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Review Article

Meta-Analysis of the Beneficial Effects of Mindfulness-Based Interventions (MBIs) on the Cardiovascular System and Prevalent Cardiovascular Disorders (CVDs)

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Abstract

Stress disrupts healthy cardiovascular function, influencing or triggering the development of cardiovascular disease (CVD) and disorders by elevating blood pressure (BP), increasing heart rate (HR), cortisol levels, and insulin resistance. The utilization of mindfulness-based interventions (MBIs) has been associated with a reduction in specific symptoms, markers, and hallmarks of CVD. This meta-analysis reports on the beneficial effects of several of these mindfulness-based inventions on the cardiovascular system in response to stress and makes a case for further research on such.

Keywords: *Cardiovascular; Hypertension; Heart Rate; Meditation; Obesity; Prayer; Yoga*

Abbreviations

ACEI:: Angiotensin-Converting-Enzyme Inhibitor; AF: Atrial Fibrillation; ANS: Autonomic Nervous System; BP: Blood Pressure; CAD: Coronary Artery Disease; CHF: Congestive Heart Failure; CVD: Cardiovascular Disease; EKG: Electrocardiogram; HDL: High-Density Lipoprotein; HPA: Hypothalamic-Pituitary-Adrenal; HR: Heart Rate; HRQOL: Health-Related Quality of Life; HRV: Heart Rate Variability; LDL: Low-Density Lipoprotein; MB-BPR: Mindfulness-Based Blood Pressure Reduction; MBI: Mindfulness-Based Intervention; PAD: Peripheral Artery Disease; RCT: Randomized Controlled Trial; VAS: Visual Analog Scale

Introduction

Cardiovascular disease (CVD) and related disorders make up a large portion of clinical conditions that typically require long-term management and consistent monitoring. In the United States, cardiovascular disorders include hypertension, coronary artery disease (CAD), ischemic heart disease, congestive heart failure (CHF), cardiomyopathy, atrial fibrillation (AF), and peripheral artery disease (PAD). While there has been advancement in the treatment of these conditions, an unmitigated cure remains to be discovered.

Hypertension remains a costly chronic condition for Americans, amounting to over $50 billion in healthcare costs annually for treatment. While pharmaceuticals remain the first line of therapy along with lifestyle changes, those individuals diagnosed with hypertension are expected to increase [1]. However, mindfulness-based interventions (MBIs) may play a role in reducing the impact of CVD and mortality.

To date, there is a lack of scientific evidence that MBI has a positive influence on CVD. However, measuring blood pressure (BP), heart rate (HR) and heart rate variability (HRV), along with other cardiovascular symptoms and markers, may provide answers to what beneficial effects can be expected with the application of MBIs regarding CVD and related disorders. With MBIs, high-density lipoproteins (HDLs) and low-density lipoprotein (LDLs) have increased and decreased, respectively [2].

CVD continues to be a prominent health concern in the United States, and, currently, cases are expected to rise in the decades to come. The absence of symptoms in the early stage of CVD is one underlying factor stopping some CVD-affected individuals from being treated sooner to halt or reverse the disease's progression. CVD lacks early-stage symptoms and seldom detected until advanced features present, which may be irreversible [3]. Nonetheless, in terms of cardiovascular health, looking at BP, HR, and HRV as indicators of cardiovascular status and treatment options may be useful.

Discussion

Continuous sympathetic nervous system activation from stress or stressors results in a prolonged and constant release of catecholamines, cortisol, and other excitatory transmitters within the human serum. In response, there are an increase in HR, BP, and lipid cytokine concentrations, which harms the cardiovascular system and function [4].

According to Hewitt., *et al.* (2017), exercise activated physiological changes resulting in improved heart rate variation (HRV), as oxygenation capacity and circulation is heightened during times of exercise; however, it remains uncertain if MBIs produce a same or similar adaptive responses. In yoga, exercise-induced oxygenation mechanisms failed to show the same impact as exercise on cardiovascular function [5]. Nonetheless, this does not mean that yoga does not have an impact on CVD. It may be that yoga's potential therapeutic benefit may operate in pathways outside of what has been observed to occur during strenuous physical activity.

Whelton., *et al.* (2017) noted that CVD is a multifactorial disease dilemma, which involves several causations. In essence, diet and food quality consumed, amount of movement (exercise), alcohol intake, nicotine use, stress, and degree of medication adherence are the most common risk factors in cardiovascular health [6].

The application of MBIs varies based on the chosen therapy, practitioner, clinical setting, and length and time of the MBI sessions [7]. Understanding these variations might prove helpful for general assessment or non-specific use. Regarding applicable research, a more measured approach might be useful to begin to develop a greater understanding of a particular intervention in CVD. Hence, a diagnosis-specific mindfulness approach—as utilized by Loucks., *et al.* (2019)— appeared to challenge previous methods of investigating MBI effects by evaluating mindfulness practices on blood pressure using a mindfulness-based blood pressure reduction (MB-BPR) program [8].

Beneficial effects of MBIs on the cardiovascular system under stress

Thayer and Lane (2007) confirmed that prolonged mental stress is associated with an increased risk of CVD and a higher association with death. The autonomic nervous system (ANS) accommodates stressors, and if stimulated "overtime", taxes neuroendocrine function, and disrupts healthy hypothalamic-pituitary-adrenal (HPA) axis activity [9]. Consequently, the role of inflammatory and cytokine markers within the body are impacted and trigger aberrations in glucose and lipid metabolism. Bouassida., *et al.* (2010) reported that in chronic conditions, which are known risk factors for CVD (such as obesity and type 2 diabetes), insulin resistance, increased cortisol, and low serum adiponectin are seen typically. Lower levels of adiponectin are correlated with insulin resistance and impaired hormone homeostasis [10].

While pharmacologic intervention is considered the most effective treatment for CVDs, their use is limited in specific situations. Conventional pharmacotherapy, as used in the treatment of CVDs, include but are not limited to beta-blockers, calcium channel blockers,

nitrates, and angiotensin-converting-enzyme inhibitors (ACEIs). While useful, such drugs have known contraindications, side effects, and unintended reactions and results. Therefore, MBIs might be able to fill a void in symptom control and management with CVD [11]. MBI may be done at home or an outside facility, with 1–3 weekly sessions done over 12 weeks [12].

The effects of MBI concerning BP, HR, and HRV remain ambiguous to date; most research on MBIs is performed using non-disease-specific mindfulness programs. The lack of diagnosis- or disorder-specific mindfulness programs may be the cause of the inconsistent results in MBI trials. Thus, examining the impact of MBI in disease-specific methods for primary outcomes might prove beneficial, in terms of assessing the acceptability, feasibility, and rationale behind the intervention [8].

MBIs can serve as "natural lubricants" to help ease the "friction" endured throughout the day and serve as a buffer from stress in CVD. As noted in other studies, chronic stress triggers ANS dysfunction and increases BP and HR, while decreasing HRV [13]. MBIs could enable patients to cope better with their condition and become resilient with practice [14].

Beneficial effects yoga on the cardiovascular system under stress

Yoga dates back to over four thousand years, emphasizing attention to and focus on posture, breathing, and reflection [15]. Although yoga, as an MBI, has various origins and variations in practice, it is practiced individually and by various groups worldwide; however, in the Western world, it is considered more as physical exercise or a non-pharmaceutical therapy [16]. The core element of yoga is a body-mind balance.

In Hewett., *et al.* (2007), researchers studied the impact of yoga on cardiovascular health by studying participants over months and assessing distinct factors of cardiac risk and health status. Measurements from sedentary habits, heart failure symptoms, HR, BP, HRV, and electrocardiogram (EKG) findings were analyzed. Intention-to-treat analysis examination uncovered that yoga intervention failed to show superiority over controls in terms of HR, HRV, and EKG improvement, yet observed positive changes in HR and BP [5].

There is little evidence to support yoga having a positive effect on HR, BP, or HRV, but there is some actual data on yoga positively affecting HR, apolipoproteins, and adipocytokines. Papp., *et al.* (2016) observed subjects engaged in yoga over 3–4 months who realized positive changes as follows: HDL precursor, ApoA1 lipoprotein (change of 0.08 g/L; 95% CI, 0.0–0.1 g/L) and adiponectin (change of 1.35 mg/L; 95% CI, 0.5–2.2 mg/L); compared to controls under meta-analysis testing [17].

Leptin is another critical hormone regulator, which is produced by adipocytes and communicates satiety by attaching to receptors found in the hypothalamus, hippocampus, and neocortex. In terms of CVD impact, Bouassida., *et al.* (2016) revealed that leptin receptor resistance is associated with a propensity to obesity [10]. However, there were no changes to leptin levels in yoga treatment groups compared to controls. When assessing adipocytokine levels among beginner and experienced yoga practitioners, Kiecolt-Glaser., *et al.* (2012) found higher adiponectin levels and lower leptin levels in the experienced yoga-practitioner group [18].

When physical activity with no mindfulness component was compared to yoga intervention alone, data from specific randomized controlled trials (RCTs), Gleeson., *et al.* (2011) observed higher levels of ApoA1 after regular yoga intervention [19]. Nonetheless, currently, mixed data exist on physical exercise and its effect on ApoA1. Therefore, more evidence remains to be discovered on whether physical exercise or the mindfulness-components of yoga are causing changes in apolipoprotein levels. When yoga was studied in perimenopausal and postmenopausal women, looking for changes in vasomotor symptoms by monitoring HRV, no improvement in HRV was observed; although, improvement in overall quality of life and sleep quality was reported [20].

Beneficial effects meditation on the cardiovascular system under stress

Generally, meditation can be viewed as an application in achieving a level of awareness in which mental clarity and stability are enhanced irrespective of feelings, emotions, or thoughts [21]. Persistent stress raises cortisol levels, leading to elevated BP and HR, which

burdens the cardiovascular system [22]. The usefulness of meditation in individual CVD states (i.e., ischemic heart disease) remains to be researched and reported. Thus, investing in a diagnosis-specific meditation approach should be thoughtfully considered to isolate particular aspects of cardiovascular change with meditation [23]. Wachholtz and Pargament (2005) demonstrated that meditation has a beneficial outcome on CVD [24].

The clinical outpatient measurements of cardiac vitality consist of HR, BP, and HRV [25]. In Sullivan., *et al.* (2009), daily meditation practices yielded different results based on the type of meditative approach used. Mindfulness-based meditation showed superiority in improving quality of life ratings with pain when compared to focused attention methods [26]. In Chang., *et al.* (2005), cognitive-behavioral strategies, along with meditation, demonstrated efficacy when performed once to twice daily for 15 – 30 minutes, averaging an hour to three hours per week over a 3 to 4-month span [27].

Beneficial effects prayer on the cardiovascular system under stress

Prayer refers to specific practices in various cultures and religions, which are known by numerous people and populations worldwide [28]. Emotional, mental, and psychological stress can have pathological consequences on one's health. Prolonged stress initiates or promotes adverse reactions in bodily tissues and organs [29].

In Koenig (2004), prayer and spiritual intervention were correlated to lower pain scores and the frequency and duration of pain. For those with terminal illnesses or conditions with no recourse of care, prayer has also been shown to be beneficial [30]. Psychological or physical forms of pain, over an extended period, can negatively impact cardiac health [31]. As reported by Posadzki., *et al.* (2015), more than ten randomized trials exist that support MBIs' (e.g., prayer's) positive impact on HRV [32].

Bussing., *et al.* (2009) demonstrated that a positive outlook, in terms of spiritual coping, was useful in managing chronic illness and controlling specific disease progression [33]. Hilton., *et al.* (2017) summarized that prayer, along with other mindfulness practices, showed a reduction in pain perception, improved depressive symptoms, and enhanced quality of life [34].

Prayer, along with cognitive-behavioral techniques, offers a method to address feelings of uneasiness, low mood, anxiousness, or fatigue. Persistent derangements harm cardiac health. In those who have cardiovascular conditions and are affiliated formally or informally with a sense of religion or spirituality, prayer might be a useful adjunct therapy [35]. Nonetheless, there is a lack of RCTs and no systematic reviews with meta-analysis regarding prayer or MBI outcomes on health-related quality of life (HRQOL) in impoverished adults [36]. Those who live with minimal monetary resources might have a cost-effective tool in prayer to address CVD.

Bridging the research gap regarding MBIs and CVDs

There remains a need to bridge the gap of scientific regarding any potential benefits MBI has on CVD to justify MBI's therapeutic use [16]. Under systematic scrutiny, Van Dixhoorn and White (2005) assessed twenty-seven controlled studies on MBI and ischemic heart disease. The MBIs employed in these studies included progressive muscle relaxation, meditation, biofeedback, breathing exercises, and deep breathing in subjects diagnosed with an ischemic cardiac event. When compared to controls, subjects who utilized an MBI with conventional therapy received more significant benefits than those who utilized conventional therapy alone [37]. However, from the twenty-seven trials, only three reported favorable data regarding HRV in response to MBI [38].

Summary

When addressing chronic pain, Monro., *et al.* (2015) observed that yoga practiced consistently for three months showed lower visual analog scale (VAS) pain scores than control groups [39]. Nevertheless, the role of yoga on vasomotor symptoms, such as night sweats and hot flashes, has failed to show benefits when compared to control groups [40]. Regarding MBI and low-income adult outcomes, the

general impression from the preliminary data (on MBI use in HRQOL) is that there are potential benefits to incorporating such therapies for selected chronic conditions [41].

When looking at symptoms and markers in the relationship of cardiovascular health and MBI, such as HR, BP, HRV, lipid levels, adiponectin, and leptin, there have been mixed findings in regards to determinants and outcomes. In limited trials with yoga, Kiecolt-Glaser., *et al.* (2010) noted adipocytokine changes, and adiponectin levels were seen to increase after 16 weeks of intervention when compared to controls; although, leptin remained unchanged after yoga intervention [42].

Currently, there is little data that support improvements in systolic or diastolic blood pressure with MBI-intervention, during, immediately after, and six weeks post-intervention. Observing HR normalization with MBI yielded mixed results [17]. HRV was shown to be higher and have a wide range in younger individuals and decreases with age. Some studies have noted increased HRV with meditation, yet consistency in the findings is lacking [12]. When assessing MBI utility, limitations exist regarding what intervention or practice participants undertake, and how that data can be accounted for in a study [17].

Conclusion

Stressors (and stress) are known to adversely affect the cardiovascular system and initiate or promote the development of specific cardiovascular disorders, as evidenced by elevated blood pressure, heart rate, cortisol levels, and insulin resistance, in addition to other symptoms and markers. Stress can compromise healthy cardiovascular function and promote specific cardiovascular disorders. Yoga, meditation, and prayer have demonstrated therapeutic safety and efficacy in improving the symptoms and hallmarks of specific cardiac disorders. However, research has been unable to predict precisely which part (and to what extent) of the cardiovascular system MBIs can affect beneficially. Undertaking further research regarding the effect of mindfulness-based interventions on the cardiovascular system and common cardiovascular disorders during stress is evidenced and seems justified.

Conflict of Interest Statement

The authors declare that this paper was written in the absence of any commercial or financial relationship that could be construed as a potential conflict of interest.

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