognitive activities, and enhances attentional capacities through gains in working memory; these cognitive gains, in turn, contribute to effective emotion regulation strategies” (Davis & Hayes, 2011, p. 200). A 2008 study revealed a negative association between mindfulness and rumination and supports the notion that mindfulness has a direct effect on emotional regulation (Chambers, Lo, & Allen, 2008; McKim, 2008). McKim also revealed that individuals who experienced ongoing anxiety, depression, and/or chronic pain had significantly lower scores on self-reported rumination, psychological distress, depression, anxiety, and physical illness after participating in an eight-week mindfulness-based stress reduction (MBSR) intervention. Mindfulness scores accurately predicted anxiety, rumination, medical symptoms, and psychological distress in McKim's study. In 2010, a group of researchers who reviewed 39 studies that assessed the efficacy of mindfulness-based therapy in reducing anxiety and depression symptoms concluded that mindfulness-based therapy may be a useful technique for potentially altering affective and cognitive processes that trigger multiple clinical issues (Hofmann, Sawyer, Witt, & Oh, 2010).

Physiological Impact of Mindfulness

Impact of mindfulness on neural reactivity.

There is evidence that mindfulness meditation has effects on neural activity in the brain. In one study by Farb et al. (2010), a group of participants who participated in an eight-week MBSR training was compared to a control group after both groups watched sad films. The MBSR program in that study consisted of mindfulness meditation and yoga. In addition to displaying significantly less anxiety, depression, and somatic distress than the control group, the MBSR training group displayed less neural reactivity via functional magnetic resonance imaging (fMRI) while watching the films than the control group. The MSBR group also displayed distinctively different neural responses while watching the sad films. These results imply that mindfulness programs increase an individual's ability to use emotion regulation strategies that enable them to selectively experience emotion in addition to processing those emotions differently in the brain (Farb et al., 2010; Williams, 2010).

Impact of mindfulness on cardiovascular reactivity.

High cardiovascular reactivity to stress and less recovery post stress puts an individual at increased risk for CVD, including hypertension and increased carotid intimal medial thickness (Gronwall, 1977). The Paced Auditory Serial Addition (PASAT) is a speeded math task that has been implemented as a laboratory stressor that is effective in raising perceived stress levels (Hirvikoski et al., 2011) and blood pressure levels (Carroll, Phillips, Der, Hunt, & Benzeval, 2011; Carroll, Ring, Hunt, Ford, & Macintyre, 2003). It was initially developed to identify individuals with a head injury and monitor their recovery (Gronwall, 1977). Neurocognitive functions such as speed of information processing, auditory attention, and working memory are believed to be assessed by the PASAT (Tombaugh, 2006). A study by Steffen & Larson (2015) incorporated the PASAT. The study involved presenting the participants with a series of digits from 1-9 via a recorded voice. The participants were tasked with adding the digits consecutively in a manner that adds the current digit to the previous digit. Normally, participants are presented with four separate blocks of 50 digits each. To increase difficulty and manipulate attention load, the intervals of time between each digit being presented are progressively lessened (from 2.4 s, to 2.2 s, to 1.6 s, to 1.2 s). The facilitators of the Steffen & Larson (2015) experiment only used 1.6 s and 1.2 s intervals.

In the Steffen & Larson (2015) study, undergraduate students in psychology courses were recruited. The students were assigned to a mindfulness exercise group (16 males and 14 females) or a control group (15 males and 17 females). The participants were selected so that the groups did not differ in the following demographic characteristics: age, gender distribution, ethnicity, years of education, baseline depression symptoms [measured by the Beck Depression Inventory-Second Edition (BDI-II)], baseline trait anxiety, or state anxiety symptoms [measured by the State-Trait Anxiety Inventory (STAI)]. The procedure began by having each participant take the BDI-II and STAI to assess their pre-PASAT moods. Next, three baseline blood pressure and heart rate values were collected from each participant. The two groups did not differ significantly in their baseline systolic and diastolic blood pressure. There was a non-significant trend involving the mindfulness group having a lower baseline heart rate than the control group (Steffen & Larson, 2015).

After the baseline values were recorded for the Steffen & Larson (2015) study subjects, the mindfulness group received basic instruction on mindfulness that coached the listeners to focus on the present moment in an open and nonjudgmental way. The mindfulness group then completed an exercise that focused on mindfulness of breathing. The control group passively listened to audio tracks that focused on the awareness of the environment and ethical conduct. All instruction for both groups was via cd audio, and bother exercises were conducted by the same voice. Subsequently, the participants took the PASAT (approximately 8 minutes in length). Upon completion of the PASAT, the participants immediately took a second STAI and then entered the recovery period, which involved sitting in a quiet room for 20 minutes. Blood pressures and heart rates were taken several times—two minutes apart—throughout the procedure and averaged. The first readings were taken at baseline, at the 6- and 8-minute marks of the mindfulness or control exercise (early mindfulness), at the 12- and 14-minutes marks of the mindfulness or control exercise (late mindfulness), at the 2- and 4-minute marks of the PASAT stressor (early PASAT), at the 6- and 8-minute marks of the PASAT stressor (late

PASAT), at the 8- and 10-minute marks of the recovery period (early recovery), and at the 18- and 20-minutes marks of the recovery period (late recovery) (Steffen & Larson, 2015).

Results of the Steffen & Larson (2015) experiment indicated that systolic blood pressure (SBP), diastolic blood pressure (DBP), and heart rate (HR) changed significantly over the course of the experiment for both the mindfulness and control group. When comparing the changes in systolic blood pressure from baseline to the end of the mindfulness exercise for the mindfulness group and the passive listening exercise for the control group, the mindfulness group experienced a significantly lower systolic blood pressure. There was not a significant difference in DBP or heart rate between the two groups at the end of the mindfulness and passive listening exercises (Steffen & Larson, 2015).

The Steffen & Larson (2015) results also showed that the mindfulness group experienced significantly lower SBP and DBP at the end of the PASAT stressor compared to the control group. Interestingly, the mindfulness group showed a decrease of 3 mmHg in SBP and 5 mm/Hg in DBP from the beginning to the end of the PASAT stressor while the control group exhibited increases of 1 mmHg and 0.1 mmHg in SBP and DBP respectively. There was not a difference in heart rate between the two groups in response to the PASAT. The aforementioned blood pressure trends imply that the mindfulness group did not experience as much physiological distress as the control group during the PASAT stressor.

When assessing cardiovascular recovery, Steffen & Larson (2015) examined the return of the blood pressures back to baseline post-stressor. At the 10-minute recovery mark, the mindfulness group showed a non-significant trend toward having a lower SBP than the control group. The two groups did not show a significant difference in SBP at the 20-min recovery mark. There was no significant difference for DBP between the two groups for either the 10-minute or

20-minute recovery marks, and there was no difference exhibited for recovery phase heart rate between the groups.

Comparison of Mindfulness with Progressive Muscle Relaxation

A study compared the effects of mindfulness meditation with that of relaxation on 45 cardiac rehabilitation patients who also suffered from depression (Delui, Yari, Khouyinezhad, Amini, & Bayazi, 2012). The forty-five patients in that study were randomly assigned to three groups: progressive muscle relaxation, mindfulness meditation, or control. (Each group was assigned fifteen patients.) The relaxation and mindfulness meditation groups each held 10 sessions of their particular technique, lasting 20 and 25 minutes respectively. In addition, the two groups practiced their techniques at home with the aid of an instructional CD. The control group did not receive any type of additional intervention outside of the normal cardiac rehab treatment. At the end of the ten sessions, there was no significant difference between depression and anxiety scores of the relaxation and control group. However, there was a significant reduction of depression score of the mindfulness meditation group compared to the control group. The heart rates and blood pressures of the participants were measured at the beginning and end of each session. When comparing blood pressures, there was no significant reduction in SBP and DBP between the relaxation and control groups. There was a significant reduction of SBP in the meditation group compared to the control group. Finally, no significant difference in heart rate was found between the relaxation and control groups. However, there was a significant reduction in the heart rate of the meditation group compared to the control group (Delui et al.).

A study by Hughes et al. (2013), compared the effects of MBSR therapy (consisting of mindfulness meditation, body scanning, and yoga) with that of progressive muscle relaxation

(PMR) on the SBP and DBP of prehypertensive patients. After eight weeks of treatment, the MBSR group had a significantly greater reduction in systolic blood pressure compared to the PMR group. (The MBSR and PMR groups experienced systolic blood pressure reductions of 4.9 mmHg and 0.7 mmHg respectively). The MBSR group also experienced a significantly greater reduction in diastolic blood pressure when compared to the PMR group. (The MBSR and PMR group experienced diastolic blood pressure reductions of 1.9 mmHg and 1.2 mmHg respectively) (Hughes et al., 2013).

Yoga

What is Yoga?

Yoga is a holistic mind-body therapy that promotes physical, mental, emotional, and spiritual well-being (Manchanda & Madan, 2014). The word *yoga* is derived from a Sanskrit word that means to yoke or join together and connotes joining the lower human nature to the higher nature (Ananda, 1981). Yoga is a 4,000 year-old practice that originated in India but has become increasingly popular in western countries (Manchanda & Madan). There are several types of yoga practices. Hatha yoga, the form of yoga that is most commonly practice in western countries, emphasizes psychophysical energies of the body (Raub, 2002). Hatha yoga emphasizes three main elements: the body, the mind, and the breath. The philosophy of yoga upholds the belief that the breath links the mind and the body (Raub). To focus on those three elements, hatha yoga employs stretching exercises and physical postures, concentration and thinking techniques, and breath control (Manchanda & Madan).

Yoga and Emotional Regulation

There is data that suggests that yoga has beneficial effects on perceived stress. A study by Michalsen et al. (2005) enrolled twenty-four females with high levels of perceived stress to evaluate the effects of yoga intervention on anxiety and stress. Participants in the yoga intervention group participated in a 90-minute session of iyengar yoga, a form of hatha yoga, twice a week for three months with a certified yoga instructor. The yoga group participants were encouraged to also practice yoga at home. The control group members were asked to maintain their regular activities and not start any other exercise or stress management program for the three-month duration of the study (Michalsen et al.).

The results at the end of the three-month Michalsen et al. (2005) study indicated that the yoga group experienced a significantly greater reduction from baseline in their Cohen Perceived Stress Scale (CPSS) compared to the control group (-13.9 vs. -1.9). In addition, the State and Trait anxiety, three dimensions of the Profile of Mood States (vigor, fatigue, depression-anxiety) and well-being scores of the yoga group improved significantly from baseline compared to the control group. The Center for Epidemiological Studies Depression Scale (CES-D) scores of the yoga group also decreased (Michalsen et al.).

A study by Banerjee et al. (2007) revealed a significant decrease in the Hospital Anxiety Depression Scale (HADS) of post-operative breast cancer patients after six weeks of yoga intervention. The control group, which engaged in a counseling program, showed no improvement in HADS scores. Another six-week yoga intervention compared a group of 42 breast cancer patients undergoing six weeks of yoga intervention with a control group of 33 breast cancer patients undergoing counseling. The yoga group had decreased HADS scores compared to the counseling group (Banerjee et al.).

Medical students form another cohort in which the effects of yoga intervention have been studied. Malathi & Damodaran (1999) compared a group of 25 medical students who participated in yoga with a control group of 25 medical students for three months. In that study, the yoga group had significantly reduced anxiety scores immediately following yoga practice and on the day of exams after yoga practice. A separate study found improved scores in perceived stress and general health scores in 14 medical students after eight and 16 weeks of yoga (Simard & Henry, 2009).

Physiological Impact of Yoga

Yoga's impact on hypertension.

Literature has suggested that yoga has positive physiological effects on the cardiovascular system, including treating hypertension. A 2000 study found that yoga exercises twice a day for 11 weeks was just as effective as standard medicinal treatment for hypertension (Murugesan, Govindarajulu, & Bera). A study by Selvamurthy et al. (1998) assessed the effects of tilt table therapy and yoga posturing on hypertension. Twenty male patients with essential hypertension were treated for three weeks with either tilt table therapy or yoga posturing to restore baroreflex sensitivity. Progressive changes in the autonomic system were determined by cardiovascular responses to head-up tilt and cold compressor stimulus, electroencephalographic indices, catecholamines in the blood, and plasma renin activity. After three weeks, the tilt table group and the yoga group experienced a significant reduction in blood pressure, indicating a gradual improvement in baroreflex sensitivity (Selvamurthy et al.,).

A study by Pal et al. (2011) selected 154 patients with a diagnosis of coronary artery disease and compared the effects of a treatment regimen consisting of yoga and medication with a regimen that consisted of only medication. The medication regimen consisted of beta-blockers, aspirin, ace inhibitors, and angiotensin receptor blockers. The yoga sessions were 35-50 minutes in duration, five days a week, for six months. After the six months, improvements in BMI, fat %, SBP, DBP, heart rate, total cholesterol, triglycerides, LDL, and HDL were seen in the yoga group when compared to the non-yoga group (Pal et al.).

Yoga's impact on cortisol levels.

Michaelsen, et al. (2005) selected a sample consisting of eleven female yoga practitioners to examine the effects of yoga on cortisol levels. The eleven females had been practicing yoga for more than three months under the direction of the same yoga instructor. In the study, salivary cortisol concentrations were measured before and after every 90-minute iyengar yoga class. Measurements showed a decrease in mean cortisol levels from 4.28 to 3.20 ng/ml.

Discussion

Mechanisms of Actions

Research data suggests that the mind-body therapies of Transcendental Meditation, mindfulness, and yoga have the potential to be efficacious interventions for stress and cardiovascular disease reduction. The mechanisms responsible for the effects of mind-body therapies are not fully understood. However, it appears that these therapies induce acute and longitudinal reductions in sympathetic tone, reactivity to stress, and the associated inflammatory responses. Studies have shown that the parasympathetic nervous system is activated by the autonomic nervous system's release of endorphins and serotonin, neurotransmitters that counteract norepinephrine, during mind-body therapies (Chiesa & Serretti, 2010; Dod et al., 2010; Ludwig & Kabat-Zinn, 2008). In addition, mind-body therapies appear to influence activation of certain brain areas, and thus, augment an individual's ability to relax while processing and coping with stress in a more advantageous manner. Such findings suggest that mind-body therapies could induce mechanisms to mitigate preexisting cardiovascular disease and, by reducing the stress response, help prevent the development of future cardiovascular disease.

In addition to having the potential to allay stress and cardiovascular dysfunction, mind-body therapies may be effective in reducing CVD risk factors. Studies have found that individuals have lowered their BMI through yoga practice. Also, studies suggest that TM normalizes neurochemical imbalances that are caused by substance abuse and motivate substance abuse, thus leading to a decrease in tobacco, alcohol, and illicit drug use (Hawkins, 2003).

Research Limitations

Though this literature review has found that mind-body therapy do show potential as techniques for stress reduction and cardiovascular disease mitigation, the gathered research does contain inherent limitations. First of all, this literature review aggregated information exclusively from studies that were printed in English, thus neglecting many studies that were conducted in the East, the area from which mind-body therapies originate. Many of the studies, particularly those for yoga and mindfulness, have small sample sizes and inconsistencies in baseline. Furthermore, some of the studies instruct participants to engage in supplemental mind-body intervention sessions at home, leading to potential variance in therapy execution among individuals when not under supervision of an instructor. Another research flaw exists in the fact the studies often do not have adequate controls. Also, the lack of standardization across studies makes it difficult to ascertain definitive answers to research questions. For example, yoga practice is often customized to individual practitioners, causing variance in techniques, frequency, and duration of practice. It is important to note that TM is considered to have a high degree of standardization in its implementation, which has led to it being the most thoroughly research mind-body therapy. A publication by Caspi & Burleson (2005) highlights several features that should be considered in meditation research: monitoring, method of assessments, integration of qualitative methods, and a pragmatic design.

Opportunities for Future Research

Though data supports the assertion that mind-body therapies have advantageous health implications, the mechanisms driving the observed effects of mind-body therapies are not thoroughly understood. Also, determining the minimum effective dose and extent of the dose-response effects of mind-body therapies would help to more definitively discern their efficacy and if/how they should be incorporated into the regimen of medical treatment and lifestyle modification. Furthermore, it would be valuable to more extensively compare mind-body therapies with traditional aerobic exercise in effectiveness to reduce stress and treat cardiovascular disease to determine if mind-body therapies can supplant traditional aerobic exercises or are most effectively used as a complement. Finally, when considering the common occurrence of noncompliance with traditional CVD medicinal treatment and the associated side effects with said medications, concerted efforts to conduct further comparison research of the effectiveness of mind-body therapies may prove to be very beneficial to the medical community as it aims to improve the benefit-risk profile of treatments.

Conclusion

The current body of research has produced encouraging results when assessing the efficacy of mind-body therapies as interventions for stress and CVD reduction. Cardiovascular disease has become the leading cause of mortality worldwide and has become a significant driver of the diminished quality of life and increasing economic losses for individuals and societies. As the medical community continues to emphasize lifestyle modifications as an essential component of the effort to oppose CVD, mind-body therapies have the potential to establish themselves as more conventional interventions.

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Abstract

Objective: This literature review investigates the therapeutic potential of three types of mind-body therapies—transcendental meditation, mindfulness, and yoga—to reduce stress, induce relaxation, and mitigate cardiovascular disease development and progression. **Methods:** The research databases, PubMed and ResearchGate, were used to gather literature related to transcendental meditation, mindfulness, yoga, mind-body therapies, and cardiovascular disease. **Results:** 87 articles—including clinical trials, literature reviews, systematic reviews, comparative reviews, meta-analyses, textbooks, and public health literature—were used for the purpose of this document. **Conclusion:** Stress is considered to be a significant driver of CVD. Individuals have reported decreases in perceived stress after practicing TM, mindfulness, and yoga. In addition, these mind-body therapies have shown the ability to reduce physiological reactivity to stress. Finally, results suggest that these three mind-body therapies are efficacious interventions for reducing types of cardiovascular dysfunction such as hypertension, atherosclerosis, and heart failure.

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Complete Title: Transcendental Meditation, Mindfulness, and Yoga: A Review of the Therapeutic Potential of Mind-body Interventions on Stress and Cardiovascular Disease

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