https://doi.org/10.48047/AFJBS.6.7.2024.3317-3327

African Journal of Biological Sciences

Journal homepage: http://www.afjbs.com

Research Paper Open Access

To Compare the Effectiveness of Diaphragm Release, Cervical SNAGs and Vagal Stimulation on Heart Rate, BP, And Skin Hydration in Prehypertensive individuals: A Critical Review

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Volume 6 issue 7 2024
Received:01June2024
Accepted:30June2024
doi:10.48047/AFJBS.6.7.2024.3317-3327

ABSTRACT

This review aimed to explore the current literature on effect of diaphragm release, vagal stimulation and Cervical SNAGs on B.P, Heart Rate and skin hydration in prehypertensive individuals. The studies published in the English language between 2000 and 2023 were included based on a search of the databases PEDro, PubMed, and Google Scholar. Studies that examined the effect of diaphragm release, vagal stimulation and Cervical SNAGs on B.P, Heart Rate in prehypertensive individuals were included in this literature review. We found a total of 44 studies describing the effect of these three intervention included in this literature review. Vagal stimulation was found to have positive outcomes in 33 studies, while 11 studies had contradictory conclusions. Based on our findings, vagal stimulation is widely used for the rehabilitation of prehypertensive individuals. The parameters used to assess the improvement mostly included Heart Rate, B.P and skin hydration. The outcome measures used in studies are usually linked to body's sympathetic control system.

However, there is a scarcity of studies on the effect of vagal stimulation which should be the outcome of any Prehypertension rehabilitation program. There is scope for future research to demonstrate the effect of vagal stimulation and its comparasion with diaphragm release and Cervical SNAGs in prehypertensive individuals.

Categories: Physical Medicine & Rehabilitation
Keywords: Prehypertension, SNAGs, Diaphragm Release

INTRODUCTION

Meditation, yoga - The pondering practices are becoming demanding among the individuals of general population. Remarkable positive effects are being recorded on physical, physiological as well as psychological wellbeing and cognitive performances [1]. The positive effects may be due to changes in autonomic balance. The balance between both the systems ie sympathetic and parasympathetic system can be achieved by releasing diaphragm to enhance specific respiratory pattern or by stimulating tone of vagus nerve or by cervical manipulation. Diaphragmatic breathing is considered as a complement for maintaining hypertensive condition of an individual [2]. Diaphragm release enhances respiration in a systematic manner, which includes the whole body, viscera, nervous system and emotional behavior [3]. The diaphragm is a very important and main muscle the contraction of which influences our respiratory pattern and thus sympathetic balance. The musculoskeletal and respiratory systems are to a greater extent affected by our lifestyle specially our sedentary behaviour, white collar jobs, working environment. The peculiar pathology behind respiratory disease is the change in muscle parenchymal structure. The diaphragm has muscle fibres that are arranged in vertical orientation and in the apposition zone they have

transverse orientation. This orientation makes decreases the diaphragm efficacy thus decreasing its pressure generating capacity. As a result diaphragm may tighten up and hence mobility is reduced which further leads to various diseases. (Debora et al, 2017)[4].

The most important mechanical cause of altered cardiovascular dysfunction may be due to spinal misalignment especially cervical spine C1 ie atlas which can injure, impair and compress neurovascular pathways in the brainstem. Changes in atlas position result in compression of vertebral artery which results in worsening B.P and heart rate[5]. The mechanism by which mobilization work is through neurophysiologic effects and stimulation of parasympathetic flow. Brainstem and carotid sinus are stimulated which further stimulates brainstem resulting in positive effects in cardiovascular and neurological pathways [6]. We used sympathetic parameters because heart rate and BP responses to cervical manipulation are currently unknown.

The vagal tone may bring about cardiovascular alterations. The sensory information collected by sensory organs indirectly reaches brain via cranial nerves resulting in higher perception and thus gives higher cognition. The cranial nerves affects functional activities of brain and thus improves clinical, cognition and behaviour of an individual [7]. The vagal stimulation has capability to shift from sympathetic to parasympathetic activation in older adults thus improving cardiovascular alterations. This is an important feature for BP & HR regulation [8,9].

REVIEW

Zoya Mehmood, Umama Ijaz et al, (2022) determined the effect of effect of Mulligan's Cervical Sustained natural Apophyseal glide and cervical traction cardiovascular and respiratory outcomes; systolic blood pressure, diastolic blood pressure, heart rate, ventilation rate, oxygen saturation, neck disability index and cervical range of motion. 84 participants with age range of 18 to 24 years of either gender with cervical pain and hypomobility were included in the study. The study results showed improvement in both groups in terms of cardiovascular and respiratory outcomes but experimental group has more significant reduction in pain and change in pulse rate. Experimental group received sustained natural apophyseal glide and traction while the control group was subjected to traction alone. A total of four sessions were provided over a course of four weeks, with two weeks interval between them.[10]

A study conducted by Lindsey K. McIntire, R. Andy McKinley et al 2021 to find out the effect of cervical transcutaneous vagal nerve stimulation on cognitive performance of human beings under sleep and stress. Subjects were randomly assigned into experimental group and control group. There were total 20 subjects in each group. The subjects underwent 34 hours of unrelenting wakefulness. Experimental group received Tvns. The patients undergoing cervical transcutaneous vagal NS showed significantly better results on arousal, multitasking and reported lower fatigue.[11]

A clinical trial conducted in 2021 by Sefa Haktan, Hatik et al reported the effect of auricular VNS which is completely non-invasive procedure on on field performance, and physiological constraints in healthy subjects.46 healthy individuals participated in the study. Numerical rating scale. Respiratory rate, pulse rate and distance covered during exercise for sports activity were assesed. The study showed positive results.[12]

The findings of a clinical series investigation by Sonia Roura, Gerard Alvarez et al (2021) investigated the effectiveness of manual therapy interventions on the sympathetic and non-sympathetic nervous system. They conducted systematic literature to determine the autonomic effect attained by manual therapy. The study also studied that cardiovascular reponses may also

be altered by the type of technique used. Area targeted is peculiar feature of getting positive autonomic responses. There were insignificant autonomic effect of manual therapy and hence its clinical relevance was not confirm.[13]

Veronica Dusi, Gaetano Maria De Ferrari (2021) Overactivation of sympathetic system and inactivation of vagal nerve may lead to the Autonomic imbalance which may result in chronic cardiac failure with reduced ejection fraction. The review emphasised on vagal stimulation which is the most researched device based autonomic therapy in stabilisation of heart failure with decreased ejection fraction.[14]

The study in 2021 by Young Hwan Choi, Se Jin Oh & Jong Hee Lee aimed to test the reliability of the Biodisplay by comparing its performance results with those of similar devices currently used to objectively assess skin hydration. For each of the 30 participants, skin hydration was measured at each of the defined points on the forearm three times using the Biodisplay and a Hydration probe (HP), an objective measurement device of skin hydration. The Biodisplay can provide reasonably reliable and accurate measurements for skin hydration with the strong points of portability and accessibility.[15]

Hsieh, Chun Ming, Lin, Wan Chen (2021) studied whether shoulder TENS used for treating adhesive capsulitis could affect vagal tone, its potential impact on heart functions. In this study, electrocardiogram (ECG) and heart rate (HR) of subjects in response to sham, right-sided, or left-sided shoulder TENS (TENS-S, TENS-R, and TENS-L, respectively; 5 min) were recorded and analyzed. During the stimulation period, TENS-R constantly and TENS-L transiently decreased the HR of subjects; both TENS-R and TENS-L increased powers of the low- and high-frequency spectra. While TENS-R exhibiting no effect, TENS-L increased the ratio of low/high-frequency power spectrum indicating TENS-R decreased the HR through potentiating cardiac vagal tone. Collectively, these results suggest TENS could be an early and non-invasive therapy for heart failure patients before considering implant devices or devices are not feasible; moreover, therapists/physicians need to carefully monitor the potential adverse events during treatment for patient safety.[16]

Helena Medeiros Rocha, MS Helga et al in 2020 observed that diaphragm release technique improves cardiac parameters like Heart rate. This was a pilot study conducted on 24 individuals with COPD which evaluates the feasibility of testing an intervention and assessing the effect of rib mobilization and a DRT on autonomic nervous system of subjects.[17]

A study in 2020 by Jakub Stepnik, Agnieszka Kedra et al concluded that osteopathic MT do not significantly improve pulmonary health but improve lung function i.e PEF in patients without lung disease. Respiratory system diseases are some of the most common pathologies worldwide. Although osteopathic technique is used mainly to treat other pathology, some osteopathic MT have been provedto improve pulmonary function of patient. Tests were performed with spirometry, forced vital capacity, forced expiratory volume, peak expiratory flow. [18]

Mathieu Picchiottino, Margaux Honore et al (2020), the autonomic activity and pain threshold can be altered thoracic spine manipulation. They conducted randomized study consisting experimental group and sham controlled group . CVS sympathetic activity was observed using systolic B.P and HR. The pain sensitivity was evaluated through pain pressure threshold. The result proved that there was insignificant effect of single session Spinal manipulation of thoracic spine on Cardiovascular activity.[19]

The review presented by Jonathan Y. Y. Yap, Charlotte Keatch, Paul R. Stoddart , Elisabeth Lambert and Tatiana Kameneva in 2020 showed the current status of tVNS with a focus on stimulation parameters, stimulation sites, and available devices. For tVNS reach its full potential

as a non-invasive and clinically relevant therapy, it is imperative that systematic studies be undertaken to reveal the mechanism of action and optimal stimulation modalities. tVNS has proven to be an effective way to modulate the central nervous system in some cases. However, the mechanism of action is not clear, and the robustness of the results is yet to be proven. The technique is safe and convenient with only a few relatively minor side effects reported.[20]

Research by Mark W. Chapleau, Diane L. Rotella in 2020 on Vagal nerve stimulation shows that once the salt-sensitive rats were induced high blood pressure by using a high-salt diet consumption for six weeks which remarkably multiplied arterial pressure, pulse rate, and episodes of arrhythmia. After four weeks ,there has been hike in mean arterial pressure and wide variety of arrhythmic episodes occurred in rats. These enhancements had been attributed to changes inside the physiology of the heart, along with reduction in action potential during speedy pacing, special dispersion of action potential , and increase in conduction velocity.[21]

Yung, Emmanuel, Oh, Cheongeun et al in 2019 conducted a study on Forty-three (23 females) participants with non-chronic neck pain (mean age 29.00 ± SD 9.09 years) randomly received AP or LAT NTM to the cervical spine. Blood pressure and heart rate were measured before, during, and after the intervention. Disability and pain were measured pre- and post-intervention. Resting systolic blood pressure (SBP) was significantly associated with average pain reduction.[22]

Annoni, Elizabeth M., Van Helden, Dusty et al in 2019 investigated vagus nerve stimulation (VNS) as a novel, device-based therapy for HTN(hypertension) treatment, and specifically evaluates its effects on long-term survival and HTN-associated adverse effects. HTN was induced in Dahl salt-sensitive rats using a high-salt diet.Acute and chronic effects of VNS therapy were evaluated through continuous monitoring of blood pressure (BP) and ECG via telemetry devices. Autonomic tone was quantified using heart rate (HR), HR variability (HRV) and baroreflex sensitivity (BRS) analysis. VNS significantly altered cardiac structure, increasing heart weight, but did not alter the amount of fibrosis in the hypertensive hearts. These results suggest that VNS has the potential to improve outcomes in subjects with severe HTN.[23]

Aishwarya Nair, Gopala Alaparthi et al did a comparative study on Diaphragmatic Stretch technique and manual Diaphragm release technique on mobility of Diaphragmatic in patients suffering from Chronic Obstructive Pulmonary disease. This randomized trial includes mild and moderate COPD but the patient were stable. Mobility of diaphragm excursion was evaluated by radiologist by ultrasonography and the therapist measured chest expansion by inch The tape. The study finally concluded that patients with Chronic Obstructive Pulmonary Disease can be treated by both the manual Diaphragm release and Diaphragmatic to improve diaphragm mobility.[24]

The review by Picchiottino, Mathieu, Leboeuf-Yde, Charlottein in 2019 compared the acute changes in markers of ANS activity between JMT applied on spinal or peripheral joints and a sham procedure in healthy or symptomatic subjects. They searched PsycINFO, PEDro, PubMed, Cochrane library, EMBASE, and Medline up to December 2017. We updated the search with PubMed, Cochrane library, EMBASE, and Medline including July 2018**.** They reviewed the literature comparing the acute changes in markers of ANS activity between JMT applied on spinal or peripheral joints and a sham procedure in healthy or symptomatic subjects. Method: We searched PsycINFO, PEDro, PubMed, Cochrane library, EMBASE, and Medline up to December 2017. The search was updated with PubMed, Cochrane library, EMBASE, and Medline including July 2018.[25]

Silva PDA, Cidral- Filho F.J in 2019 conducted a study wherein they confirmed Acute effect of non-invasive electric stimulation of the vagus nerve upon blood pressure and heart rate variability

in hypertensive people and that they observed remarkable development in BP and HR variability and proved. Thus Vagal stimulation is used to manipulate blood pressure and heart rate. [26]
In 2018, Waheed Manati, Julien Pineau, and colleagues demonstrated a substantial correlation between cardiac stability and sympathetic balance. One way to alter the vagal antiarrhythmic effect is to lower heart rate. Sixteen pigs were used in the experiment; they were clamped while under general anesthesia. These pigs had an obstructed anterior interventricular artery. Two groups were formed out of them. While the second group's heart rate was regulated at 190 beats per minute using atrial electrical stimulation, the first group's heart rate remained erratic. Each pig had two occlusions, one with stimulation and one without, separated 30 minutes apart. The rhythmic action of the heart was noted. It was noted how long it takes for ventricular fibrillation (VF) to start following blockage. This length of time indicates an antiarrhythmic impact. The study's findings demonstrated a marked increase in the amount of time needed for ventricular fibrillation following blockage. Heart rate might be kept constant. Pigs' atrial electrical stimulation shortened the time it took for ventricular fibrillation (VF) to start following coronary artery occlusion. Patients with hypertension had pressure applied to their paravertebral ganglion regions.[27]
In 2018, Badran, Bashar W., and Dowdle, Logan T. investigated how afferent vagal networks were affected by electrical stimulation of the auricular branch of the vagus nerve (ABVN) by transcutaneous auricular vagus nerve stimulation (taVNS). This was a single-blind, crossover taVNS/fMRI experiment with 17 healthy people. Participants received either left tragus (active) or earlobe (control) stimulation at 500 μs 25 HZ for 60 s (repeated three times over six minutes) based on parameters that have been demonstrated to impact heart rate in healthy people. An investigation into the effects of active stimulation, control stimulation, and comparison was conducted using whole brain fMRI analysis. An examination of the midbrain and brainstem region of interest was also carried out. Significantly higher BOLD signals were obtained by active stimulation in the right frontal cortex, bilateral insula, and contralateral postcentral gyrus. In the contralateral postcentral gyrus, control stimulation resulted in the activation of BOLD signals. Tragus stimulation resulted in noticeably higher BOLD rises in the left prefrontal cortex, right caudate, bilateral anterior cingulate, cerebellum, and mid-cingulate in the active vs. control contrast. They came to the conclusion that the cerebral afferents of the vagal pathway are activated upon stimulation of the tragus.[28]
In 2017, Bashar W. Bardan, Oliver Mithoefer, and colleagues reviewed the physiological impacts on the brain. Auricular vagus stimulation was used on the tragus, and MRIs were performed to examine the effects on different brain regions. A single trial study with seventeen healthy individuals was carried out. The subjects got earlobe control stimulation and active stimulation of the left tragus. A complete brain MRI was performed. MRI scans revealed notable alterations in a number of different brain areas. Significant BOLD values were seen in different brain regions. The study's findings indicated that electrical stimulation through the tragus caused the cerebrum's affrent fibers in the vagal pathway to become active.[29]
In 2017, Debora Fortes Marizeiro and Ana Carolina Lins Florencio conducted a study on inactive women to determine the impact of diaphragmatic myofascial release on lumbar spine range of motion, posterior chain muscular flexibility, respiratory muscle strength, and thoracic wall mobility.75 sedentary women were divided into two groups at random: the control group and the experimental group, which each received two sessions of diaphragm myofascial release techniques. The diaphragm myofascial release technique enhanced the range of motion of the

lumbar spine, the thoracic mobility, and the flexibility of the posterior chain muscles in female patients.[30]

In a 2017 study on pain-free individuals, Emmanuel Yung and Cheongeun Oh divided their patients into two groups at random. While the second group received a placebo as a control, the first group received cervical mobilization. They studied the impact of cervical mobilization in a patient whose blood pressure was almost normal. When compared to a placebo, 44 healthy, pain-free people participated in the trial. The amount of Postero Anterior glide applied caused a brief decrease in Systolic blood pressure, but not to the extent that it was noticeably different.[31]

In 2017, Harald M. Stauss came to the conclusion that activation of both B and A fibres occurs when lower stimulation frequencies and longer pulse length are combined. Rats were used in the study to determine how stimulation affected the respiratory and cardiovascular systems of the animals. Rats' right and left cervical regions were stimulated vagally. The study was conducted on rats that were hypertensive. Rats were put under anaesthesia, and a fake stroke was created. Heart rate and arterial blood pressure were measured to observe the effects of right and left side vagal stimulation. VNS delivered using bipolar coil electrodes to the cervical area. The stimulation parameters that were examined were 3 and 6 volts, 2 Hz to 20 Hz in frequency, and 50μs to 20 ms in pulse duration. Variations in the systolic blood pressure indicated shifts in the breathing rate. A fibres are activated by low frequency and short pulse length, and B fibres are also recruited by extended pulse duration. Compared to right-sided cervical VNS, left-sided cervical VNS significantly improved the cardiorespiratory responses in rats.[32]

A 2017 study by M. De Couck and R. Cserjesi examined the effects of both short- and long-term transcutaneous Vagal NS on heart rate in healthy subjects. In study1, they used a within-experimental design to test a brief 10-min. T-VNS on the right ear versus a sham. The study's findings demonstrated a significant rise in just one HRV component after right ear stimulation. The long-term effects of t-Vagal NS (1h) on the right ear were discovered in a second study. In females, the right vagal NS clearly increased the HRV, but not in males.[33]

In 2017, Xiao M. and Zi Q.Y examined the impact of diaphragmatic breathing on higher functions, specifically affect, cognition, and the cortisol response under stressful settings. Forty participants were randomly assigned to each of the two groups. There was a noticeable improvement in the group receiving diaphragmatic breathing treatment in terms of stress, cognition,andaffection.[34]

In 2017, Yuan Yuan and Jonathan L. Hassel measured sympathetic tone in individuals with epilepsy. 26 patients with drug-resistant epilepsy participated in the trial. ECG electrodes were utilised to continuously monitor the activity of the cutaneous sympathetic nervous system. According to the study, patients who had left Vagal nerve stimulation (VNS) exhibited reduced cutaneous sympathetic nerve activity and heart rate (HR) compared to those who did not get VNS. [35]

A 2017 study by Zong-Baohe and You-kui Liv examined rats' misaligned atlantoaxial joints. As a therapeutic intervention, mobilisation of the atlantoaxial joint was performed. They looked into how the heart changed both before and after the treatment. The study's finding was that both groups' participants' systolic and diastolic blood pressure, or SBP and DBP, were noticeably higher than those of the control group.[36]

A pilot study with 51 patients was carried out in 2016 by Christine M. Goertz, Stacie A. et al. In the first, a group underwent spinal manipulation, while in the second, a controlled group followed a sham technique. For the purpose of controlling blood pressure, the effectiveness and safety of toggling recoil spinal manipulation were noted. 51 patients undergoing treatment for stage 1

hypertension or prehypertensive stage. After spinal manipulation, there was no discernible change in the individuals' blood pressure from the sham group.[37]

A 2016 study by Darling Kescia and Debora Fortes examined the effects of manual therapy on the diaphragm, respiratory muscle strength, and thoracic cavity movement in forty female students with sedentary lifestyles aged 18 to 35. The techniques used were double diaphragm and diaphragm lift. The diaphragm was the target of manual therapy (MT), which significantly increased the respiratory muscle's muscle strength.[38]

In order to synchronise the cardiac cycle with vagal stimulation on the vital signs, such as heart rate and blood pressure, Dennis T.T. Plachta and Josef Zentner (2016) used rats. In the study, six male Wistar rats took part. They were given isoflurane anaesthesia, and the vagal nerve was wrapped in a multichannel electrode. Blood pressure in the left carotid artery was observed. Electrodes with subcutaneous placement were used to perform an ECG. Rats' vagal nerves were stimulated by eighteen different parameters lasting between 15 and 30 ms.Over the course of 30 minutes, blood pressure might be significantly reduced while remaining steady.[39]

A pilot study by Sokolovic, Sekib, et al. (2016) examined how vagus nerve stimulation affected the cardiovascular system in people with hypertension. The device was surgically inserted under the skin on the left side of the body to provide electrical impulses. There were no variations in heart rate noted. After the initial Vagal NS, there was a negligible rise in blood pressure. The heart and blood pressure did not significantly correlate.[40]

50 patients with NSNP were included in a single blinded randomised control clinical trial by Shahzada Iftikhar Hussain in 2016. The patients were divided into two groups using a basic number table in accordance with CONSORT (Consolidated Standards of Reporting Trials) criteria. NAGS was applied to the Mulligan mobilisation in group A, and Maitland mobilisations, grades I and II, were applied in group B. Additionally, both groups received short wave diathermy (ENRAF NONIUS Curaplus 970) in a co-planer, continuous mode, frequency 27.12 MHz, wavelength 11 metres, for 15 minutes, and conventional therapy in the form of ultrasonic therapy (ITO US – 100) in continuous mode, frequency 1 MHz, intensity 1.0 W/cm2 with 70% for 5 minutes. Four weeks of therapy were offered. The Neck Disability Index (NDI) scale and the Numerical Pain Rating Scale (NPRS) were used to assess pain and disability. After two and four weeks of therapy, an assessment was conducted at zero. It was determined that in Grades I and II, mobilising Mulligan, or NAGS, was more successful than mobilising Maitland in terms of improving NPRS and NDI scores in patients with nonspecific neck discomfort.[41]

Gierthmuehlen, Mortimer, Plachta, and Dennis T.T. investigated how metoprolol-treated rats' blood pressure, heart rate, and respiratory rate were affected by selective vagal nerve stimulation. Effect of metoprolol-treated rats' blood pressure, heart rate, and respiratory rate on selective vagal nerve stimulation. The purpose of this study is to look into how the β1-selective blocker metoprolol affects the effects of sVNS, particularly in relation to heart rate. A polyimide multichannel-cuff electrode was used to selectively activate the aortic depressor nerve fibres in ten male Wistar rats by wrapping it around the vagal nerve bundle. The stimulation parameters, which ranged from 30 to 50 Hz in frequency, 0.3 to 1.8 mA in amplitude, and 0.3 to 1.3 ms in pulse width, were tailored to each animal's thresholds. A microtip transducer in the carotid artery was used to monitor blood pressure responses, while electrodes in the chest were used to capture electrocardiography. The animals exhibited a considerable drop in both their heart rate (HR) and mean arterial blood pressure (MAP) following the intravenous administration of metoprolol (2 mg kg-1 body weight).[42]

In 2016, Hyun-Ju Moon and Sung-Hak Cho conducted a comparison of the short-term outcomes of alternative treatment approaches in reducing prehypertensive patients' blood pressure and pulse. Four groups of twelve patients each were randomly selected from a total of 48 prehypertensive patients, and each group was given a different intervention. The hot pack (HP) group received heat treatment, the ultrasound (US) group had an ultrasound massage, and the myofascial release (MFR) group received myofascial release. The control group was instructed to rest. Prior to and following the intervention, the blood pressure and pulse rate were recorded.There was significant improvement in BP and pulse rate in group receiving myofasial release.[43]In 2015, Kaur Amandeep and Maheshwari Preksha conducted research on the impact of belly breathing exercise on cardiovascular response in hypertensive individuals. Thirty subjects were divided into an experimental and control group in this quasi-experimental investigation. For ten days, subjects in the experimental group exercised twice a day while breathing deeply into their abdomens. The blood pressure significantly dropped.[44]

Conclusions

In our review, 19 studies suggest positive outcomes owing to vagal stimulation in prehypertensive individuals on B.P, Heart Rate and hydration. 12 studies indicated uncertainty where authors had conflicting views about the use of vagal stimulation. Few studies favour the use of diaphragm release and Cervical SNAGs. The review revealed that Vagal stimulation is widely used for the rehabilitation of prehypertensive individuals all over the world. The areas of improvement analyzed in the studies on prehypertensive individuals mostly involve Heart Rate, BP and skin hydration. The parameters and outcome measures used in studies investigating the effect of Vagal stimulation are mostly linked to body's autonomic nervous system. There is a scarcity of published data available on the comparasion of Vagal stimulation, Diaphragm release and Cervical SNAGs on autonomic nervous system in prehypertensive individuals. There is scope for future research to analyze the significant effect of Vagal stimulation on sympathetic parameters and how it can prevent risk. Studies with larger sample sizes and homogenous groups along with a clear elaboration of controlling sympathetic parameters strategies should be conducted to gain deeper insights into the topic.

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