Biofeedback of Heart Rate Variability in the Treatment of Chronic Diseases: A Systematic Review

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Abstract
Background: HRVB (heart rate variability biofeedback) is a non-pharmacological method for chronic diseases evaluation.
Methods: Adults chronic sufferers, HRVB as the primary therapy with or without controlled circumstances, and psycho - physiological results as regression analysis were all included in a systematic search.
Results: There were 21 publications in overall. HRVB was found to be feasible in chronic patients with no adverse reactions, according to the findings. Significant favourable impacts on hypertension and cardiovascular prognostic, inflammation condition, asthma issues, depression and anxiety, sleeping disruptions, cognitive function, and pain were reported in diverse patient characteristics that could be linked to enhanced quality of life. Increases in treatment practice were accompanied by increases in heart rate variability, implying that HRVB may have a regulatory influence on autonomic function.
Conclusions: HRVB has the potential to help individuals with chronic conditions. More research is needed to reinforce these findings as well as identify the most efficient strategy.
Keywords: Biofeedback, psychology, heart rate, chronic disease

Introduction

No communicable chronic conditions, such as cardiovascular diseases, malignancy, chronic lung disease, obesity, and mental health problems, had been accountable for about 70% of all mortality globally in 2016, according to the World Health Organization. Their worldwide incidence is rising, and the resulting socially and economically implications are becoming more severe.[1]

As a result, a fundamental priority for transforming healthcare and lowering health-care expenditures is the efficiency and profitability of diseases control. Chronic disorders are often caused by disturbances in the autonomic nervous systems (ANS) balancing, which result in sympathetic sensory overload and a shortage of vasodilatation.[2]

This dysautonomia can be viewed as a result of disease, but it can also be viewed as a key potential cause in the onset and progression of chronic diseases. Physiological changes such as stress hormone production and secretion (e.g., cortisol, norepinephrine), sleeping disturbances, pro-inflammatory cytokine production (e.g., IL-6), hypertensions, or immunological malfunction can all lead to health decline and the formation of comorbidity.[3]

Furthermore, a modelling depending on various epidemiological research found a relationship between reduced vagus nerve function and the aetio-pathogenesis of cardiovascular disorders, cancer, and Alzheimer's disease. Emphasis is being placed on therapies that could boost vagal activity and re-establish independent balancing in this context.[4]

Heart rate variability (HRV) is an indicator of health that is used to estimate parasympathetic performance and is evaluated at resting. Low HRV is a predictor of cardiovascular illness and death risks, while elevated HRV represents the ability of the heart system to respond to internal and extrinsic alterations (e.g., anxiety, activity). Short-term autonomic modulation by the sympathetic nervous system (SNS) and the vagus nerve of the parasympathetic nervous system (PNS) causes cardiac variability.[5]

Each of those interconnected systems govern heart rate (HR) by increasing or shrinking it in response to physiological processes underlying in short-term HRV management, including baroreflex control and respiratory sinus arrhythmia (RSA). The first enhances HR once BP drops and reduces HR whenever BP rises; the latter enhances HR during intake and reduces HR during expiration.[6]

Physiological elements (e.g., hormones, inflammatory condition), neuropsychiatric elements (e.g., feelings, anxiety, cognitively regulations), and ecological or health behaviours all have a role in the long-term regulatory frameworks of HRV (e.g., physical exercises, tobacco, alcohol).[7]

HRV is defined by time fluctuations among each heartbeat and is connected to the electrocardiogram's RR interval (ECG). ECG or pulse wave measurements are used to determine HRV levels in both the time and frequency domains.[8]

The root mean squared of consecutive RR interval disparities shows largely parasympathetic activity in the temporal domain, while the standard deviations of normal-to-normal RR intervals (SDNN) indicates both sympathetic and parasympathetic variations on HR. Short-term HRV assessment is mostly focused on the HRV power spectrum, which is separated into high frequency (HF; 0.15–0.4 Hz) and low frequency (LF; 0.04–0.15 Hz) regions that tend to correspond with various physiological systems in the frequency response.[9]

The HF-band represents respiratory impacts on HR modulation (RSA), which are caused by parasympathetic cardio vagal output, which causes rapid variations in HR. Aside from that, the LF-band correlates to bar reflex activities, which would be a virtuous cycle between sensory receptors and the brainstem that regulates blood pressure through both sympathetic and parasympathetic output, resulting in significantly slower fluctuations in HR.[10]

LF-band, in particular, must be regarded as a representation of the baroreflex activity generated by both sympathetic and parasympathetic HR frequency modulation, rather than as the sole representation of sympathetic stimulation. The intricacy of the physiological systems included in autonomic cardiovascular responses such as RSA and baroreflex activities should therefore be taken into account when interpreting the HRV power spectral density.[11]

HRV is controlled by the brainstem, cortical, and sub - cortical regions, and mental function may be altered by HRV due to neuronal interactions between the central autonomic networks and heart activities. According to current studies, the amygdala, insula, and anterior cingulate are all implicated in emotion regulation, implying that emotion and HRV are linked.[12]

Because vagal outflow prevails during rest due to substantial cardio modulator impacts, the authors proposed a neurovisceral implementation strategy in which vagal activities promote reciprocal heart-brain connection, implying that HRV may affect cerebral activities.[13]

Following that, according to McCraty and coworkers' psychophysiological theory, a particular cardiac rhythm pattern emerges once HR synchronises with other oscillatory components including RSA and baroreflex at a particular resonant frequencies equivalent to 6 breaths/min. Sine wave oscillations of respiration, HR, and BP represent synchronisation of these oscillatory processes and indicate a "coherence condition." HRV is considerably boosted under these situations, according to the authors, due to increased vagal activation, which could have a good impact on brain activities and, in particular, emotional control. These heart-brain connections caused by vagal afferents and afferents indicate that vagal nerve stimulation has a role in the pathophysiology of chronic disorders and that vagal-activating therapies may be problematic.[14]

HRVB (heart rate variability biofeedback) is a non-pharmacological method that improves emotional self-regulation and autonomic cardiac modulation by boosting HRV and recovering cardiac vagal function.[15]

Once breathing is around 6 breaths per minute, the baroreflex and the breath synchronise, resulting in a unique HRV signal sequence. This cardiac synchronization condition arises at a resonant frequencies of about 0.1 Hz, resulting in large amplitudes in HRV sine wave oscillations and a noticeable peak in the HRV power spectrum's LF-band. Various researches have looked into the impacts of HRVB on different psychophysiological complaints associated with chronic diseases since the late 1990s, and Lehrer has recommended a standardised technique of practice. HRVB has been shown to have good effects on stress in a meta-analysis, while a systematic review found that HRVB may have advantages for athletic performance.[16]

The goal of this systematic review was to see if HRVB may be an efficient and realistic non-pharmacological strategy for managing chronic illness sufferers. As a result, we conducted a review of all research involving elderly patients that looked at the impacts of HRVB training on psychophysiological results connected to chronic disorders.

Method

Search Strategy

Publications from the bibliographic resources PubMed/Medline, Springer Link, and ScienceDirect/Elsevier, that were submitted between 2010 and 2020, were reviewed.

Eligibility Criteria

All publications that matched the relevant particular needs of the established PICOS criteria relating to demographic, interventions, comparisons, outcomes, as well as research designs have been included in the systematic review: affected individuals (over the age of 18) with chronic diseases; accounting the impacts of HRVB as a destined therapies for psychophysiological diagnoses as regression model; assessing learning outcomes of HRVB from minimally two sessions with guidelines for regulate frequencies respirations at roughly 6 breaths/min; and using a biofeedback equipment showing the HRV in actual time. We included all research strategies and comparisons methodologies with or without a control group to introduce a comprehensive assessment of HRVB interventions for outcome measures. The study involved investigations that used HRVB lonely, HRVB in conjunction with standard treatment, or HRVB in conjunction with another non-pharmacological interference, but only if the procedure would include a control group that received the same standard care or non-pharmacological interference, in order to assess the HRVB's real benefit. Due to potential confounder's issues in the interpretation of the data, we omitted investigations that coupled HRVB instruction with another non-pharmacological treatment when the procedure did not provide a control group that permitted us to separate the HRVB different impacts.

Data Processing and Study Collection

To eliminate unintentional inclusion and exclusion, research screening was performed manually reviewing abstracts and then making revisions depending on the contents of each publication. Publications were initially categorised based on whether or not they fulfilled PICOS requirements; subsequently, publications that matched our eligibility requirements were documented, with information on procedure, measures, and outcomes.

Results

Our screening approach turned up 626 papers (PubMed: 95; ScienceDirect: 23; Springer Link: 508), plus three more papers found through sourced citations. Numerous entries were deleted using the selection approach shown in Figure 1 due to duplication (repeated: 39) or because they were not relevant research articles. By implementing the previous reported qualifying criteria in this sequence to the final 463 publications, 434 were exempted: Adult people with chronic illnesses, excluding those medical settings such as substance abuse problems (due to the complicated matter concerning behavioural problems) and pregnant women (and wasn't a chronic condition); interventional research of HRVB exercise (2 or more discussions with particular respiration guidelines); and the use of a biofeedback instrument (heartbeat detector or ECG) with real-time HRV monitor.

A collection of 21 investigations had been considered, encompassing 883 participants and sample sizes ranging from 13 to 210, with the primary goal of analysing psychophysiological results. There were 11 randomised controlled trials, 4 unregulated investigations, and the rest were pilot, feasibility, or laboratory investigations that included a wait-list comparison group, an apparently healthy comparison group, a

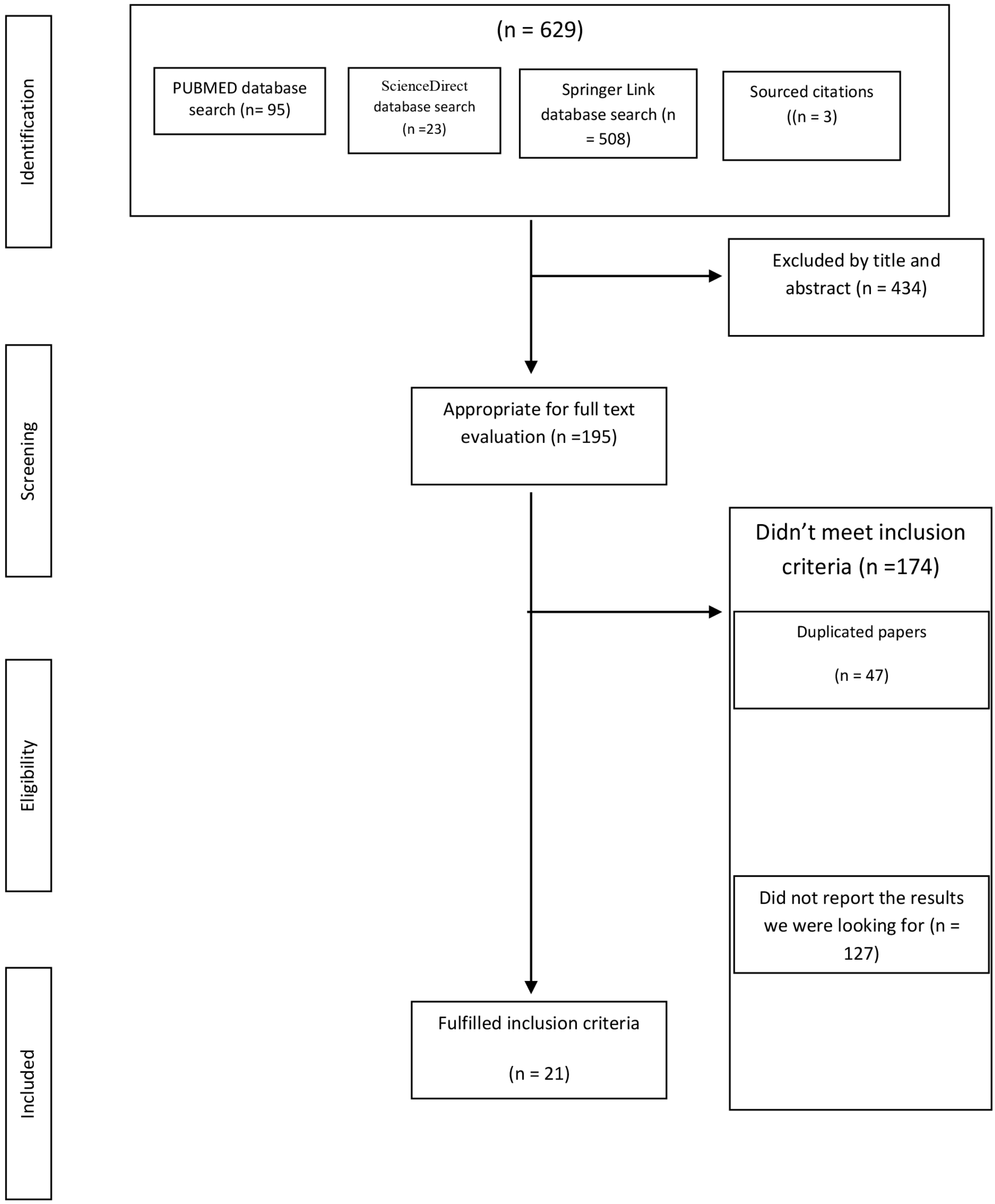

Fig. 1 **Flow chart for the literature search.**

conventional treatment control group, or another interventional control subjects. Just trials examining the impacts of HRVB separately have been included in the randomized investigations. The only difference between the intervention and control groups in randomized research was the HRVB treatment: HRVB vs. no treatment; HRVB vs. other treatments; HRVB + standard care vs. identical standard care; HRVB + alternative treatment vs. same other interference; HRVB + other interventions vs. same other intervention Table 1 summarises them and categorises them by kind of chronic condition.

Feasibility in Chronic Patients

Adhesion

HRVB was evaluated in people with a diagnosis of chronic conditions and in a number of clinical settings. In a one-year longitudinal research, the maximal attrition incidence for HRVB respondents was observed to be about 25%, while assessed employment levels for HRVB everyday routine were over 70%.[17] Time limits, transportation challenges, and other factors were mentioned in investigations as factors for

Table 1. **The baseline characteristics of each included study**

Study	Sample	Study designing	Dependent fasthma control testors and fulfilment time	Heart rate variability biofeedback intervention	Viability	Significant changes in heart rate variability biofeedback cohort	Heart rate variability ineck disability indexes	Non-significant outcomes
Cardiovascular diseases								
Climov et al. (2014)	Coronary artery diseases Age ranged from 45–80	• Randomized control Trial • Heart Rate Variability Biofeedback + standard care (n = 13) Standard care (n = 11)	HOSPITAL ANXIETY AND DEPRESSION SCALE; Type D personality; BLOOD PRESSURE; HRV Interventions before and after	10 trainings (45–60 minutes) twice a week + daily	• 7 individuals who have slipped out of the neck impairment index (careers and time limitations)	Not determined	• Increase in the average consistency rating ** correlated with SDNN	I • HOSPITAL ANXIETY AND DEPRESSION SCALE; Type D personality; BLOOD PRESSURE
Nolan et al. (2010; 2012)	Hypertension Age ranged from 35 to 64 years	• Randomized control Trial • HEART RATE VARIABILITY BIOFEEDBACK (n = 35) • Autogenic relief (n = 30)	BLOOD PRESSURE; baroreflex sensitivity; high-sensitivity C-reactive protein; IL6; HRV • Interventions before and after	Over the course of eight weeks, there will be six 60-minute training sessions and a 20-minute daily asthma control test.	Not determined	• Daytime BLOOD PRESSURE** and 24 h systolic BLOOD PRESSURE*, and pulse pressure*	• Increase of HF power** and INTERBEAT INTERVAL** during cognitive task • Changes in HF power are negatively related to increases in high-sensitivity C-reactive proteins. *, responsiveness to baroreflexes *, and INTERBEAT INTERVAL*	• Sensitive to the baroreflex • Changes in INTERLEUKIN-6 had no effect on HRV parameters or baroreflex responsiveness.
Patron et al. (2013)	Following heart surgery, the patients' ages ranged from 52 to 69.	• Randomized control trial • HEART RATE VARIABILITY BIOFEEDBACK + stress managements (n = 13) • Stress managements (n = 13)	SPIELBERGER STATE ANXIETY INVENTORY; CENTER FOR EPIDEMIOLOGICAL STUDIES-DEPRESSION SCALE; HRV • Interventions before and after	Over the course of two weeks, there will be five 45-minute training sessions and a 15-minute daily asthma control assessment.	Not determined	• Depression (CENTER FOR EPIDEMIOLOGICAL STUDIES-DEPRESSION SCALE*)	• Overall power is increasing **; • Changes in HRV were found to be inversely related to changes in depression*	• SPIELBERGER STATE ANXIETY INVENTORY

(*Continued*)

Table 1. **The baseline characteristics of each included study—Continued**

Study	Sample	Study designing	Dependent fasthma control testors and fulfilment time	Heart rate variability biofeedback intervention	Viability	Significant changes in Heart Rate Variability Biofeedback cohort	Heart rate variability ineck disability indexes	Non-significant outcomes
Yu et al. (2018)	Coronary artery disease Age range 35–70 years	• Randomized control trial • HEART RATE VARIABILITY BIOFEEDBACK + standard care (n = 105) • Standard care (n = 105)	BECK DEPRESSION INVENTORY; CHINESE HOSTILITY INVENTORY-SHORT FORM; HRV; cardiovascular prognosis • Interventions before and after • Follow-up after a year	Six weekly training sessions	• Dropout rate of 26.47% in the HEART RATE VARIABILITY BIOFEEDBACK group and 34.44% in the control group	• Depression (BECK DEPRESSION INVENTORY total score**; cognitive depression subscale**); • Hostility** (CHINESE HOSTILITY INVENTORY-SHORT FORM); • At the follow-up, the results remained the same; • Readmissions are reduced. * and at follow-up, emergent vinsomnia intensity indexts **	• Respiratory rate was decreased **; • At the follow-up, the rise in LF power** was sustained	• At the follow-up, there was no difference between the groups in terms of reducing all-cause readmissions and all-cause ambulatory care.
Obesity								
Meyer et al. (2018)	Individuals with a BMI of 30 or higher are considered obese. The participants ranged in age from 18 to 45 years old.	• Pilot study • HEART RATE VARIABILITY BIOFEEDBACK (n = 10) • Wait-list control (n = 10)	PERCEIVED STRESS SCALE; PATIENT HEALTH QUESTIONNAIRE-DEPRESSION AND ANXIETY; SHORT FORM GENERAL HEALTH SURVEY; SELF-EFFICACY; HRV • Interventions before and after • 3-months follow-up	6 trainings weekly	• Eight people dropped out of the intervention.	• Depression (PATIENT HEALTH QUESTIONNAIRE-DEPRESSION AND ANXIETY*); • Stress (PERCEIVED STRESS SCALE*); • Self-efficacy (SELF-EFFICACY sum score*); • Quality of life (Bodily total ranks* and mental total goals scored** were preserved at follow-up on SHORT FORM GENERAL HEALTH SURVEY) • Pooled results	• SDNN** performance improvement, total power **; • The reduction in respiratory rate* was sustained at the follow-up.	Not determined

(*Continued*)

Table 1. **The baseline characteristics of each included study—Continued**

Study	Sample	Study designing	Dependent fasthma control testors and fulfilment time	Heart rate variability biofeedback intervention	Viability	Significant changes in Heart Rate Variability Biofeedback cohort	Heart rate variability ineck disability indexes	Non-significant outcomes
Asthma								
Lehrer et al. (2018)	Asthma The participants ranged in age from 27 to 47 years old.	• RANDOMIZED CONTROL TRIAL • HEART RATE VARIABILITY BIOFEEDBACK group ($n = 31$) ELECTROENCEPHALOGRAM BIOFEEDBACK + soothing music + a group of people exhaling at a rate of 15 breaths per minute ($n = 33$)	METACHOLINE CHALLENGE TEST; ASTHMA CONTROL TEST; ASTHMA QUALITY OF LIFE; spirometry and impulsive oscillometry; everyday complaints and maximum outflows; expelled nitric oxide • Interventions before and after	Short protocol ($n = 20$): 6 HEART RATE VARIABILITY BIOFEEDBACK trainings over 10 weeks + 20-minutes per day prasthma control testice Long protocol ($n = 11$): 10 HEART RATE VARIABILITY BIOFEEDBACK ten weeks of practice Plus a daily prasthma control test of twenty minutes	• 19 percent of the total of patients leave out.	• Asthma complaints (ASTHMA CONTROL TEST**; ASTHMA QUALITY OF LIFE**); • Sensitivity of airways (METACHOLINE CHALLENGE TEST**); • Functioning of the lungs (maximum velocity *); • Dysfunction of the airways with intervals of poor asthma symptoms* (nitrogen dioxide released *)	Not determined	• Just after therapy, there was no difference in ASTHMA CONTROL TEST, ASTHMA QUALITY OF LIFE, METACHOLINE CHALLENGE TEST, or maximal circulation across groupings; • There is no difference between a quick and a lengthy treatment.
Chronic brain injury								
Kim et al. (2013)	Chronic brain injury Age = 23–63	• Pilot study • HEART RATE VARIABILITY BIOFEEDBACK ($n = 13$) • No control group	INTEGRATED VISUAL AND AUDITORY; CONTINUOUS PERFORMANCE TEST; BEHAVIOR RATING INVENTORY OF EXECUTIVE FUNCTION-ADULT; HRV • Interventions before and after	Weekly treatment of ten sessions and a residential asthma control assessment from session four.	• Not determined	• Not determined	• Improvement in the consistency proportion* and the LF/HF proportion **; • The coherent ratios* and the LF/HF ratio were connected with emotional stability and verbal memories (BEHAVIOR RATING INVENTORY OF EXECUTIVE FUNCTION-ADULT) **; • Attention (INTEGRATED VISUAL AND AUDITORY + CONTINUOUS PERFORMANCE TEST) correlated with LF/HF**	• Not determined

(*Continued*)

Table 1. **The baseline characteristics of each included study—Continued**

Study	Sample	Study designing	Dependent fasthma control testors and fulfilment time	Heart rate variability biofeedback intervention	Viability	Significant changes in Heart Rate Variability Biofeedback cohort	Heart rate variability ineck disability indexes	Non-significant outcomes
Chang et al. (2020)	Acute ischemic stroke	• RANDOMIZED CONTROL TRIAL HEART RATE VARIABILITY BIOFEEDBACK + standard care (*n* = 19) • Standard Care (*n* = 19)	MINI-MENTAL STATUS EXAMINATION; HOSPITAL ANXIETY AND DEPRESSION SCALE; HRV • Interventions before and after • One and three months	4 days of training process + 20 minutes of daily asthma management testing over three months.	• Three people had to drop out. • On-the-bedside training sessions are monitored.	• Anxiety and depression (HOSPITAL ANXIETY AND DEPRESSION SCALE*) at 1 and 3 months • Cognitive functions (MINI-MENTAL STATUS EXAMINATION**) at 1 and 3 months	• Decrease of heart rate* at 1 and 3 months; • Increase of SDNN*, RMSSD*, LF* and total power* at 1 and 3 months	Not determined
Chronic pain								
Dobbin et al. (2013)	Refrasthma control testory irritable bowel syndrome Age = 18–60	• HEART RATE VARIABILITY BIOFEEDBACK (*n* = 31) • Hypnotherapy (*n* = 30)	• RANDOMIZED CONTROL TRIAL • Interventions before and after • Follow-up after three months	IRRITABLE BOWEL SYNDROME SYMPTOM SEVERITY SCORES; HOSPITAL ANXIETY AND DEPRESSION SCALE Over the course of twelve weeks, there will be three 60-minute training courses and a 20-minute daily asthma control assessment.	• 15 dropouts (7 in HEART RATE VARIABILITY BIOFEEDBACK group)	• Symptoms (IBSSSS*) at post-intervention; • Anxiety and depression (HOSPITAL ANXIETY AND DEPRESSION SCALE*) • At the follow-up, the results remained the same.	Not determined	• There has been no distinction on the HOSPITAL ANXIETY AND DEPRESSION SCALE after the treatment.
Weeks et al. (2015)	≥3 months of chronic discomfort (fibromyalgia, headaches, neuropathy, etc.) 45 to 68 years old	• RANDOMIZED CONTROL TRIAL HEART RATE VARIABILITY BIOFEEDBACK (*n* = 10) • Feedback fade (*n* = 10): feedback levels were slowly reduced from 90% to 0%.	10-cm visual analog scale (VAS); PAIN DISABILITY QUESTIONNAIRE; 11-ITEM TAMPA SCALE OF KINESIOPHOBIA • Interventions before and after • Follow-up after three months	Over the course of three weeks, there will be nine training sessions.	• 6 dropped out of the interventions; • At the follow-up examination, three were missing.	• Not determined	• Not determined	Pain intensity on VAS, TSK 11, PAIN DISABILITY QUESTIONNAIRE

(*Continued*)

Table 1. **The baseline characteristics of each included study—Continued**

Study	Sample	Study designing	Dependent fasthma control testors and fulfilment time	Heart rate variability biofeedback intervention	Viability	Significant changes in Heart Rate Variability Biofeedback cohort	Heart rate variability ineck disability indexes	Non-significant outcomes
Cancer								
Greenberg et al. (2015)	Non-small cell lung cancer (NSCLC) is a type of lung cancer. The participants' ages ranged from 46 to 71.	• Interbeat intervallity feasibility analysis • HEART RATE VARIABILITY BIOFEEDBACK group (*n* = 16) • There is no control group.	HOSPITAL ANXIETY AND DEPRESSION SCALE; PATIENT HEALTH QUESTIONNAIRE; FASTHMA CONTROL TESTL; Distress Thermometer and Problem Areas • Interventions before and after	Six exercise sessions (30–45 minutes) throughout chemotherapy Plus a daily asthma management assessment of 20 minutes	• There were eight cases in total; • 1 had finished the program; • HEART RATE VARIABILITY BIOFEEDBACK done during chemotherapy; • Throughout training sessions, the potential to reduce respiratory rate, heart rate, and anxiety	• There are no statistical analysis available.	Not determined	Not determined
Depression								
Caldwell et al. (2018)	Major depressive disorder (MDD) is a type of depression that 18 to 25 years old	• RANDOMIZED CONTROL TRIAL • HEART RATE VARIABILITY BIOFEEDBACK + psychotherapy (*n* = 10) • Psychotherapy (*n* = 10) • Non-depressed control group (*n* = 11)	BECK DEPRESSION INVENTORY; HRV • Interventions before and after	Five sessions + 15–20 minutes of asthma symptoms at home. Over the course of six weeks, 4–5 instances each week	Not determined	• Depression (BDIII**)	• SDNN**	Not determined
Hartogs et al. (2017)	Major depressive disorder (MDD) The participants ranged in age from 23 to 62	• Experimental study • HEART RATE VARIABILITY BIOFEEDBACK (*n* = 10) • There is no control group	BECK DEPRESSION INVENTORY; POSITIVE OUTCOME LIST; HRV • Interventions before and after	Eight weekly training sessions (45–60 minutes) + a daily prasthma control test of twenty minutes	• Three failures due to a lack of motilized visual and aural integration; • Seven people finished the entire program; • One depressive worsening	Five participants have had clinical benefits: • Depression (BDI) • Elements of resiliency (POSITIVE OUTCOME LIST Autonomy ratings); (HAMD total score**)	• During the program, the degree of consistency of five participants improved. • The average HR has decreased *	Not determined

(*Continued*)

Table 1. **The baseline characteristics of each included study—Continued**

Study	Sample	Study designing	Dependent fasthma control testors and fulfilment time	Heart rate variability biofeedback intervention	Viability	Significant changes in Heart Rate Variability Biofeedback cohort	Heart rate variability ineck disability indexes	Non-significant outcomes
Lin et al. (2019)	Major depressive disorder Age ranged from 20 to 75 years.	• Case-control study • HEART RATE VARIABILITY BIOFEEDBACK ($n = 24$); • Control of the waiting list ($n = 24$)	BECK ANXIETY INVENTORY; BECK DEPRESSION INVENTORY; PITTSBURGH SLEEP QUALITY INDEX; PRE-SLEEP AROUSAL SCALE; HRV • Interventions before and after • Follow-up after one month	Six weekly training sessions (60 minutes) Plus daily prasthma control testice of 10 minutes	• There were five withdrawals.	• Depression (BECK DEPRESSION INVENTORY total score**, cognitive depression*, somatic depression*); • Anxiety (BECK ANXIETY INVENTORY total score**); • Sleep (PRE-SLEEP AROUSAL SCALE total score*, PITTSBURGH SLEEP QUALITY INDEX total score**, and cognitive arousal of PRE-SLEEP AROUSAL SCALE**) • At the follow-up, the results remained the same.	• Respiratory rate decreases **; • SDNN**, LF power*, LF/HF*, and overall power* all increased**; At the follow-up, the results remained the same.	• No difference between groups for PITTSBURGH SLEEP QUALITY INDEX and PRE-SLEEP AROUSAL SCALE total scores
Chronic stress								
De Bruin et al. (2016)	Chronic stress evaluated from PERCEIVED STRESS SCALE score Age ranged from 18 to 40	• RANDOMIZED CONTROL TRIAL • HEART RATE VARIABILITY BIOFEEDBACK ($n = 25$) • Meditation for awareness ($n = 27$) • Physical activity ($n = 23$)	ACS; BEHAVIOR RATING INVENTORY OF EXECUTIVE FUNCTION-ADULT; FFMQSF; SELFCOMPASSION SCALE-SHORT FORM; PENN STATE WORRY QUESTIONNAIRE • Interventions before and after • Follow up after 6 months.	Over the course of five weeks: 1st week: 10 minutes per day 2nd week = 15 minutes per day Weeks 3–5 = 20 minutes per day	• There were 19 withdrawals in the HEART RATE VARIABILITY BIOFEEDBACK category, including one in the HEART RATE VARIABILITY BIOFEEDBACK cohort (occupations and time constraint); • Participants with an attendance rate of more than 70% showed greater gains.	• Attention control* (ACS); • Executive functioning* (BEHAVIOR RATING INVENTORY OF EXECUTIVE FUNCTION-ADULT); • Mindful awareness* (FIVE FACET MINDFULNESS QUESTIONNAIRE-SHORT FORM); • Self-compassion* (SELFCOMPASSION SCALE-SHORT FORM); • Worrying* (PENN STATE WORRY QUESTIONNAIRE) • When compared to its peers, attention control and executive functioning had small impact values at follow-up.	Not determined	At the post-intervention and follow-up, there was no substantial distinction.

(*Continued*)

Table 1. **The baseline characteristics of each included study—Continued**

Study	Sample	Study designing	Dependent fasthma control testors and fulfilment time	Heart rate variability biofeedback intervention	Viability	Significant changes in Heart Rate Variability Biofeedback cohort	Heart rate variability ineck disability indexes	Non-significant outcomes
Hallman et al. (2011)	Stress related chronic neck shoulder pain Age ranged from 25 to 50 years	• Pilot study • HEART RATE VARIABILITY BIOFEEDBACK ($n = 12$) • The control group ($n = 12$) participated in sessions 1 and 10 without receiving any guidance in between.	Borg CR10; STRESS MEDICINE SYMPTOM SCALE; HOSPITAL ANXIETY AND DEPRESSION SCALE; SHORT FORM GENERAL HEALTH SURVEY; NECK DISABILITY INDEX; HRV • Interventions before and after	Ten training sessions every week.	Not determined	• Quality of life (on the SHORT FORM GENERAL HEALTH SURVEY, bodily pain*, social function*, and vitality**)	• LF power** increases; LF power*, pNN50*, and INTERBEAT INTERVAL * improve throughout stress recovery.	• STRESS MEDICINE SYMPTOM SCALE, Borg CR10, and NECK DISABILITY INDEX, HOSPITAL ANXIETY AND DEPRESSION SCALE
Van der Zwan et al. (2015)	Chronic stress was assessed using SCALE OF PERCEIVED STRESS The participants ranged in age from 18 to 40 years old.	• RANDOMIZED CONTROL TRIAL • HEART RATE VARIABILITY BIOFEEDBACK ($n = 26$) Physical exercise ($n = 23$) Meditation for awareness ($n = 27$)	DEPRESSION ANXIETY STRESS SCALES; PITTSBURGH SLEEP QUALITY INDEX; SCALES OF PSYCHOLOGICAL WELL-BEING • Interventions before and after • Follow up after six months	Over the course of five weeks: 1st week: 10 minutes per day 2nd week = 15 minutes per day Weeks 3–5 = 20 minutes per day	• Nine post-test and/or follow-up examinations were missing; • Individuals with a participation rate of more than 70% showed greater gains.	• Stress**, anxiety**, and depression** (DEPRESSION ANXIETY STRESS SCALES); • Well-being** (SCALES OF PSYCHOLOGICAL WELL-BEING); • Sleep quality* (PITTSBURGH SLEEP QUALITY INDEX); • At the follow-up, the results remained the same.	Not determined	• At post-intervention and follow-up, there were no differences between groups.
Psychiatric disorders								
Jester et al. (2018)	Indications of psychiatric diseases (depressive, anxiety, and bipositive outcome listar disorders) The ages of the participants ranged between 63 to 96 years old.	• Experimental study • HEART RATE VARIABILITY BIOFEEDBACK ($n = 20$) • No control group	SPIELBERGER STATE ANXIETY INVENTORY; BECK DEPRESSION INVENTORY; TRAIL MAKING TEST PART A AND B Interventions before and after	Over the course of three weeks, there will be six 30-minute training sessions plus a home asthma control assessment two times per week.	• Participants highlighted the impact of HEART RATE VARIABILITY BIOFEEDBACK on stress or concern (67%), depression or sorrow (56%), and stress (44%); or no benefits of HEART RATE VARIABILITY BIOFEEDBACK on tension (50%); • Anxiety symptoms are slightly worsened (competitive nature of BF software) one participant has confirmed this.	• Depression** (BDIII); • State anxiety** and trait anxiety** are two types of anxiety (SPIELBERGER STATE ANXIETY INVENTORY); • Attention skills (TMT-A**)	Not determined	Not determined

(*Continued*)

Table 1. **The baseline characteristics of each included study—Continued**

Study	Sample	Study designing	Dependent fasthma control testors and fulfilment time	Heart rate variability biofeedback intervention	Viability	Significant changes in Heart Rate Variability Biofeedback cohort	Heart rate variability ineck disability indexes	Non-significant outcomes
Schuman et al. (2018)	Post-Traumatic Stress Disorder (PTSD). The participants ranged in age between 26 until 50 years old.	• Pilot Study • HEART RATE VARIABILITY BIOFEEDBACK ($n = 6$) Controlling the waitlist with breathing techniques ($n = 6$)	PTSD CHECKLIST FOR THE DSM5; HRV • Interventions before and after • Follow up ranged from four to 16 weeks.	Over the course of 4 weeks, One session + 10–15 minutes twice daily prasthma control testice	• The procedure was performed by ten people; • Daily prasthma monitoring testice participation rate of >70%; • Symptoms include a decrease in individuals' irritability, anxiety, and sleep disturbances.	• PTSD-specific symptoms (PTSD CHECKLIST FOR THE DSM5*) maintained at follows-up • The results have been combined.	• RMSSD* increased at the 16-week follow-up	Not determined
Tan et al. (2011)	Post-Traumatic Stress Disorder (PTSD). The participants ranged in age from 24 to 62 years old.	• Pilot study • HEART RATE VARIABILITY BIOFEEDBACK + standard care ($n = 10$) • Standard care ($n = 10$)	CLINICIAN-ADMINISTERED PTSD SCALE; PTSD CHECKLIST-SPECIFIC Interventions before and after	Over the course of 8 weeks, there will be 8 training sessions (half an hour each) and a 20-minute asthma control test two times per day.	• 1 dropout (transport problem); • Participants rated the HEART RATE VARIABILITY BIOFEEDBACK intervention as an 8/10 for satisfasthma control and that they had a pleasant time.	• PTSD-specific symptoms (CLINICIAN-ADMINISTERED PTSD SCALE**; PTSD CHECKLIST-SPECIFIC*)	Not determined	• At the end of the intervention, there was no difference between the groups.
Trousselard et al. (2016)	Remitted schizophrenia Age ranged from 25 to 46 years.	• Pilot study • HEART RATE VARIABILITY BIOFEEDBACK ($n = 10$) • No control group	SPIELBERGER STATE ANXIETY INVENTORY; DEROGATIS STRESS PROFILE; POSITIVE AND NEGATIVE SYNDROME SCALE; WARWICK–EDINBURGH MENTAL WELL-BEING SCALE; FREIBURG MINDFULNESS INVENTORY Interventions before and after	Weekly training sessions of 8–12 hours (one hour) plus daily relaxation techniques.	• No dropout; • Most people want to remain after quitting; • In individuals with a high level of complaints, there are more benefits.	• Mindfulness* (FREIBURG MINDFULNESS INVENTORY); • Anxiety stressors* and emotional stressor* (DEROGATIS STRESS PROFILE)	Not determined	WARWICK–EDINBURGH MENTAL WELL-BEING SCALE, POSITIVE AND NEGATIVE SYNDROME SCALE, SPIELBERGER STATE ANXIETY INVENTORY

*<0.05; **≤0.01; "Not determined" implies that this data was not noted in the study.

withdrawals,[18–20] and medical defects.[21] Because to significant dropout rates in lung cancer sufferers owing to disease-related health and lifestyle decline or mortality, one procedure was early discontinued.[21]

Satisfaction

Generally, participants were pleased with the stress reduction and positive feeling improvement they experienced while biofeedback, and the advantages lasted for a long time.[17,20,22,23] None of the respondents in any of the research looked at expressed displeasure. Participants with remitted schizophrenia readily finished the intervention with no participation requirement, and the majority expressed an incentive to keep afterward due to claimed psychological advantages.[23] There was a 67 percent acceptance rating for beneficial effects on anxiety or worry amongst elderly patients with psychiatric conditions, as well as 56 percent satisfaction for state of depression or sorrow and 50 percent satisfaction for stress.[22]

Adverse Effects

HRVB was found to have no major side effects, indicating that it is safe to use in patients with chronic conditions. Other minor side effects were noted, including such anxiety, due to the intrinsic pressure felt by sufferers to fulfil the biofeedback device's predefined respiratory objectives.[22] A familiarisation phase was adopted in a procedure to gradually eliminate the respiratory rating from a natural rhythm of ~14 breaths/min to a goal rate of ~6 breaths/minute to minimise any frustrations linked to sluggish breath and hyperventilation.[24]

Efficacy in Terms of Psychophysiological Results

Cardiovascular Disorders and Hypertensive Disorders

HRVB was helpful in lowering 24-hour systolic blood pressure (−2.1 0.9 mmHg, $P = 0.03$) and 24-hour pulse pressure (−1.40.6 mmHg, $P = 0.02$) following 8 weeks of regular practise, according to a randomised controlled trial (RCT) involving 65 participants (autogenic relaxation).[25] A trial of 24 patients with atrial fibrillation found no change in blood pressure.[18] Since the participants were already on beta-blocker medications when the trial began, all initial systolic and diastolic BP readings were within normal ranges through the latter example, which indicates a substantial restriction of the outcomes. As a consequence, HRVB appears to have a beneficial effect on blood pressure in hypertensive individuals and cardiovascular prognosis in heart sufferers.

Inflammatory Condition

In a research of 65 hypertension individuals, a negative relationship between alterations in the inflammatory condition (evaluated by highly sensitive C-reactive proteins and interleukin-6) and efferent vagal activity (evaluated by HF power, RR interval, and baroreflex activities) was discovered.[26] The researchers hypothesized that increasing efferent vagal action would reduce pro-inflammatory mediators, implying that HRVB could have anti-inflammatory properties.

Asthma Disorders

All asthma attacks and lung capacity increased in two Randomized trials with 94 and 64 participants, respectively, and airway inflammation decreased. When compared to the control group, food and medicine intake was decreased after 10 weeks of daily HRVB practise, indicating that HRVB has a lot of potential in the particular treatment of asthma attacks.[27] HRVB was more successful in lowering prescription usage 30 and airways inflammations than electroencephalogram (EEG) biofeedback and standard treatment,[27] It was also just as efficient as active controls at alleviating asthma attacks,[27] bronchial permeability and lung capacity.[27]

Anxiety, Depression, and Psychological Response

HRVB was found to have substantial favourable impact in 12 of the 15 research that looked at depression as a predictor variables; similarly, HRVB was found to have significant positive impacts in 9 of the 12 studies that looked at stress and anxiety. In 12 investigations involving 326 different patient features who suffered from mental illness, depressed mood, tension, and anxiety were considerably reduced,[28–30] persistent discomfort,[31] chronic stress,[32] psychiatric disorders[22,23] and obesity.[33] Anxiety and despair levels were reduced over many weeks to a year after HRVB treatment.[30–32]

Other beneficial psychological consequences were assessed, including greater mindfulness practice, self-compassion, and well-being. In two investigations with a total of 151 patients suffering from chronic stress[19,32] and one research with ten participants in remission from schizophrenia, there was a reduction in worry or anger.[23]

Disruptions in Sleep

Three of the four studies that looked at sleep problems found that HRVB improved sleeping patterns in individuals with severe depressed disorders,[30] and anxiety symptoms (totalling 162 participants). Increases in sleeping were linked to lower levels of depression[30] and stress.[32]

Characteristics of Post-Traumatic Stress Disorder (PTSD)

In three investigations involving 60 patients, PTSD-specific indicators decreased considerably following 4–8 weeks of HRVB therapy. In a research with a small sample size of 20 participants, HRVB was found to be no more efficient than the traditional therapy.[20]

Cognitive Performances

Massive gains in attention skills and executive functioning in individuals afflicted by chronic stress,[19] executive function in individuals with mental signs, 38 have been implemented to enhance cognitive capacities. In addition, individuals who had an acute ischemic stroke improved their cognitive function significantly.[23,24] Nevertheless, no improvement in cognitive abilities were identified in 13 individuals with persistent brain damage, which is likely owing to the kind of neurological problems.[34]

Pain

50 participants with irritable bowel syndrome and 24 individuals with stress-related chronic neck-shoulder pain improved following HRVB exercise.[35] Improvements were sustained three months following HRVB exercise, according to one research.[31] A further research, nevertheless, contradicts these

findings, finding no substantial pain decrease in patients with diverse chronic pain characteristics.[36] There was no information about the prescriptions and/or use of painkillers.

Lifestyle

Advancements in quality of life, particularly a rather more active lifestyle and a rise in both social and physical performance, were found to be linked to a reduction in pain 50 and PTSD-related indicators.[17]

Discussion

Modifications in HRV may Mitigate the Relationship of Interventions

The HRVB benefits on HRV were documented in 11 of the 21 investigations in the literature review. The lowered mean HR[25] and breathing percentage at rest[30,33] all over meetings, as well as the enhanced cohesion proportion throughout sessions,[18] showed highest synchronisation between respiratory and cardiovascular processes, recommend that individuals correctly performed HRVB activities and demonstrate the impacts of routine practice. HRV indicators that increased in time, such as SDNN,[24,29,30,33] pNN[31] or RMSSD,[24] and in frequencies, such as overall power,[24,30,33] suggested an improvement in cardiac autonomic regulation. 9 Numerous studies have found that higher HRV values are linked to better outcome measures. In patients with chronic brain damage, a higher consistency proportion was linked to enhanced affective and psychological functioning.[37] In cardiovascular events, greater HF power was linked to lower stress and anxiety levels, as well as lower inflammation condition in hypertensive individuals.[26] As a consequence, the authors suggest that by boosting overall HRV and completely overwhelming cardiac vagus nerve activity, HRVB could have inhibitory action on autonomic function implicated in physiological control systems. The central-autonomic combination of vagal afferents may help to improve psycho - physiological performance in a more cohesive and effective process in this manner.[38] Furthermore, by optimising and enabling interrelated biological processes, 0.1 Hz oscillations as a resonant frequencies may play a prominent part in physical and mental health.[39] HRVB could be a potential strategy for managing a broad variety of ailments conditions and their effects by increasing vagal heart activity.[40]

Troublesome Explanation of HRV

The HF power reflects PNS arousal while spontaneous breathing at resting (about 10–15 breaths/min), while the LF power mostly indicates baroreflex action influenced by both SNS and PNS. Whereas an elevation in HF strength indicates an elevation in PNS arousal, a rise in LF power may result in a rise in baroreceptor regulation controlled by ANS control and cannot clearly differentiate synchronous from parasympathetic involvement. The findings of HRV in the spectral domain in the research used in this study were characterized as the reinstitution of cardiac vagal regulation, expressed in either HF or LF regions. Furthermore, the effect of respiratory rate on HRV radio spectrum demonstrates that for a respiratory rate under 9 breaths/min, vagal activities may pass over into the LF-band.[41-43] Latest discoveries reveal that parasympathetic inhibition can remove HRV power in the LF-band in healthy persons beneath slow breathing conditions, showing the importance of cardiac vagal activity throughout a limited range of frequencies of 4–9 breaths/minute.[44] In this respect, some studies propose increasing the frequencies limitation between the HF and LF bands from 0.15 Hz to 0.1 Hz to account for the particular effects of slow breathing on the HRV frequency distribution as well as the complicated interactions among PNS and SNS signalling heart-brain connections.[39]

Numerous technical features of HRV signal acquisition, including such monitoring length, instrument employed (ECG or pulse sensor), HRV variables evaluated, and respiratory circumstances, vary between procedures. Ventilation was not measured in any of the procedures, therefore not determined on breathing rate, tidal volume, or intake to exhalation ratios was supplied, although their recognised impacts on HRV.[45] Respiratory variables should be observed to interpret the data more precisely because variations in rhythms of respiration may alter the HRV power spectrum as a potential mediator.[43] Other variables that may play a role in HRV regulation, such as medicine and physically activities,[46] must also be taken into account. As a consequence, studies relating to the increase of HRV indices must be regarded with caution, as they do not show a direct cause-and-effect connection among HRVB and ANS control.

HRVB Versus Other Interventions

The known methods implementations were also explored as component of this systematic review. HRVB was largely effective when opposed to normal care or waiting listing controlled trials[47,29,30,33,35] but not when contrasted to active controls that included various non-pharmacological treatments.[19,27,31,32] Autogenic relaxing, progressive muscle relaxation, electroencephalogram biofeedback,[27] hypnotherapy, 50 mindfulness training, and physical activity[19,32] have all been shown to improve psycho - physiological results. HRV indicators were not enhanced by any of the other non-pharmacological treatments utilised as a controlled group, indicating HRVB's distinct abilities on autonomic cardiac modulation (Table 1). Whenever HRVB is used in conjunction with regular care, the findings demonstrate that it can be used as an adjunctive therapy for clinical patients. Nevertheless, since of potential confounders, we eliminated some of the studies that show promising prospects for integrated non-pharmacological therapies in chronic illness treatment, such as physically exercises, healthcare management,[48] or relaxation techniques.[49]

Guidelines for HRVB Training Regimes

The majority of the regimens we looked at gave 4–12 monitored workshops with ongoing home practise. Home practise was created to strengthen diaphragmatic breathing instructions and enhance HRV responsiveness, whereas monitored training were offered to ensure that HRVB activities were completed. The authors discovered a dose-response relationship between HRVB practise and symptomatology decrease[19,32] implying the need of consistent practise and the presence of a practise barrier at which HRVB can deliver the desired results. We may estimate that optimum practise should comprise at least one monitored workshop accompanied by consistent home practise of at least 10 minutes daily for four weeks depending on the examined publications. This finding is consistent with previously reported HRVB protocol guidelines, which suggest 5 monitored sessions with 20-minute daily practises.[50] Patients may choose shorter practise hours if they are concerned about dropping out due to time constraints. HRVB practise, on the other hand, is likely to be helpful when tailored to the patient's profiles and skills, with the option of providing more monitored sessions and extended procedures as needed.

Guidelines for HRVB Training Programs

The researchers of the examined procedures have offered a series of findings: To prevent minor side effects, provide a familiarisation phase of slow breathing activities at the start of the treatment (anxiety or breathlessness);[47,24] practice the slow abdomen breathing exercises by introducing pursed-lips abdominal breathing with slightly delayed exhale;[24] and, all through the session, gradually reduce the amount of time subjected to optical biofeedback in order to develop full independence in HRVB practise.[36] Lehrer's methodology includes a brief anti-hyperventilation warning ("In hopes of avoiding hyperventilation during the timed respiration activity, kindly eliminate exceedingly breathing techniques.").[50] Participants who are new to 0.1 Hz respiration must be given instructions to "breathe superficially and spontaneously." Even though it has been demonstrated that an participant's HR frequencies range makes it easier to enter cardiac coherence phase,[51] HRVB has often been established on roughly 6 breaths/min. In terms of the inhalation/exhalation proportion (i/e), a lower i/e ratio appears to result in enhanced relaxing, reducing stress, mindfulness, and good energy in participants 68, and a 1/2 proportion could boost baroreflex responsiveness.[52] Others' findings, on the other hand, demonstrate that a 1/1 ratio is more beneficial than extended exhalation (40 percent intake and 60 percent expiration) in increasing HRV.[53] As a result, more research is required to explain these various issues and to find the best beneficial breathing technique.

Future Studies Possibilities

Our findings are consistent with earlier studies that show HRVB has a favourable impact on clinical results and demonstrate that HRVB is a viable and prospective treatment option for people with chronic conditions.[40,54,55] The researchers concluded that HRVB could help restore autonomic heart control and emotional self-control, as evidenced by the positive association between clinical results and HRV indicators.[26,37,34,56] Given the role of the autonomic nervous system in pathogenesis6 and the fact that HRV is a measure of cardiac morbidity, a potential regulating impact of HRVB on functional status provides attractive alternative therapy possibilities. Our research is hampered by the lack of risk-of-bias evaluation of the included research, despite the fact that it gives a qualitative summary of HRVB outcomes and methods. Given the diversity of procedures employed in HRVB studies, subsequent papers should emphasise analysing risk of bias, evaluating the significance of every report's results, and doing meta-analyses to get more firm conclusions on the possible impact of HRVB.

Further controlled trials are needed to much more precisely assess the efficacy of HRVB in comparison to standard treatment and effective control circumstances (e.g., relaxation, mindfulness meditation, physical exercise). As potential confounders, respiratory rhythm (incidence, peak flow, and inspiration to exhalation ratio), physical activity, and medications should all be observed.[46] As according respiratory rate and HRV signals collection, the various time and frequency parameters of HRV should be properly analysed.[42] Investigators may be inspired by a beautiful study whose findings were released after the comprehensive study's eligibility deadline.[57] It was carried out on depressed patients, and the procedure was based on a very thorough medication regimen that included a 5-week HRVB intervention during psychiatric inpatient recovery. The findings demonstrated an increase in HRV-LF amplitude and consistency ratios, as well as a reduction in depression scores and resting breathing rate, indicating that physicians have great potential. Different analysis techniques to enhance the extracting included in HRV must be prepared and implemented in the future for a reliable estimation of functional connectivity utilising HRV. Quantitative evaluations of HRVB's impact on sympathetic cardiac control could possibly be more useful.[58] Lastly, in future investigations, established protocols for both treatment procedures and data collection should be observed to improve the effect of meta-analyses and review articles.[43]

Conclusion

The efficacy of HRVB as an adjunctive therapy in patients with chronic conditions is highlighted in this comprehensive review. Because of the wide range of individuals and results, it's hard to draw mechanical generalizations about how HRVB affects intervention effects. HRVB may have a regulatory influence on autonomic heart control by enhancing HRV and recovering vagal functionality, according to our findings. The enhanced vagal flow may therefore impact brain activities and improve emotional self-regulation, implying that HRVB could be useful as a supplemental remedy for various of chronic conditions. Considering the excellent benefits of HRVB on psychophysiological results across a variety of patient characteristics, it's apparent that HRVB has a bright future in the treatment of chronic disorders. Confirming these findings, clarifying the understanding of the HRV power spectrum, and determining the most effective strategy in chronic disease management will require more research.

Conflict of Interest

None.

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