Review Article

Link between Yoga and Heart Rate Variability: Can Yoga Enhance the Cardiac Resonance

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Abstract

Cardiac resonance is a complicated phenomenon involving the coordinated oscillations of numerous circulatory system components, such as electrical activity, contraction and relaxation, and blood flow. It is critical for the normal functioning of the heart and for maintaining blood flow throughout the body. Cardiac resonance is defined as a series of tiny waves produced by the heartbeat and overlaid on flow data and airway pressures. A variety of technologies, including cardiac magnetic resonance (CMR) imaging, can be used to identify these waves. CMR is a strong noninvasive method for seeing and quantifying heart anatomy and function in great detail. CMR can be used to assess cardiac resonance in both healthy and heart disease patients. A regular and coordinated pattern of oscillations characterizes cardiac resonance in healthy persons. In patients with heart illness, however, cardiac resonance can be interrupted, resulting in diminished cardiac function and decreased blood flow. The intricate role of cardiac resonance in cardiac health and disease is continuously being studied by researchers. However, it is obvious that cardiac resonance is an exciting area of research that has the potential to change the way to identify and treat heart illness. Yoga is a mind–body practice that has been demonstrated to have numerous cardiovascular health advantages, such as improved heart function, reduced inflammation, and lower blood pressure. Yoga is hypothesized to promote cardiac resonance by encouraging coordinated oscillations of numerous cardiovascular system components. Various researches have shown buoyant results such as yoga can be helpful in improving heart rate variability, cardiac resonance and reducing arterial stiffness. Stress can disrupt cardiac resonance and increase the risk of heart disease. More research is needed to completely understand the mechanisms that impact cardiac resonance and the long-term advantages of yoga for heart health.

Keywords: *Cardiac magnetic resonance, cardiac resonance, cardiovascular disease, heart rate variability, mind–body intervention, yoga*

Introduction

The term resonance system refers to a system that, when stimulated, produces oscillations of single frequencies with large amplitudes to generate sine wave oscillations of large amplitudes.[1] As far as the control of circulation is concerned, feedback systems are primarily responsible, such as baroreflex control, which can be characterized as an output signal based on the RR interval and an input signal based on the systolic blood pressure (BP).[2] Feedback control system is stable when there is no delay between two physiological processes however oscillation starts when there are delays which cause resonance at particular frequency.[3] A constant delay oscillation feedback system is based on the principle that all oscillation feedback systems have resonance properties. There is a vibration or oscillation occurring in each organ of the human body that can be equated to resonance. As with any living organism, resonance is abundant in the human body as well as in nature and it is important for every living or nonliving being to have a peculiar resonance frequency (RF) or oscillation in order to function properly.

Resonance in the heart which regulate heart rate (HR), contraction, relaxation and pumping action of the heart maintaining blood flow through coronary vessels. In essence, cardiac resonance phenomenon, also known as cardiogenic oscillation, which is a set of small waves produced by the heartbeat, which is then superimposed on flow signals and airway

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pressures.[4] Cardiac resonance is said to occur at 0.1 Hz or at 0.02–0.03 Hz and is affected by height and sex of person but not by age and weight.[5] The heart does not behave just as a metronome, but HR shows oscillation which depends on various parameters. These oscillations in the heart are called heart rate variability (HRV) and it reflects the health of the heart and it can be used as a monitoring tool for various clinical conditions associated with cardiac and autonomic nervous system (ANS).[6] Short- and long-term variability in these oscillations or HR is associated with vagal and sympathetic function of ANS. Frequent alteration in HRV is associated with various cardiac illnesses. Increased baseline HR and loss of HRV are associated with poor health.[7] In the same way that muscular exercise stimulates the reflexes of the somatic nervous system, HRV produces high-amplitude oscillations in the cardiovascular system. These oscillations are responsible for enhancing the efficiency of the automatic reflexes (e.g., baroreflexes).[8] Heartbeats transfer mechanical energy from the heart to the lungs, which enhances intrapulmonary gas mixing. Local mechanical disturbances induced by the heartbeats may have an impact on respiratory mechanics in relation to the heart-lung coupling. By virtue of their close proximity, the heart naturally oscillates the lung.[9] Therefore, both organs are affected by each other's behavior. Baroreflex closed system control the HR and BP in relation to each other. During increased BP, baroreflex triggers HR to decrease, whereas during decreased BP, HR is triggered to be increased to balance both the physiological processes.[10] In this paper, we are trying to explain in detail how different types of yogic breathing and meditation are helpful in maintaining cardiac resonance. In various studies, it has been observed that slow breathing activates the parasympathetic nervous system (PNS) and also stimulates distinct autonomic nerve system branches, which impact skin resistance, metabolism, and oxygen intake. It has been demonstrated that any tranquilizing breathing or alternate nostril breathing through the right, left, and both nostrils raise baseline oxygen consumption, which is suggestive of sympathetic discharge of the adrenal medulla. On the other hand, it has been demonstrated that inhaling through the left nostril increases volar galvanic skin resistance, which is interpreted as a decrease in sympathetic nerve activity.[11] While nostril breathing and breathing exercises can modify the ANS, further investigation is needed to completely comprehend their therapeutic advantages.

Variables of Cardiac Resonance

The resonance property of the coronary artery has been implicated in the development of coronary artery atherosclerosis. Unequal distribution of atherosclerosis has led to the hypothesis of involvement of biomechanical factors too.[12] There are very limited studies in this field but what is known is that the cardiovascular baroreflex system also has resonant property; Coronary blood vessels contract and relax as per external stimuli, thus showing resonant characteristics. HRV is the variation of time period between two consecutive beats and is one of the most studied parameters of cardiac resonance. HRV is the ability of the heart to adapt to varying demands due to external stimuli. It is one of the important parameters to test ANS. Normal variability of HRV depends on sympathetic and PNS, which also controls baseline HR. Thus, HR and HRV are interrelated and vary in supine and standing posture.[13] HRV has an important role in diabetic patients and in patients of postmyocardial infarction patients. The physiological origins of HRV are the fluctuations of the activity of cardiovascular vasoconstrictor and vasodilator centers in the brain. Normally, these fluctuations are a result of BP oscillation (baroreflex modulated), respiration, thermoregulation, and circadian biorhythm. All these factors can influence the length of beat-to-beat intervals, named R-R intervals.[14] There are several methods to estimate HRV and has been easier these days with the developments of newer software and computer technologies. Analysis of HRV can be done using different domain such as frequency domain analysis, statistical, geometric, and nonlinear parameters. The statistical method used RR interval (mean and variance) HRV. Time domain analysis commonly includes SDNN, average HR, SENN, SDSD, RMSSD, NN50, and PNN 50% [Figure 1].[15]

For sympathetic and parasympathetic system contribution for HRV frequency domain analysis is better. Very low frequency (VLF), low frequency (LF), high frequency (HF), ratio of LF/HF common parameters in frequency domain analysis and these are best parameter for ANS system analysis. VLF is mediated by sympathetic nervous system (SNS) activity. HF is associated with activity of PNS, LF primarily indicates SNS also partly indicate PNS. Their ratio indicates sympathovagal balance.[16] Newer nonlinear methods have been added like Lyapunov exponents, i/f slope, approximate entropy, detrended fluctuation analysis.[17] HR is an independent risk factor for cardiovascular death in cardiac patients. HRV and HR are interrelated, HRV depends on average HR and its variability.[18] It is still unclear that how much HR or variability in HR has an impact on HRV. There is a mathematical and physiological association between HRV and HR depending on the relationship between RR interval and HR and autonomic control of the heart, respectively. It is observed that if HRV is dependent on HR, it is more predictive for cardiovascular outcome, and if dependence of HRV is less than HR, it is more predictive of noncardiac disease outcomes. HR also has an impact on HRV reproducibility; hence, HR should be kept in mind when comparing HRV in any patient. It is possible to remove the impact of HR on HRV and also it is possible to enhance the HR impact on HRV.[19]

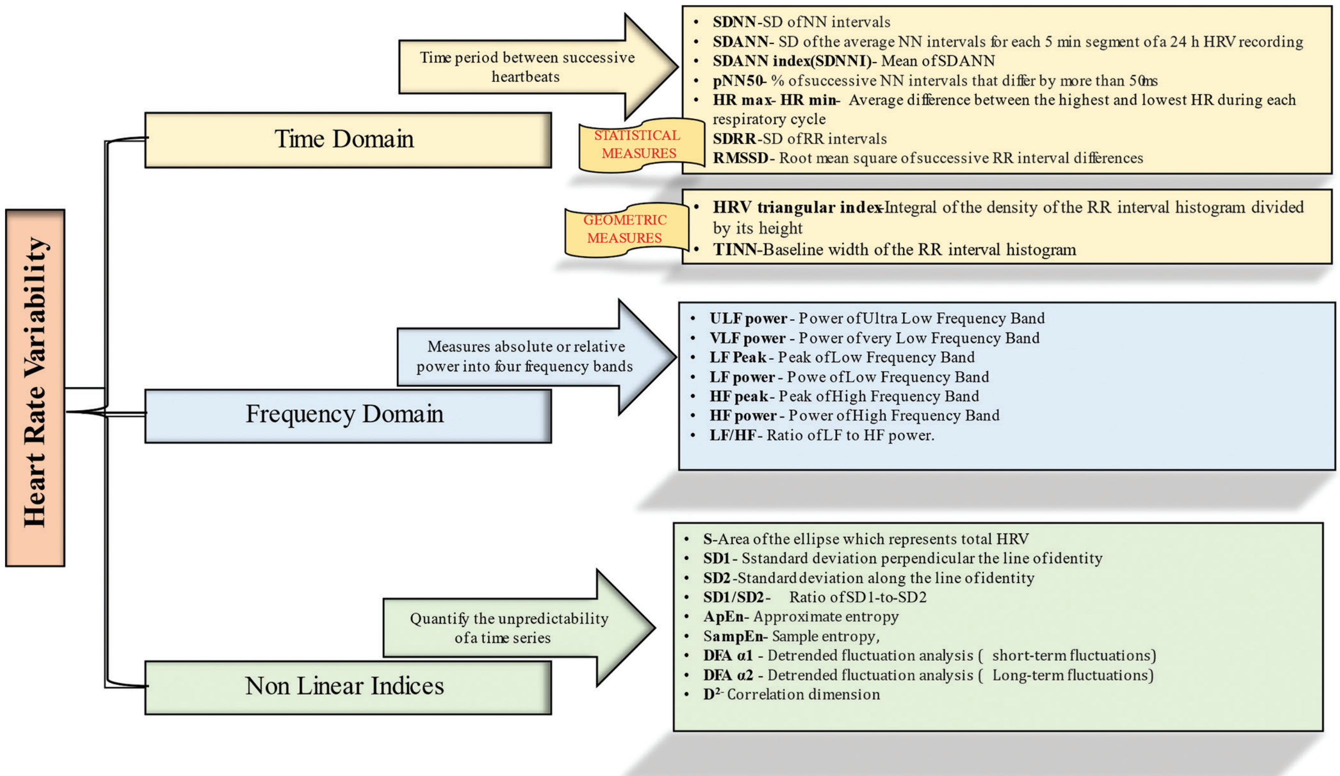

Figure 1: Domains of Heart Rate Variability

Cardiac Resonance and Various Diseases

HRV is altered in various conditions such as hypertension, diabetes, postmyocardial infarction states, and psychiatric illness. Other factors which affect HRV are neurological issues, drugs, etc., Traditional as well as nonlinear HRV alteration is associated with mortality in postmyocardial infarction patients.[20] HRV is depressed in patients with chronic heart failure and also shows a positive correlation with the New York Heart Association class, lower left ventricular ejection fraction, and the presence of ventricular tachycardia in patients with heart failure.[21] Acute decompensation of congestive heart failure further reduces HRV measures and baroreceptor sensitivity,[22] In coronary ectasia also, time domain indexes are reduced due to changes in vagal and autonomic tone.[23] Besides alteration in various cardiac disease states, HRV has been proposed for cardiac risk assessment in low-to-intermediate risk patients.[24] In their study, a new HRV parameter DyDx was developed after 1 h of Holter monitoring and from detrended RR time series using different multipoles. HeartTrends DyDx algorithm is a novel digital-health modality for enhanced detection of myocardial ischemia in patients without known coronary artery disease (CAD). It has been observed that the frequency of myocardial ischemia was significantly higher among patients with low HRV (11%) as compared with those with high HRV. Accordingly, they showed that low HRV was associated with a sensitivity of 71% for the detection of myocardial ischemia, a specificity of 60%, a positive predictive value of 11%, and a negative predictive value of 97%. Studies done on rats suggested that sinoaortic denervation leading to impairment of baroreflex sensitivity decreases HRV in myocardial infarction, and also leads to worse cardiac remodeling and increased mortality.[25] There is an alteration in cardiac autonomic regulation even in patients with asymptomatic atherosclerosis.[26] In stable ischemic heart disease, HRV is significantly reduced and there is a positive correlation between reduced HR recovery and severity of coronary lesions.[27] Reviews of studies also showed that lower time domain parameter of HRV and high LH/HF ratio is associated with a higher risk of mortality even in patients with postcoronary stenting,[28] HRV risk score of >4 is associated with increased acute complication in patients presenting with chest pain in the emergency department. HRV risk score includes HR, SBP, respiratory rate, and LF/HF ratio. This score predicts outcome better than ST/T changes and troponin levels.[29] However, HRV alteration is not a marker of LV systolic dysfunction.[30] Alteration in HRV on dynamic electrocardiogram in acute MI patients is associated with an increased incidence of VF.[31] In post-MI patients with intraventricular conduction abnormalities, there is a reduction in LF power and increased power and number of peaks in HF range in frequency power spectrum in QRS frequency profile.[32] A rare cardiac arrhythmia known as Brugada syndrome is defined as prolonged ST-segment elevation in the right precordial leads and electrocardiographic right bundle branch block. This condition is linked to ventricular fibrillation and an increased risk of sudden cardiac mortality, primarily in younger guys with hearts that are anatomically normal. In a study, it was discovered that Brugada syndrome is linked to breathing disorders during sleep rather than impaired cardiac autonomic regulation. It is linked to a lack of cardiac autonomic regulation.[33] In diabetic patients, cardiac autonomic neuropathy is best improved by post exercise HRV parameters then resting HRV parameters.[34] In patients of metabolic syndrome, only the presence of prediabetes is associated with altered parameters of HRV and HR turbulence like SDNN, SDNN index, SDANNN, RMSSD, pNN50, turbulence onset, and turbulence slope.[35] This study shown that yoga practitioners have a greater homeostatic capacity and autonomic, metabolic and physiological resilience as compared to non-yoga practitioner.[36] Indian Asians have low cardiovascular autonomic function as compared to European descent due to higher blood glucose levels [Figure 2].[37]

Resonance Respiration and Heart Rate Variability

Breathing has a great influence on HR and HRV. During inhalation, HR increases, and during exhalation, HR decreases because of changes in vagal tone during respiration.[38] Respiratory sinus arrhythmia (RSA) is the variation in HR with respiratory phases and represents hemostatic reserve capacity and is mediated by the vagus nerve. Slow respiration is associated with higher HRV. RSA reflects cardiopulmonary interaction and is a measure of parasympathetic cardiac control.[39] For measurement of RSA cardiopulmonary resonance indices such as resonance amplitude, bandwidth and quality factors has been proposed.[40] For optimum HR, HRV and cardiac functioning RF for each individual should be measured and breathing should be matched to RF. However, RF is not static in an individual, varies day to day, and also can be modified with various training.[41] Biofeedback training consists of feeding back beat-by-beat HR data during slow breathing maneuvers, such that the participant tries to maximize RSA, create a sine-wave-like curve of peaks and valleys, and match RSA to HR patterns. During HRV biofeedback, the amplitude of HR oscillations grows too many times the amplitude at rest, while the pattern becomes simple and sinusoidal. This pattern occurs in almost everyone and is often achievable within a fraction of a minute even in persons who have never previously been exposed to the technique. A study has reported that when RSA (or the parasympathetic dominance) could be created at will by breathing exercises (like in biofeedback training), the physiological impacts exerted by yoga could also be attained intermittently even by inexperienced subjects without a need for a special long-term training. The mechanism for this effect lies in a confluence of processes: (1) phase relationships between HR oscillations and breathing at specific frequencies, (2) phase relationships between HR and BP oscillations at specific frequencies, (3) activity of the baroreflex, and (4) resonance characteristics of the cardiovascular system. When a person breathes at their identified RF breathing rate, HR and breathing become synchronized and the highest levels of HRV are typically obtained.[42] At about 6 breaths per min, HR and breathing become resonance. Every individual has their own RF which varies from 4.5 to 7 breaths per min; in studies, the most common RF breathing is 5.5 BPM. RF breathing also impacts vascular tone, and RF breathing decreases BP and reduces BP response during stress. Interestingly, this can be observed even with one 15-min session of RF breathing.[43]

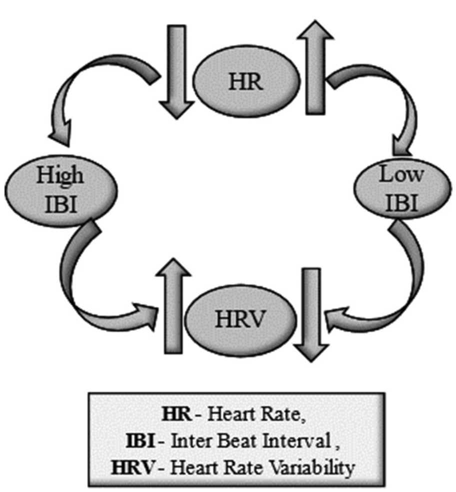

Figure 2: Mechanism of HRV

Yoga and Heart Rate Variability

Yoga is a combination of physical postures and regulated breathing, which is known to provide physical and mental wellness for practicing individuals.[44] Regulated HR is one of the major physiological parameters of physical fitness and its tendency to affect the nervous system which links it to mental well-being also. Two main constituents of the nervous system are sympathetic nervous system(SNS) and Parasympathetic nervous system(PNS). Increased or decreased HR activates respective component of the nervous system (SNS/PNS) and contributes to the fluctuating HR which affects the HRV. SNS dominance regulates the fight or flight response while PNS activates rest or digest response. For maximum well-being, only 20% of SNS dominance is required and 80% should be PNS dominance. Different components of HRV which are described in this article are measures of good and poor health and many cardiovascular associated morbidities. In contrast to that, raised HRV is a measure of good health. HRV is a noninvasive assessment of cardiac autonomic tone which quantify the beat-to-beat variation.[45] Stress and Incoherent breathing increase the SNS dominance and reduce the HRV by increasing HR, however relaxation and coherent breathing decrease the HR, increase the HRV and activate the PNS which is an indicator or good health. Besides that the synchronisation of Parasympathetic dominance , low HR, and increased magnitude of breathing oscillations, i.e. synchronicity of HRV with respiration is termed as RSA which increase after relaxation techniques.[46] The presence of RSA patterns in the HR time series is ensured to enhance pulmonary gas exchange and baroreflex sensitivity (BRS).[47] BRS basically stands for Baroreflex sensitivity, Variations in the baroreceptor-heart rate reflex (baroreflex sensitivity, BRS) are linked to the inverse decrease in parasympathetic activity and corresponding elevation in sympathetic activity that coincide with the onset and advancement of cardiovascular disorders. Consequently, baroreflex assessment provides useful information for risk stratification and other clinical management aspects of patients with heart disease. In a study on middle-aged women, common frequency domains of HRV such as LF, HF (indicators of sympathovagal balance), and LF/HF ratio (vagal activity) were found to be improved after yogic practices, which indicates that yogic practice maintains sympathovagal balance and is associated with low vagal activation.[48]

Breathing is a fundamental strategy in eliciting physiologically significant changes in HRV. Pranayama, one major component of yoga regulates breathing patterns by controlling breath in different styles for different periods of time. Low-frequency controlled breathing (<12 cpm) and the internal mechanisms associated with yogic methods are quite related to each other. Usually, we breathe in HF (>12 cpm) which makes SNS dominant and exhibit relatively weak RSA and HRV parameters variations become insignificant.[49] The sensitivity of the objective parameters of HRV to respiration (or parasympathetic dominance) has been discussed in a few reports.[46] As per physiological perspective, an increase in RSA exerts a favorable impact on pulmonary gas exchange by keeping tidal volume and the breathing frequency constant. Yogic methods of controlled breathing make use of these physiological gains by breathing at lower rates and dictate their internal breath control paradigm. There are different methods which can be used to achieve breath control, and these methods include rosary prayer,[46] Ave Maria,[50] and Om mantra chanting.[51] Along with controlled breathing, attention is also an important part of some of the yogic traditional techniques such as Trataka and Dharna. Cognitive attention is also associated with some of the tasks which are part of yogic practice and can be detected using HRV. Spectral components of HRV involved in cognitive tasks have been recognized in earlier studies. Increased cognition level reduces cardio-respiratory coupling, i.e. RSA orderliness measured by HRV.[52]

Respiratory modalities such as tidal volume, respiratory rate, airflow pattern, recruitment profile of respiratory muscles, etc., get influenced either in an inhibitory or excitatory way by behavioral reflexes of the central nervous system (CNS).[43] Yogic methods of breathing retention are not voluntary, but it could be invoked by focused attention on breathing pattern. Attention is a strategy that demands long-term practice. All aspects of yoga, such as asanas, pranayama, and meditation, provide a guiding mechanism which might help in regulating the breathing pattern and achieving attention which ultimately improve breathing pattern in longer time period. Practicing these techniques for regulated breathing benefits practitioners to achieve long-term health.[53]

Cardiac Resonance and Possible Mechanism of Yoga

Yoga is a traditional form of practice that combines various poses and breathing techniques to help practitioners enter a contemplative state. Although yoga is thought to have originated about 5000 BC, clinical applications of yoga and other comparable alternative therapies have only lately been examined in the framework of contemporary medicine. Till now, a possible mechanism in different clinical conditions is missing and unexplained. For, cardiac resonance and yoga the scientific as well as daily languages available for its description are profoundly limited. For instance, vagal tone which is often measured by HRV can be altered by acupuncture, transcendental, Zen, and several types of meditation and breathing techniques used in yoga.[46,54,55] In another study, they have shown that the efferent parts of the vagal nerve complex are essential for controlling the body's inflammatory response to viral disease. Through acetylcholine binding to the alpha-7 nicotinic receptors on activated macrophages and other cytokine-producing cells, it modulates forms of physical trauma and psychosocial stress by altering nuclear factor-kappa B, a crucial regulator of the cerebral amyloid angiopathy (CCA) network among many other pathways.[56,57] A study done by Goldstein *et al*. shows the neurophysiologic model of pranayama. They have observed that the neuroendocrine and immunological systems generate a similar repertoire of peptide and nonpeptide neurotransmitters and cytokines that interact with the same receptors in both systems.[58] The immune system can operate as a sensory organ due to the whole biochemical information circuit between neurons and immune cells which shows that humoral factors and nerve signaling are two transduction routes that are connected. According to recent reports, oxytocin, a basic neurohypophyseal hormone thought to modulate social bonding and lactation, directly regulates bone mass. Furthermore, certain cytokines are expressed in the hypothalamus, which helps to activate intracellular inflammatory signal transduction. Another example comes from Brown and Gerbarg, who discuss the effects of yogic breathing techniques on physiologic reactions to stress and the maintenance of stabilization of baseline functioning. These techniques include aspects of breath holding, laryngeal contracture, inspiration against airway resistance, and prolonged expiration against airway resistance. They achieve this through a combination of efferent and afferent vagal activity (which modifies CNS behaviors), as well as through improvements in baroreflex sensitivity and a decrease in chemoreflex sensitivity.[54,59] An increasing amount of research demonstrates the advantages of yoga when used in conjunction with traditional treatments for a wide range of medical diseases, such as atrial fibrillation, heart failure, chronic pain, and orthopedic problems, among many others.

Atrial arrhythmias are initiated and maintained in part by the ANS. More rigorous research is needed in this field by doing more clinical trials and multicentric studies.

Resonance Breathing Techniques

Natural tendency of human being is to breathe at the rate of 20–40 breaths per min, which is referred as incoherent breathing which implies to reduce HRV and SNS dominance. Resonance or coherence breathing refers to the taking long and slow breath (using different breathing techniques), usually 5 breaths per min. Regular practice of coherence breathing is associated with many benefits such as improved sleep quality, more vital energy, increased performance and reduced pain. There are different coherence breathing techniques in yogic system which are being practiced from years to get control over breathing pattern and HR. Table 1 describes few studies and their impact on different parameters of HRV. Some of them are described in this article with evidence from studies that have been conducted on the effect of these practices.

Bhramari pranayama is one of the resonant breathing techniques which involve the production of humming bee sound and during the practice of *bhramari*, increased HR and LF band of HRV and reduced HF band of HRV has been reported which returned to the normal range after practice.[65] Several studies have been already conducted which show the multifaceted benefits of *Bharamri pranayama*. It is effective in balancing the sympathovagal tone,[66] shift in cardiac autonomic modulation towards parasympathetic predominance,[67] reduces the risk of infection, enhances autonomic function, and improves sleep quality in healthy individuals.[68] It is also helpful in reducing stress, anxiety, and burnout in corporate culture. These practices are able to benefit practitioners in both shorter and longer term but for achieving longer term health benefits, regular practice is required.

Alternate nostril breathing (*Anulom Vilom*/*Nadisodhan Pranayama*)**,** another yogic breathing technique in yoga which involves inhalation from one nostril and exhalation from the other nostril, leads to a significant increase in standard deviation of all NN intervals, LF component, LF/HF ratio and significant decrease in HF component, which implies to significant increase in cardiovascular oscillations and baroreflex augmentation, so directly related to decreased frequency of cardiac, neurological and hypertensive disorders. The effect of this technique persisted even after practice as reported by Nivethitha *et al*.[66] In all yoga practices such as mediation, relaxation, yogic breathing, or integrated yoga practices, vagal dominance is observed during and after yogic practices. Also, it is observed that vagal tone is increased in yoga practitioners than in subjects who practice aerobic exercise.[67] Breathing practice in yoga involves various breathing patterns with frequent ranging from <1 BPM to more than 120 BPM. These patterns can have a significant effect on HRV and RSA. Kapalbahti breathing at 120 or 60 BPM decreases vagal activity both in time and frequency domain. On the contrary, slow breathing increases HR fluctuation in LF band. Some slow breathing can increase HR. This can be explained by the fact that slow breathing is an active process with more attention and increased metabolic rate, meditation is a passive process with reduced attention and lesser metabolic rate.[68]

Sectional breathing and yogic breathing

Sectional breathing is part of yogic breathing which consists of two parts chest breathing and abdominal breathing. In a study done by Kumaresan *et al*. have observed that when slow abdominal breathing combined with electromyographic biofeedback could reduce sympathetic activity and also could enhance vagal tone activity in prehypertension subjects.[69] Another study shows how voluntary slow breathing affected vagally mediated HRV. The average rise in multiple HRV

Table 1: Effect of breathing techniques on heart rate variability parameters and physiologic benefits

Authors and year	Breathing	Physiologic benefits	HRV parameters
Telles *et al*., 2014[60]	ANB and breath awareness	↓BR, SBP during ANB	No change in frequency, ↑RMSSD, ↑NN50 during ANB, no change in time domain
Raghavendra *et al*., 2013[61]	Breath regulation with relaxation	↓HR during relaxation with breath regulation	↑LF power, ↓HF power, ↑LF: HF ratio, ↓VLF power during both interventions
Muralikrishnan *et al*., 2012[62]	Isha yoga with deep breaths	Parasympathetic activation and vagal tone improvement	↓LF power, ↑HF power, ↑SDNN, ↑NN50, ↑pNN50 in yoga practitioners as compared to controls
Ghiya and Lee, 2012[63]	ANB and paced breathing	-	↑TF power, ↑LF power, ↑HF power
Bernardi *et al*., 2001[64]	Mantra chanting, Ave Maria Rosary	↓BR and↑BRS during both interventions	High amplitude HR oscillations in LF band during intervention
Bhaskar *et al*., 2017[50]	Long Sudarshan Kriya yoga (cyclic slow, medium and fast breaths)	↓HR following interventions	↓LF power, ↑HF power, ↓LF: HF ratio, ↑SDNN, ↑RMSSD, ↑pNN50
Nivethitha *et al*., 2017[65]	Bhramri Pranayama	SBP↓, DBP↓, MAP↓	HR LF↑HF↓

HRV: Heart rate variability, HR: Heart rate, LF: Low frequency, HF: High frequency, VLF: Very low frequency, BRS: Baroreflex sensitivity, SBP: Systolic blood pressure, ANB: Alternate nostril breathing, SDNN: Standard deviation of all NN, DBP: diastolic blood pressure, MAP: Mean arterial pressure, RMSSD: Root mean square of successive differences, BR: Baroreceptor reflex, ↑: Increasing, ↓: Decreasing indicators, particularly those indicating vagally mediated HRV, is evident in the data overall, providing evidence in favor of the proposed mechanism of intentional slow breathing on the vagus nerve. RMSSD and low frequency absolute power were found to have significantly increased.[70] Abdomen breathing is also helpful on the variability of HR in male smokers.[71] These are the few in-expensive, affordable, and easily accessible techniques which is helpful in maintaining our cardiac health.

Breathing-based meditation: A study done by Kim *et al*. shown that deep breathing, physically moving the thorax and abdomen to achieve the deepest respiration rate, can considerably boost HRV with the maintenance of mean vagal or sympathetic tone, simple breath retention can also increase HRV with less sympathetic activation.[72] In another study done by Natarajan *et al*. shown that conscious breathing results into considerable increase in the autonomic balance index.[73] Yoga may decrease HR without corresponding decrease in HRV and have positive clinical outcome. This may be due to the resonance effect of breathing and rhythmic muscle contraction during various yoga postures leading to vagal dominance and enhanced baroreflex gain.[69]

Mantra Chanting and Cardiovascular Resonance

OM chanting is one of the traditional scientific chanting. Nonpaced OM chanting dramatically improves the synchronization of breathing, HR, and systolic BP cycles. Two oscillations exist in heart period and systolic BP during one breathing cycle for breathing (chanting) frequencies of about 0.05 Hz: the first oscillation is caused during inhalation in the beginning of OM, whereas the second oscillation is not induced by respiration. This study indicated that OM chanting had a significant impact not just on breathing but also on HR and BP.[72,73] These could be used therapeutically.

Discussion

There are various evidence available in yogic aspects which show yoga is helpful in improving cardiac resonance and slow breathing is more impactful in favoring in parasympathetic tone, while kapalbhati decreases vagal tone and sensitivity of arterial baroreceptor.[60] Power yoga leads to increased HR and body temperature.[57] It is considered that slow breathing leads to stretch-induced inhibitory signals and hyperpolarizing current through neural and nonneural tissue. This leads to parasympathetic activation.[71] In another research article, *Bhastrika* leads to a significant decrease in LF component of HRV.[74] It is the first evidence that 4 weeks of *Bhramri pranayama* considerably lower the levels of anxiety and negative affect, and that these changes are connected with the modulation of activity and connections in brain areas involved in emotion processing, attention, and awareness. *Bhramri pranayama* also causes parasympathetic predominance and decreases HR.[75] Studies done by Bhavnani *et al*. show that Pranav pranayama, along with increased vagal dominance and dressed HR also increases endogenous nitric oxide production. They have also mentioned that Sukha pranayama also decreases HR even in short span of time.[76] *Mukha bhastrika* when practiced for long duration leads to beneficial cardiac autonomic activity.[77] It is also advised that slow-paced *bhastrika* also decreases HR.[73] There are limited studies available which show a correlation between cardiac resonance and yoga. In developing nations like India, we need to work more on Cardiac rehabilitation. For that, yoga can be a cost-effective tool for rehabilitation purposes in different conditions of cardiovascular diseases. The mechanism behind cardiac resonance and how yoga acts on it is lacking in scientific publications. We need more rigorous studies to support this statement that how yoga is effective in improving cardiac resonance. In future, there is need of more rigorous research including multicentric studies which includes cardiac rehabilitation, explaining mechanistic view of resonance, more molecular and animal model-based studies which will provide definite explanation behind every outcome.

Conclusion

Controlled low-frequency breathing is fundamental in delivering physiologically significant variations in HRs of yogic practitioners. Furthermore, focused attention and low-frequency breathing are co-existing inherent strategies in yogic techniques which might play an important role in psychophysiologically adapting a nonpractitioner to get trained in yoga to derive long-term physiological benefits.

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Conflicts of interest

There are no conflicts of interest.

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