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Heart Rate Variability Biofeedback and Hypertension: Searching for A Correlated Stance

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Abstract

This article explores the role of heart rate variability biofeedback (HRVBF), a mind-body medicine modality, essential for the comprehension, development, analysis of hypertension (HTN), and the management of chronic disorders. The topic is rooted in a quest for awareness of heart rate variability (HRV), HRV biofeedback (HRVBF), preventive approaches to hypertension (HTN), and efforts to decipher a correlated stance between HRVBF and hypertension. Biofeedback is a non-surgical therapeutic method with negligible side effects seeking to maintain a homeostatic balance in the human body, with the individual in control of positive life-changing therapeutic interventions such as heart rate, breathing, and mechanisms for blood pressure. This article considers a systematic review of sixty-three articles, from which fifty-two were read and analyzed, and eleven appraised. The reviews helped explore the various theories about HRV biofeedback (HRVBF) as an essential tool to assess cardiac autonomic function considering the onset of hypertension. The current evidence shows that HRVBF, HRV, and HTN warrant a significant look at how crucial it is in the involvement of the neuro-cardiovascular system. For a clear interpretation of the mechanisms involved, this article uses the lenses of HRVBF, HRV, HTN, and presents an assessment of heart rate variability biofeedback efficacy, and challenging explanations of HRV.

Three primary questions enunciated to ascertain if a correlation exists between HRVBF, and hypertension (HTN) are:

1) Is HRV biofeedback (HRVBF) important in detecting individuals with a higher risk of hypertension?
2) What is the association between HRV biofeedback (HRVBF) and hypertension?

Do people with decreased HRV biofeedback have a higher propensity for hypertension?

Keywords: *Heart rate variability, Heart rate variability biofeedback, hypertension, vascular tone, heart rate, baroreflex system.*

Introduction

Many researchers have highlighted the positive impacts of heart rate variability biofeedback (HRVFB), as a mind-body medicine modality, heart rate variability (HRV) on the cardiovascular systems, hypertension, and other medical disorders [1, 3, 6, 9, 10, 11, 12, 13, 14, 15, 18, 19, 24, 25, 27, 28, 31]. Despite its benefits, HRVBF calls for additional studies, due to its mechanism and outcomes [6].

In considering the questions espoused by this article, one needs to be cognizant of the parameters involved in both HRVBF, and HRV for a viable assessment of the sympathetic activities involved, and the effects of biofeedback [7]. Additionally, it is paramount to consider the effects of HRVBF based on its clinical outcomes (study design and comparison techniques with or without experimental or control group) in hypertension or varying levels of blood pressure [21]. Associated with this line of reasoning are a plethora of prospective, cohort, randomized controlled trials (RCTs), pre and post-test and review outcome studies about HRV, and HRVBF with limited sample sizes, which obscure the benefits [10,13,20 & 31].

Studies from various researchers [4,5,19,25,24,28 & 29], appear to be the exceptions. While the noted concerns are presented, it is noteworthy to agree that detected changes in blood pressure are also possible through the pressure receptors, or baroreflexes in the great carotid arteries, and the aorta sensing changes that trigger reflex responses leading to an adjustment in heart rate (HR), vascular tone (VT), and blood pressure [28].

Baroreflex System

The baroreflex system is a broad component of blood pressure (BP) control. The first assertion is that the baroreflex system (BR) for blood pressure control is a more precise example of two interconnected closed loops systems: the heart rate (HR), and BP control systems, as the first [28]. The baroreflex controls blood pressure (BP) by increasing HR, when there is a decrease in BP [high HRV], and vice-versa. Respiratory sinus arrhythmia (RSA) promotes an increase in heart rate increase during inspiration, and a decrease at expiration. The second assertion relies on the vascular tone (VT) control system, and blood pressure control system. It is through these two systems that the baroreflexes project their effects on the physiological variables indicating vascular tone (VT), and blood pressure (BP recording) [28]. The results of HR on BP are automatic or mechanical, all through the effects of blood flow alterations on tension in the vessels. Many researchers have also identified the physiological mechanisms implicated in many diseases affected by HRVBF: improved autonomic control, better baroreflex sensitivity, and vagal stimulation [6,15 & 12]. The baroreflex system serves as a negative feedback system due to baroreflexes' actions. Are proposed the following hypotheses, equivalent portions of the physiological factors supporting the closed-loop model of the baroreflex, the control of HR, BP fluctuations, and vascular tone (VT) [28].

1. The participant generates HR status during biofeedback.
2. HR sinus vacillations create BP vacillations due to changes in blood flow.
3. The baroreceptors sense BP and regulate the brain towards controlling HR, and VT, leading to change in BP.
4. HR and VT are drawn from efferent nerve impulses.
5. There is interrelatedness between HR, VT, and BP spreading through the baroreflex system [17].

In the same vein that HRV biofeedback generates instant large-scale increases. In the gain, the baroreflex yields beneficial consequences for curing high blood pressure [12]. Similarly posited the beneficial effects of HRVBF occur because of the stimulation of the baroreflex, and gas exchanges in RSA [28]. This process called the "resonance frequency" protocol adopted in HRVBF has therapeutic benefits for a variety of disorders. The resonance frequency is defined as the breathing pace producing the highest HRV, quantified by the biofeedback indexes of HR Max- HR min, SDNN (standard deviation of NN intervals), and heart rate fluctuations [16].

Heart Rate Variability Biofeedback (HRVBF)

Heart rate variability biofeedback (HRVBF) is a therapeutic intervention, free of pharmacological strings, used to control the regulatory effects of autonomic cardiac regulation by increasing heart rate variability (HRV), and vagal influence. It allows an individual to restore cardiac vagal control and change the variability and prevailing rhythms in the heart activity [5, 18]. Vagal control is the influence of the vagus nerve on cardiac management. A real-time, moment-to-moment electronic feedback is in place allowing an individual to produce changes and increased rates in HRV [17]. Credible research has shown its efficacy in hypertension, and an expanding number of other disorders [15].

HRVBF Training

HRVBF training consists of snowballing the total amount of HRV in a precise frequency array. The HRVBF training considers HRV frequency ranges to concentrate on increasing heart rate. Two key factors in HRVBF training are respiratory sinus arrhythmia (RSA), and HRV. RSA is the most noticeable factor of HRV. RSA implies a decreasing heart rate flow across respiratory patterns [1]. HRV is a moment in time between heart rate, termed the RR intervals, and a decent approach to identifying the gravity of hypertension, and other cardiovascular issues**.** HRV has measuring features on two statistical domains: a) the time domain analysis [19].

Time domain analysis implies the variability of contiguous normal RR intervals over some time. The different measures of HRV are:

1) The mean normal-to-normal R-R interval

2) The standard deviation of RR intervals during a period: SDN

3) The root mean square of successive differences between R-R intervals during a period of time (rMSSD). SDNN (standard deviation of NN intervals) signifies complete variability, and rMSSD calculates the variations in the autonomic nervous system

functions. The mean R-R interval measures the totality of the levels of parasympathetic and sympathetic effects [25].

b) The frequency-domain methods of HRV. The domain ranges espoused by many researchers [18,19] are:

VLF: very low-frequency power (0.003-0.004Hz) LF: low-frequency power (0.04-0.15Hz)

HF: high-frequency power (0.15-0.40 Hz) VHF: very high-frequency power (0.40-0.50Hz) TP: total power

Low-frequency power/high-frequency power (LF/HF)

As elucidated, high-frequency power is attributed to vagal adjustment function, RSA, highest changes in respiratory rates, whereas lesser frequency potential is associated with pressure reflex control in the autonomic nervous system sinus node [19]. Moss adds that it seems ideal to increase heart rate change in the low-frequency range. The aim is to increase the percentage of complete heart rate change plummeting in the LF range [18]. Correlating with the spectral analysis, he associated the frequency ranges with biological changes from high frequency to ultra-low frequency, and there are parasympathetic trails, impacts of BP rhythms on the heart, sympathetic stimulations, and slower biological results [18].

HRVBF Training Process

The process consists of breathing for 5- 6 breaths per minute by a respiratory biofeedback device and an abdominal band measuring enlargement and retrenchment of the abdomen while breathing, permitting the baroreflexes and the breath to be synchronized, and producing a precise pattern of HRV. In HRVBF training, and HRV, two key components are paramount to consider:

1. Increased heart variability based on frequency ranges.

   Direct heart rate directions through "spectral analysis" [18].

Spectral analysis exposed the constituent rhythms that produce the full rhythm of the heart activity indicators [5]

After the breathing segments halt, an assessment of the breathing patterns is done, and breathing is repeated with cycles of pauses. Based on the established biofeedback manuals [12], a necessary primary resonance frequency (RF) assessment before the breathing procedure is done, then a treatment protocol is followed thereafter [15]. During the treatment, the biofeedback manual training requires the clinician to position the patient to the HRVBF equipment, refine the RF assessment, then reviews RF breathing episodes, focusing on the abdominal breathing patterns, and ask the patient to use breathing with a pacer, allowing self-regulation on skills to counteract the symptoms [16, 15].

Heart Rate Variability (HRV)

Several authors advance that HRV is the variability occurring in heartbeats interval reflecting the autonomic nervous system (ANS) action. Others advanced that HRV is a measurable balance between sympathetic and parasympathetic tones, and is used as a marker for cardiac health, and foreseeing cardiovascular outcomes [19]. Accordingly, heart rate variability is the difference within the cardiac cycle between heart rates [18]. It is an index for morbidity and wellness [15]. Lehrer considers HRV as a biomarker of health, and questioned whether HRV has become "the snake oil of biofeedback" [5, 12].

In assessing HRV, it is plausible to realize that there is a strong interdependence between HRV and HRVBF. The use of ECG for the analysis of HRV is a common tool in assessing HRV, blood pressure, and hypertension, and sensors detecting heartbeats, based on blood pressure measurements (oscillographic), optical pulse oximetry, and photoplethysmography [23,29]. Photoplethysmography is an optical device that detects blood volume changes in the microvascular bed under the skin.

The degree of HRV assessment seems to rely on the heart rates, and cardiac variability results, from the sympathetic nervous systems (SNS) control in the short- term, through the baroreflex control, RSA, and the vagus nerve [5].

The inherent HRV levels of measurements in the time and frequency domains signaled in the previous section of this article show that the interdependence between HRVBF is important to tackle physiological and mechanical mechanisms associated with a disease continuum. In the time domain, the standard deviation of normal-to-normal R-R interval (SDNN) involves both sympathetic and parasympathetic activities of HR. The root mean square of successive R-R interval difference (rMSSD) suggests parasympathetic activity [5,25]. High frequency (HF: 0.15-0.40 Hz), and low frequency (LF: 0.04-0.15Hz) seem to be linked with physiological processes. Heart rate variability (HRV) is affected by various cardiovascular risks, including hypertension, and research inquiries disclosed that weakened HRV is associated with renal organs [19]. Numerous studies have also focused on the association between HRV, and HTN period opined that HRV appears across a broad spectrum of blood pressure, and lower HRV was linked with elevated blood pressure in a cohort study of 3577 individuals at baseline [19, 25]. Moreover, heart rate variability is important in identifying people at risk of developing hypertension [9].

HTN, HRVBF, and HRV

As the leading cause of death in the world [30], hypertension is one of the most chronic health problems associated with concomitant diseases [19]. The seventh report of the Joint National Commission on prevention, detection, and treatment of hypertension guidelines [20], classified blood pressure based on stage, systolic and diastolic values, in mmHg.

Normal BP is a <120 systolic, and <80 diastolic BP. Pre-hypertension is 120-138 systolic BP or 80-89 diastolic BP.

Stage I is 140-159 systolic BP or 90-99 diastolic BP. Stage II is >159 systolic BP or >99 diastolic BP.

This classification is necessary to assert and measure the effectiveness of HRVBF interventions, and HRV because behavioral interventions can facilitate BP reduction in hypertensive individuals. In a pre-posttest study design study about nurse-led home-based biofeedback of 173 patients [4], the researchers conclude that the use of home-based biofeedback offers positive results in reducing blood pressure in hypertensive patients.

Additionally, there is a considerable frame of evidence in agreement with non-pharmacological interventions in the management of hypertension [4]. Data also suggest that breathing exercises are efficient modalities in the management of hypertension when coupled with bio feedback, and relaxation therapies in hypertension seem to suggest parasympathetic control, which can lead to decreased blood pressure [14]. Since the Framingham cohort study [25], the literature on HRVBF with significant sample sizes appeared to be scant [6]. Considering the promise of heart rate variability biofeedback (HRVBF), one can assert that the use of biofeedback is a recognized reality in treating hypertension. Hypertensive individuals can take control of their autonomic functions through biofeedback relaxation training, as a form of behavioral therapy to respond to stressors [20]. An additional review of the literature indicates that biofeedback training may be advantageous to the treatment of essential hypertension and decrease in systolic pressure during HRVBF training sessions may lead to higher expectations [7].

Other researchers describe HRV as a model of numerous frequency elements from high frequency (HF) rhythm of 0.15-0.4 Hz, usually corresponding to respiration, and low frequency (LF) rhythm between 0.05-0.15 Hz, related to BP fluctuations (Task Force of the European Society of Cardiology and the North American Society of Racing and Electrophysiology Task Force [28]. HRV has been evaluated as a predictor of hypertension, and recreation techniques can lead to elevated HRV, but the limitation of HRV measurement and the relationship between hypertension are salient [27]. Monitoring HRV is a viable alternative option for hypertension [19]. In persons with increased blood pressure, there is an aptitude to improve the total power of the heart rate variability (HRV) continuum through HRVBF for vagal cardiovascular management claim [21]. While analysis of the HRV power spectrum accounts for some physiological mechanisms [5], there are environmental factors that also play crucial roles in the progress of hypertension [29]. The utilization of biofeedback with HRV produces better control of heart rate, systolic, and diastolic blood pressure, and progress in HRV indicators, [10, 26], and others argued for RSA inclusion in any HRV analysis, as a component of HRV.

The Research Questions Continuum

Consistent with the quality of the literature search or the systematic reviews, and considerations that HRVBF and HRV have a mutual standing stance, elucidations of the research questions expose the realm of their viability. The satisfaction or non-satisfaction of the research questions is based solely on systematic reviews, not statistical correlational relationships. However, the possibility for further statistical analysis is beyond the scope of this article. The search for a correlated stance is the product of the studies considered.

Research Question 1 (RQ1). Is HRV biofeedback important in detecting individuals with a higher propensity for Hypertension?

Although heart rate variability (HRV), and vagal influence are essential pillars of HRVBF, the literature does not necessarily imply that HRV biofeedback (HRVBF) can help identify individuals with higher risks of hypertension [25, 29]. The reason, despite the autonomic nervous system's involvement in the regulation of blood pressure, is the temporal sequence linking hypertension and HRV is unclear [24, 25]. Further explanation that the association between HRV, and incident hypertension warrants investigations. However, another study concluded that HRV may be essential in identifying individuals at higher risk of hypertension [9]. Other studies have reported unaltered heart rate variability among hypertensive patients [29]. It can also be argued that because changes in HRV occur at a low-frequency due to the resonance effect, which varies between different individuals [28], the influence of HRVBF on detecting individuals with a higher risk of hypertension cannot be easily assessed. Nonetheless others, advanced that HRVBF achieved a significant reduction in BP. The clinical significance is paramount [22]. Thus, RQ1 does not appear to be conclusive.

Research Question 2 (RQ2). What is the association between HRV biofeedback and Hypertension?

Many studies have highlighted the association between HRV biofeedback and hypertension [4,5,7,13,14 & 19]. The efficacy of biofeedback-assisted breathing relaxation interventions on blood pressure of hypertensive patients, pre and post-tests showed that HRVBF was exceedingly significant in the systolic limit with $p < 0.001$ [4]. Using a randomized controlled trial of 65 patients with recorded BP, researchers concluded that HRVBF was effective in reducing a 24-hour systolic BP [5]. The conclusions in the considered studies show that HRVBF biofeedback training yielded significant decreases in systolic pressure during periods, diastolic pressure between sessions, and in patients with distinct severity of hypertension [7, 19]. Prior studies showed that treating high blood pressure with HRVBF as a single modality or with a fusion of other therapies has been effective [23]. A positive association between HRVBF and hypertension exists.

Research Question 3 (RQ3). Do individuals with decreased HRV biofeedback have an increased risk for hypertension?

The assertion, that HRV appears across a broad spectrum of blood pressure, and lower HRV was associated with higher blood pressure in a cohort study of 3577 individuals at baseline, infers a positive answer [25]. But the notion of decreased HRVBF does not appear to be achievable because HRVBF therapy encompasses so many modalities to choose from thermal, electromyographic biofeedback (EMG), electrodermal activity (EDA), blood pressure, pulse waves, RSA, etc. [32]. Biofeedback for hypertension is usually offered as a package (Health and Public Policy Committee) [8]. It would be asinine not to determine the type of modality involved. Thus far, the literature surveyed posited heart rate variability biofeedback under a wide lens of scholarly inquiry, and very few limited studies have alleged the types of HRVBF modalities [2, 23] RQ3 is inconclusive.

Heart Rate Variability Biofeedback and HRV Assessment

The problems with HRVBF reside in its efficacy, the small sample sizes considered in the studies surveyed and evaluated, and the lack of replication with limitations of statistical significance [32]. The efficacy of biofeedback was assessed by comparing systolic and diastolic blood pressure values, HR, and HRV indices, indicators of optimal (O), and sensitivity (S) among different patients [10]. Biofeedback with HRV was instrumental for achieving better HR control, diastolic and systolic blood pressure, and HRV improvement indices [10]. However, the replication of such a study can be problematic [2, 3]. Eckberg argued that respiratory sinus arrhythmia (RSA) is autonomous of blood pressure fluctuations [3]. Furthermore, in the studies considered, it appears evident that the results of HRV in the frequency domain were excessively interpreted to ascertain vagal control, exemplified in the domain as HF or LF realms.

Conclusion

The systematic reviews presented in this article emphasize the viability of HRVBF, HRV, and hypertension. One of the research questions exhibited in conclusiveness in the association of HRVBF, hypertension, and individuals at risk. The systematic analysis suggests a possible correlated stance, which can be the inquiry of further quantitative research. There are fundamental problems in assessing the efficacy of biofeedback, related to unstandardized treatments, insufficient sample size, lack of replication, clinical significance, and unreported clinically relevant outcomes in many of the studies. Despite these shortcomings, HRVBF, shows a positive stance on hypertension. Further research on heart rate variability biofeedback (HRVBF) is needed.

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