# Can natural ways to stimulate the vagus nerve improve seizure control?

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ABSTRACT

The vagus nerve (VN) is the longest cranial nerve innervating the neck, thorax and abdomen, with afferent fibres transmitting a range of interoceptive stimuli and efferent fibres to somatic structures and autonomic preganglions. Over the last few decades, electrical stimulation of the VN using implanted devices (VNS) has been developed leading to its approval for the treatment of epilepsy and depression. More recently non-invasive devices to stimulation the VN have been developed. The VN has many functions and the activity that is most amenable to assessment is its effect in controlling the cardiac rhythm. This can be easily assessed by measuring heart rate variability (HRV). Decreased HRV is a result of poorer vagal parasympathetic tone and is associated with a wide range of ill health conditions including a higher risk of early mortality. People with epilepsy, particularly those with poorly controlled seizures have been shown to have impaired parasympathetic tone. So, might natural ways to stimulate the VN, shown to improve parasympathetic tone as indicated by increased HRV, improve seizure control? There are numerous natural ways that have been shown to stimulate the VN, improving HRV and hence parasympathetic tone. These natural ways fall mainly into 3 categories – stress reduction, exercise and nutrition. Though the natural ways to stimulate the VN have been shown to increase HRV, they have not been shown to reduce seizures. The exception is listening to Mozart's music which has been shown to increase parasympathetic tone and decrease seizures. Clearly much more work is required to examine the effect of the various ways to increase HRV on seizure occurrence.

Key words: epilepsy, vagus nerve, HRV, parasympathetic, psychological stress, exercise, nutrition, seizures

## 1. INTRODUCTION

The vagus nerve (VN), is the $10^{th}$ cranial nerve and is the longest cranial nerve, originating from the medulla oblongata and exiting the skull through the jugular foramen, innervating the structures in the neck, thorax and abdomen. It is involved in autonomic, cardiovascular, respiratory, gastrointestinal, immune, and endocrine systems. The vagal afferents sense a variety of interoceptive stimuli including pressure, pain, stretch, temperature, chemical, osmotic pressure, and inflammation. The vagal efferents innervate both somatic structures and the autonomic nervous system, with fibres to both sympathetic and parasympathetic preganglions. Most VN fibers (60-80%) are afferent fibers from the visceral organs. Detailed anatomy and physiology of the VN have been reviewed [1].

Electrical VN stimulation (VNS) was first tested during the late $19^{th}$ Century, by James Corning, an American neurologist. He was not able to demonstrate an effect on seizures. Corning hypothesized that the VNS would affect cerebral blood flow, which was thought at that time to be the cause of epilepsy. By 1952, VNS was shown in animals to affect the electric currents in the VN and produce changes in the ECG [2]. Subsequent animal studies (reviewed in [3]) contributed to better understanding of VNS and these led to human studies [4, 5]. In 1994, a randomized, multicenter, double-blind study in 67 people with refractory seizures, showed a significant reduction in seizure frequency after 14 weeks of VNS [6]. In 1997, the US Food and Drug administration approved an implanted left cervical VNS device for managing treatment-refractory epilepsy, and subsequently, in 2005, approved its use for chronic treatment-resistant depression. A VNS device has also received in 2015 European approval for the treatment of chronic heart failure. This approval was based on an open study in 60 people with severe heart failure, showing significant improvement in a number of cardiac function measures [7].

More recently, non-invasive VNS devices have also been developed. A trans-auricular VNS device is one such non-invasive device, which stimulates the auricular branch of the VN, was approved in Europe for the treatment of epilepsy and depression in 2010 [8], and pain in 2012 [9]. A non-invasive hand-held trans-cervical VNS device, which stimulates the cervical branch of the VN has received European clearance for use in a range of conditions including  acute and prophylactic treatment of primary headaches, medication overuse headache, reactive airway disease, as well as adjunctive therapy for epilepsy, for preventing and reducing the symptoms of certain anxiety and depression conditions, gastric mobility disorders, and irritable bowel syndrome [3].

## 2. VNS MECHANISM

The precise mechanism of action of VNS is not fully understood.  It has many effects, which can by itself but more likely in concert with others exert the observed anti-seizure properties. These effects include desynchronization of neuronal activity, hippocampal plasticity, anti-inflammation and modulation of neurotransmitter release [10].

The VN senses peripheral inflammation and the signals transmitted to the brainstem then, in turn, generate action potentials carried by the efferent fibres of the VN to the spleen where the production of pro-inflammatory cytokines are inhibited. This has been termed the inflammatory reflex [11]. VNS can activate this reflex. Using the endotoxemic rat model, an anti-inflammatory effect was elicited by trans-auricular stimulation of the auricular branch of the VN. The study showed trans-auricular stimulation decreased levels of inflammatory cytokines in serum, such as TNF-α, IL-1β, and IL-6, as well as the pro-inflammatory transcription factor NF-κB. These anti-inflammatory effects were abolished by vagotomy or administration of an α7nAChR (nicotinic acetylcholine receptor) antagonist [12]. Indeed, a number studies using animal models of inflammatory diseases have demonstrated the beneficial effects of VNS[13].

So VNS probably exerts its anti-seizure effects through a combination of a number of central nervous system effects and its peripheral anti-inflammatory effects.

VNS can trigger the systemic release of catecholamines that can alleviate asthma attacks. It induces anti-nociception by modulating multiple pain-associated structures in the brain and spinal cord affecting peripheral/central nociception, opioid response, inflammation process and pain-related behaviour [10]. VNS is currently undergoing many trials to explore its potential for various other clinical disorders: headache, arthritis, asthma, pain, fibromyalgia, bipolar disorder, and dementia [1].

## 3. ASSESSING VAGUS NERVE FUNCTION

The VN is complex with afferents sensing a variety of interoceptive stimuli, efferents to the autonomic nervous system and somatic structures including the majority of the muscles to the pharynx and larynx. Although the VN serves many functions but its role in generating parasympathetic tone is central to our discussion. The vagal parasympathetic tone is modulated by excitatory input from baroreceptors, chemoreceptors, trigeminal receptors and cardiopulmonary receptors; and inhibitory input from pulmonary stretch receptors, visceral and somatic receptors [14]. Vagal activity can be assessed by examining its effects on the heart using various procedures.

*3.1 Autonomic function tests*

These include deep breathing, Valsalva manoeuvre, isometric exercise, cold pressor, and tilt-table test. Heart rate and blood pressure changes during the tests provide a measure of sympathetic and parasympathetic reactivity [15]. These tests are used less often and have been largely replaced by measures of heart rate variability (HRV).

*3.2 HRV using electrocardiogram (ECG)*

Successive R-R intervals are obtained from continuous ECG recordings. These provide instantaneous heart rates which are used to calculate HRV. HRV depends mainly on the influence of sympathetic and vagal activity on the sinus node. There are many ways to analyze ECG recordings for HRV. Though there is some consensus on the interpretation of the results, there are still areas of debate. The two main methods most commonly used are assessing time domain parameters and assessing frequency domain parameters. In the time domain analysis, HRV is generally assessed by determining SDNN (SD of R–R intervals); however, other measures can also be used including SDANN (SD of average R–R intervals), RMSSD (root mean square of successive differences) and the HRV triangular index [16]. In frequency domain analysis, most investigations suggest that high-frequency (HF) components reflect the parasympathetic tone, whereas low-frequency (LF) components are considered to have both sympathetic and parasympathetic influences, and LF/HF ratios are thought to reflect sympathovagal balance or sympathetic modulations [16].

In a study analysing 24-hour ECG recordings from children, all time domain and frequency domain measures significantly correlated with each other. There were, however, differences in the strength of the correlations. All time domain measures were more highly correlated with HF components than with LF components [17], which suggests that an increase in HRV (as assessed by time domain measures) generally implies a greater increase in HF components and, hence, parasympathetic tone than sympathetic tone. Hence, the following HRV parameters are generally considered to be markers autonomic function and in particular the tone of the parasympathetic system: SDNN, RMSSD, total power and HF power.

### *3.3 HRV using photoplethysmography (PPG) technology*

PPG uses an optical sensor attached to the earlobe or finger to detect cardiac pulse wave by detecting the changes to light absorption as a consequence of the changes in a number of hemoglobin molecules in the skin during the pulse wave. HRV obtained from PPG have been shown to be highly correlated with ECG derived HRV and can be used to assess vagal tone [18]. There are a number of devices using PPG technology that are available to the public e.g. HeartMath's emWave2 for use with home computers and Inner Balance for use with Apple Inc. devices. Recently PPG technology has been implemented in mobile devices by using the cameras as the optical sensor, making home monitoring of vagal tone very easy and affordable. Also, it has been shown that the maximum variation in heart rate (the largest respiratory sinus arrhythmia, also a measure of HRV) during a 1 min deep breathing test showed a better correlation with age when compared using parameters derived from 5 min HRV recordings [18]. Hence a fairly easy algorithm can be used to determine age-adjusted vagal tone.

In general, a high HRV indicates a dominance of the parasympathetic nervous system/vagal tone, the side of the autonomic nervous system that promotes relaxation, digestion, sleep, and recovery. The parasympathetic system is also known as the "feed and breed" or "rest and digest" system. A low HRV indicates the dominance of the sympathetic nervous system, the fight or flight side of the autonomic nervous system associated with stress, overtraining, and inflammation.

## 4. DECREASED PARASYMPATHETIC TONE IN PEOPLE WITH EPILEPSY

In a meta-analysis including 39 studies, people with epilepsy had significantly lower HF, SDNN, RMSSD compared to controls. This supports the suggestion that epilepsy is associated with sympathovagal imbalance, with a decrease in parasympathetic tone [19]. A study which evaluated 19 subjects with refractory epilepsy, RMSSD was used as the measure for HRV. RMSSD was then correlated with SUDEP-7 inventory, which is a measure that reflects the severity of epilepsy – the number of seizures, the duration of epilepsy and the number of AEDs used. The study found a significant inverse correlation between RMSSD and SUDEP-7 scores, suggesting that more severe epilepsy is associated with poorer parasympathetic autonomic function [20]. In another study of 61 subjects, those with intractable epilepsy had greater sympathetic and lower parasympathetic tone compared to those with well-controlled epilepsy [15]. Hence, there is good evidence that people with epilepsy have a poorer parasympathetic tone which is even more impaired in those with severe epilepsy.

## 5. DECREASED PARASYMPATHETIC TONE IN OTHER MEDICAL CONDITIONS

In the prospective Atherosclerosis Risk in Communities study, which included 12,162 participants, one of the outcomes showed that a low HRV was associated with an increased risk of Parkinson disease

[21]. Using HRV as a measure of VN activity, a number of studies have shown a relationship between poor VN activity and inflammatory conditions such as rheumatoid arthritis [22], atherosclerosis [23] and Crohn's disease [24]. In a study involving 1882 subjects with ages ranging 21-76 years, a decreased HRV was identified as a significant predictor for the development of diabetes, cardiovascular disease and early mortality [25].

A low HRV is associated with a wide range of health conditions and is even associated with an increased risk of early mortality.

## 6. VNS EFFECTS ON PARASYMPATHETIC VAGAL TONE

A study was conducted with 48 healthy participants. Following transcutaneous electrical auricular VN stimulation (tVNS), HRV measurements and microneurographic recordings were undertaken. The study found that active tVNS significantly increased HRV, indicating a shift in cardiac autonomic function toward parasympathetic predominance. Microneurographic recordings showed a significant decrease in frequency and incidence of muscle sympathetic nerve activity. The study showed tVNS can increase HRV and reduce sympathetic nerve outflow [26]. In a study including 9 people with refractory epilepsy, the initiation or resumption of VNS following battery replacement was associated with a significant decrease in LF and LF:HF ratio indicating a change in autonomic balance in favour of parasympathetic dominance [27].

Conversely, there are a number of studies showing no change in HRV following VNS [28, 29]. In one particular study involving 17 children aged 3-16 years, VNS was reported to increase sympathetic tone *during sleep* [30]. Some studies have shown variable effects on HRV depending on stimulation conditions and showing interindividual differences [31]. Thus, the studies conducted so far do not provide a clear view on the effects of VNS on HRV. Further work in this area is required to fully understand effects of VNS on the autonomic nervous system.

## 7. RATIONALE FOR STIMULATING THE VAGUS NERVE IN PEOPLE WITH EPILEPSY

People with epilepsy have been shown to have poorer vagal/parasympathetic tone when compared with control populations. It has also been shown that severe epilepsy is associated with decreased parasympathetic tone compared to those with better seizure control. Decreased parasympathetic tone also appears to be associated with a number of negative health outcomes. These observations suggest that improving parasympathetic tone may improve seizure control and general health in people with epilepsy. Stimulating the VN with implanted devices has been shown to improve seizure control and indeed some studies show VNS to improve parasympathetic tone. Implantable VNS devices incur significant costs and support from health care professionals. The non-invasive VNS devices are much better with respect to these considerations. These observations raise the question: Are there natural ways to stimulate the VN and increase parasympathetic tone? Indeed there are a whole gamut of procedures that have been shown to increase parasympathetic tone as demonstrated by the procedures to increase HRV.

## 8. NATURAL WAYS TO STIMULATE THE VAGUS NERVE

The natural ways to stimulate the VN can be listed by the 3 main categories of lifestyle factors that are thought to have an important impact on an individual's health. The 3 main factors are nutrition, exercise and psychological stress. Reducing psychological stress is likely to have the greatest impact on people with epilepsy, who generally regard stress as the commonest trigger for seizures [32] . Ways to reduce psychological stress will be discussed first.

## 8.1 Reducing psychological stress

### 8.1.1 Slow breathing exercises

In a study including 39 healthy volunteers, the effects of slow breathing pace (respiratory rate 6 breaths/min) for 5 mins on heart rate and blood pressure was assessed. In another 10 volunteers, the breathing exercise was performed 30 mins after an oral intake of 20mg hyoscine, a drug that is known to block vagal parasympathetic tone. The slow breathing exercise produced a significant fall in both the systolic and diastolic blood pressure with a slight fall in heart rate. No significant alteration in both blood pressure and heart rate was observed in volunteers who performed the same breathing exercise following oral intake of hyoscine. These results suggest that slow breathing exercise can stimulate the VN increasing vagal tone, lowering blood pressure and heart rate [33].

Slow breathing at 6 breaths/min can increase HRV, but determining the individual's resonant breathing frequency with feedback techniques and then continuing to breathe at that frequency produced an even greater increase in HRV [34]. An individual's resonant breathing frequency was determined by finding the frequency (4.5 to 6.5 cycles/min at 0.5 cycles/min intervals) at which respiratory sinus arrhythmia was maximal.

### 8.1.2 Chanting

A study with 12 healthy volunteers (9 men), examined the effect of 'OM' chanting compared with the pronunciation of 'ssss' on the neurohemodynamic responses using functional Magnetic Resonance Imaging (fMRI). When comparing the resting brain state with the state during 'OM' chanting, the latter state produced significant bilateral deactivation of orbitofrontal, anterior cingulate, parahippocampal gyri, thalami and hippocampi. In addition, the right amygdala was also shown to demonstrate significant deactivation. In contrast, the pronunciation of ‘ssss’ showed no changes. The authors suggest that the sensation of vibration experienced during 'OM' chanting produce the brain deactivation through stimulation of the auricular branch of the VN. Similar deactivation have been recorded with VNS used in depression and epilepsy [35].

In a study of 15 healthy 18 year olds, analysis of HRV and respiratory sinus arrhythmia showed that humming and mantra chanting increased vagal tone [36].

8.1.3 Music therapy

A study invited 23 subjects who had received treatment for cancer and recovered, they participated in a 2-hour music therapy session, including singing, listening, learning and performing music. HRV assessed after the sessions showed that measures of parasympathetic activity were significantly increased after the sessions [37].

8.1.4 Listening to Mozart’s music

Listening to Mozart’s K448, a sonata for 2 pianos, has been shown to reduce seizures in Long-Evans rat, interictal epileptiform discharges and seizures in children [38]. A randomized controlled study, has shown that listening to K448 every evening for 6 months significantly reduced epileptiform discharges and the incidence of a seizure recurrence in children diagnosed with their first unprovoked seizure [39]. Mozart K545 [40] and other Mozart music [41] also appear to have similar effects but K448 has been best studied. So far, It has been shown that there is parasympathetic activation in children listening to Mozart K448 and 545 [42] and this is likely to be one of the mechanisms for the effect of Mozart’s music on seizures [38].

8.1.5 Positive emotions and positive social connections

In a randomized study, 65 participants were randomly assigned to an intervention group or to a waiting-list control group. Those assigned to the intervention group practiced loving-kindness meditation to self-generate positive emotions. Participants in the intervention group increased in positive emotions and vagal tone (by determining the HF component using frequency domain analysis) relative to those in the control group. Analysis using different models suggest that the positive emotions effect on vagal tone was mediated by increased perception of social connections [43].

It is of interest to note that a meta-analysis including 148 studies (308,849 participants) showed a 50% increased likelihood of survival for participants with stronger social relationships. The influence of social relationships on risk for mortality is comparable with well-established risk factors for mortality such as smoking [44].

8.1.6 Mindfulness practice

A number of recent studies have provided preliminary evidence for mindfulness practice and its association with increased parasympathetic tone [45, 46]

8.1.7 Practice forgiveness

In a study including 60 healthy females, HRV was assessed during baseline (thinking about a transgressor and feeling frustrated) and recovery conditions. Subjects were randomized to 3 recovery conditions: forgiveness (imagine forgiving the transgressor); extended frustration (continue thinking about transgressor); and distraction (reading neural material). Participants in the forgiveness group had higher HRV compared to both the extended frustration and distraction conditions [47].

8.1.7 Laughter

Several studies have shown an association between laughter and better health [48-50]. In a pilot study, 6 participants awaiting organ transplantation met for 10 sessions over 4 weeks. The 20 min laughter intervention sessions consisted of 5 mins simple breathing and stretching exercises, 10 mins of laughter alternating with clapping and chanting and ending with 5mins of meditation. Following the laughter intervention sessions, SDNN and RMSSD were consistently increased in all subjects [51]. The results indicate an increase in HRV and hence activation of the VN following the laughter intervention.

## 8.2 Exercise

### 8.2.1 Aerobic

In an animal study, mild exercise has been shown to increase gastric motility. This effect is thought to result from stimulating the VN, as the effect from exercise is abolished after vagotomy [52]. Studies have shown that cardiac vagal tone as assessed with HRV is increased in athletes compared to sedentary controls [53]. A study offered an exercise program that was followed by a sedentary adult males group. When compared with the control group, the results showed significant changes in HRV parameters that are indicative of enhancing vagal tone in the group that followed the exercise program[54]. Another study showed the increase in vagal tone becomes particularly evident following vigorous exercise [55]. The ILAE task force has summarised the evidence for the beneficial effects of exercise on seizure control [56]. Some of these effects may result from exercise stimulating the VN.

### 8.2.2 Stretching

HRV has been shown to be increased post stretching exercise in 15 healthy pregnant women [57], and in 10 young men with low flexibility levels [58].

8.2.3 Resistance training

Resistance training has been shown to increase HRV in 13 subjects with chronic obstructive pulmonary disease [59], in 20 males with coronary artery disease [60] and in 24 obese adolescents [61].

8.2.4 Yoga

A number of studies have shown the effect of various yoga practices on increasing HRV. In a recent study with 40 subjects who practised yoga physical postures, breathing exercises and meditation for 1 hour a day for 1 month. After 1 month, both time domain and frequency domain HRV analysis showed an increase in parasympathetic tone [62]. So various yoga practices seem to activate the VN.

## 8.3 Nutrition

8.3.1 Omega-3 fatty acids

Results from a research study involving 180 Polynesian adults have shown a correlation between omega-3 fatty acid status and HRV: erythrocyte DHA (docosahexaenoic acid, a long chained omega-3 fatty acid found in fish) concentration was significantly correlated with HF power and RMSSD [63], measures of parasympathetic tone. Indeed a growing number of studies have shown an increase in HRV with higher fish intake or omega-3 fatty acid supplements. In a population-based cross-sectional study, increasing fish consumption was significantly correlated with several HRV indices (higher RMSSD, higher HF power, lower LF/HF ratio) indicative of higher parasympathetic activity [64]. In a randomized study including 95 male subjects, thrice weekly consumption of Atlantic salmon over several months led to a significant increase in resting HF power compared to the control group [65]. Hence increasing consumption of fish may help to stimulate the VN.

8.3.2 Probiotics

It is thought that the gut microbiome can affect human brain health through a number of different mechanisms. One of these is through stimulation of the afferent neurons of the VN [66]. In animal studies, the probiotic bacterium *Lactobacillus rhamnosus* has been identified and shown to cause neurochemical changes in the brain, these changes are abolished after vagotomy [67]. Therefore, it may be plausible that consuming more fermented foods, improving the gut microbiome, may lead to stimulating the vagal afferents to the brain.

8.3.3 Fasting

A number of studies in humans have shown that calorie restriction over 6 months leads to increased HRV [68]. Studies using animals have looked at the effect of calorie restriction and intermittent fasting and found both intervention increased HRV [69]. It has also been suggested that intermittent fasting through its metabolic effects may have anti-seizure effects [70].

## 8.4 Other procedures

8.4.1 Massage

Many massage techniques have been shown to increase HRV/ vagal tone including Chinese head massage [71]; traditional Thai shoulder, neck and head massage [72]; traditional Thai back massage [73]. Even self-massage has been shown to increase HRV [74].

8.4.2 Cold water facial immersion

Studies have shown that subjects submerged to mid-sternal level in cold water kept at 14 - 15 degrees C [75] or cold water (10 – 12 degrees C) facial immersion [76] following exercise led to greater reactivation of the parasympathetic system as assessed by HRV indices. Acclimation to cold has also been shown to increase parasympathetic tone [77].

#### 8.4.3 Gag reflex

In a study of 12 male university students, the gag reflex elicited by tactile stimulation of the posterior pharyngeal wall using a cotton cover swab in sitting position produced a significant rise in heart rate over the next 5 mins but a significant fall in LF and LF/LH ratio and showed a trend for an increase in HF. The results indicate the gag reflex can stimulate the VN [78]. Some people as part of their oral hygiene scrape their tongue following brushing their teeth. Tongue scrapers/cleaners which are widely available can be used to elicit the gag reflex when the regions of tongue towards the back of the throat are scraped.

#### 8.4.4 Sleeping on your right side

In a study of subjects with coronary artery disease, the control group with patent coronary arteries show the highest parasympathetic tone following 5 mins of lying in the right lateral decubitus position. Parasympathetic activation was the lowest in the supine position [79]. This study suggests that lying on your right side when sleeping is likely to be best for stimulating the VN.

## 9. DISCUSSION

VNS has been clearly shown to have both central and peripheral effects. It is likely that the central effects are responsible for its efficacy but it is possible that its peripheral effects particularly its effects on inflammation contributes to its efficacy on seizures. The use of natural ways to stimulate the VN are likely to involve the vagal afferents and central connections, at present, we only have evidence of its efferent effects through assessing HRV. Like VNS, the natural ways to stimulate the VN are likely to have central effects which may contribute to seizure reduction. Even if the natural ways to stimulate the VN do not have central effects, its peripheral effects are likely to be beneficial to people with epilepsy. Almost all the natural ways to stimulate the VN above have been shown to increase HRV.

Careful examination of the studies conducted suggest that manoeuvres to increase HRV are more effective in subjects with poor HRV. This is intuitively what one might expect and moreover, has been discussed a review that assessed the effect of exercise on HRV [80]. People with epilepsy and particularly those with poorly controlled seizures have been shown to have decreased parasympathetic tone, hence, ways to stimulate the VN are likely to produce greater increases in parasympathetic tone than in normal subjects.

Many different methods to stimulate the VN have been discussed. It is likely that a combination of different natural methods will need to be used to produce a measurable improvement in HRV. It would probably be best to select methods from all the different approaches – reducing psychological stress, exercise and nutrition. The standard medical paradigm can be referred to as monotherapeutics, i.e. one therapy, one drug for each health condition. Combinations are then used when the single therapy approach is not effective. There is now a growing awareness that comprehensive management of ill health requires multiple approaches including management of lifestyle factors. An example of the preliminary data showing signs of success using multiple approaches is the reversal of the cognitive decline in people with Alzheimer's and cognitive impairment, which includes an individualized, iterative, multi-pronged program including optimising biomarkers, nutritional supplements, fasting, exercise, brain stimulation, stress reduction and sleep optimization [81, 82].

There is good evidence that people with epilepsy have poorer HRV and hence, have impaired parasympathetic tone, but there are no data in the literature that has looked at increasing HRV using the methods mentioned above, that would lead to better seizure control. The exception is listening to Mozart's music which has been shown to increase parasympathetic tone and decrease seizure occurrence. Clearly, more work is required to demonstrate that other methods of increasing parasympathetic tone are also accompanied by a reduction in seizures. In the meantime, people with epilepsy can adopt some of the natural ways to stimulate the VN as most of them have been shown to improve parasympathetic tone which has positive benefits for general health.

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