The Vagus Nerve: function, dysfunction, and the frequency of balance.

Introduction:
The vagus nerve is a cranial nerve that has been gaining popularity in a wide variety of health and wellness industries from yoga studios to medical facilities and everything in between. The reasons for this is the discovery of the important role the vagus nerve has in activating the parasympathetic nervous system (rest and digest) and regulating the sympathetic nervous system (fight or flight). These two functions of the autonomic nervous system are both needed in order for us to respond to our environments appropriately as well as maintain the normal functioning of our body when we are at rest. Healthy functioning is when the sympathetic and the parasympathetic are in equilibrium with each other, alternating states of alertness and rest as we respond to stimuli in both our internal and external environments. It is when we experience circumstances, both real and imagined, that keep us hyper alert or immobilized (or oscillating between the two) for a prolonged period of time that we can find ourselves in trouble. Having a chronically dysfunctional autonomic nervous system creates stress and exhaustion which can lead to chronic conditions or disease. Research has shown that stimulating the vagus nerve can help activate our parasympathetic nervous system by increasing vagal tone and therefore regulating the sympathetic response. This paper aims to provide an introductory overview of the nervous system, review the form and function of the vagus nerve, and offer insight into some ways that frequency can be used to regain and maintain balance.

Divisions of the Nervous System:
The nervous system is our communication highway, constructed of nerve cells (neurons) that form cable-like fibrous structures that connect us to everything in our internal and external environments. It is the control center of the body that coordinates all functions.

Although it is an extremely complex structure, we begin to understand it by breaking it down into two categories: the central nervous system (CNS) and the peripheral nervous system (PNS). The CNS includes the brain and the spinal cord. The PNS includes all of the nerves that branch off of the brainstem and the spinal cord. There are 43 pairs of peripheral nerves; 12 cranial nerves (branching from the brain stem) and 31 spinal nerves (branching from the spinal cord). The peripheral nerves go to all of the 12 body systems, passing information to and from the brain via electrical impulses and chemical signaling. There are motor fibers that have efferent pathways (information sent out from the brain) and sensory fibers that have afferent pathways (information sent to the brain). Some nerves are one directional (efferent or afferent), while others are bidirectional (efferent and afferent).

The peripheral nerves have a root-like structure, being the largest the closer they are to the CNS and branching out to fine fibers the further they extend out towards the organs and extremities. A microscope is needed to see the smallest nerve fibers as they are not visible to the human eye.

The peripheral nerves are categorized into two subdivisions, the somatic nervous system (SNS) and the autonomic nervous system (ANS). The somatic nervous system controls voluntary functions of the body through muscle movement, mediates reflex actions, and receives sensory input. It contains sensory neurons that send information from the muscles, joints, and skin to the brain and motor neurons that send information from the brain to the skeletal muscles.

The autonomic nervous system regulates involuntary functions of the body such as breathing, heart rate, gland secretion, and digestion. The ANS is divided further into two subcategories. The sympathetic nervous system ("fight or flight") mobilizes the body when it perceives a threat and the parasympathetic nervous system ("rest & digest") helps the body return to a state of relaxation where the body functions at its optimal level. These two divisions of the ANS communicate via efferent and afferent pathways, transmitting information between the body systems and the brain.

Vagus Nerve Anatomy:
The vagus nerve is one of the 43 peripheral nerves. It is the X (10th) cranial nerve originating from the brain stem, specifically the medulla oblongata whose main function is to regulate the body's essential involuntary functions. It is the longest of the cranial nerves.

The vagus nerve got its name from Latin. *Vagus* translates to "Wanderer". It is easy to see why this structure would be called a wanderer when trying to follow it from its origin in the brainstem to where it seemingly disappears somewhere in the abdominal cavity. Nerves run in pairs, so the vagus nerve is actually two nerves, not one, that travel down both sides of the body. It has its own peripheral branches that extend out to reach organs and other structures along its pathway, such as the larynx, vocal cords, the skin of the ear canal, and the internal organs. It is involved in many functions of the body such as swallowing, vocalization, breathing, sensation reception in the ear, heart rate, digestion, communication, regulating the body's response to stress, and promoting relaxation.

Beginning at the medulla oblongata, the nerve leaves the skull at the jugular foramen (a hole in the base of the skull where delicate structures such as blood vessels and nerves pass). Traveling downward and branching outward and even upward, it reaches the facial muscles, ears (skin of the ear canal, triages, tympanic membrane, and outer ear), the larynx, and the tongue. It continues down the neck bundled up with the carotid artery and jugular vein eventually sending fibers to the heart and the roots of the lungs where the heart and the lungs connect. It travels through the esophageal hiatus (a hole in the respiratory diaphragm) alongside of the esophagus to the stomach and branches to the other abdominal organs from the celiac plexus (solar plexus). It is possible that it extends beyond the abdomen, however it most likely becomes too microscopic to follow.

The vagus nerve is part of the parasympathetic division of the autonomic nervous system. It is a multidirectional nerve, having both efferent (motor) and afferent (sensory) fibers giving it the ability to both send and receive messages to and from the central nervous system. It is often divided into the ventral vagus nerve (above the diaphragm) and the dorsal vagus nerve (below the diaphragm). It plays an essential role in maintaining homeostasis in the body.

Vagus Nerve Function & Dysfunction:
The activity of the vagus nerve is often referred to as vagal tone. High vagal tone is associated with optimal activity. In this state it promotes relaxation, maintains body systems function, and aids in the recovery from the sympathetic "fight or flight" response. High vagal tone helps regulate healthy speech and communication, digestion and gut health, lower resting heart rate, increased heart rate variability, and social and emotional connection. It helps to keep us physically, mentally, emotionally, and socially balanced.

Low vagal tone is associated with dysfunction and can disrupt physical, mental, emotional, and social balance. This can result in digestive issues, mental health challenges, emotional dysregulation, fatigue and low energy, low heart rate variability, and an increase in stress.

Causes of vagus nerve dysfunction are numerous, complex, and not well understood. It can be triggered by physical, mental, and emotional events. Some examples are physical injuries such as head trauma and whiplash, surgical procedures, chronic inflammation, autoimmune diseases, stress (both real and imagined), emotional trauma, diabetes (which can cause neuropathy), and some infections such as Lyme disease or Epstein-Barr virus.

If low vagal tone becomes chronic a wide range of symptoms, conditions, and/or diseases can result. Some of these include cardiovascular disease, chronic pain syndromes, diabetes, anxiety, migraines, digestive disorders such as IBS, acid reflux, sleep disorders, brain fog, difficulty breathing, hoarseness, and depression.

If any of these more serious conditions develop, it is important to seek the care of an appropriate medical professional. However, increasing vagal tone can help balance the autonomic nervous system and positively affect all of the body's functions. Vagal nerve stimulation is an approach used to increase vagal tone that has been gaining popularity in the wellness industry with a wide variety of methods. It has even been referred to as the potential "off switch" for disease.

The Frequency of Balance

Vagal nerve stimulation is a treatment or practice that alters the activity of nerves and influences the release of neurotransmitters (such as norepinephrine and serotonin) in the brain. It calms abnormal electrical activity, increases blood flow in the brain, stimulates healthful hormone and enzyme production, increases neuroplasticity, and modulates the entire autonomic nervous system. There are many forms of vagal nerve stimulation that are generally classified as either invasive or non-invasive.

Invasive battery operated devices are similar to a pacemaker and are implanted under the skin near the chest with wires connecting to the vagus nerve in the neck, sending electrical impulses to the brain. The FDA has approved its use for epilepsy, depression, and stroke rehabilitation, but it has also been shown to have positive therapeutic effects on other conditions such as anxiety, obesity, Rheumatoid arthritis, and Alzheimer's disease. Although relatively safe, there are some side effects associated with any invasive procedure such as pain and inflammation, infection, and/or tissue damage. Shortness of breath, hoarseness, changes in voice, and headaches have also been reported.

Non-invasive vagal stimulation technology works in a similar fashion, but has few if any side effects. Focused ultrasound (FUS) uses sound waves and external electrode devices use mild electrical impulses that are applied on the skin over the nerve to stimulate or inhibit neurosignaling. They are small hand-held devices that can be used at home under the proper guidance of a medical professional. Common areas of application are at the ear and throat. They are used for epilepsy, anxiety, depression, reducing blood pressure and inflammation, pain management, diabetes, and obesity.

Another non-invasive approach is sound therapy. Recorded sound vibrations are played via headphones, vocalizations are made by the individual, or instruments are used to stimulate the

vagus nerve endings located in the ears, throat, and chest. The vibrations are carried along the nerve to the brain and the various organs it connects to. Below are some examples of sound therapies:

- **Filtered Music Therapy:** specific frequencies are accentuated in recorded music that stimulate the vagus nerve out of hyperarousal or shutdown and into a more regulated, grounded state through the ears. Stephen Porges, creator of the Polyvagal Theory, developed a filtered music therapy called the *Safe and Sound Protocol* (SSP). Frequencies found in human speech are prioritized and the individual's own voice can be incorporated. This approach often combines other therapies such as talk therapy to increase efficacy.

- **Humming, Singing, Gargling, and Chanting:** vocalizations directly affect the vagus nerve as it connects to the vocal cords. Om chanting is believed to stimulate the auricular branch of the vagus nerve, which runs through the ear canal. Combining deep breathing, meditation, or cold therapy can amplify these benefits.

- **Musical instruments:** playing instruments can also have a profound effect on the vagus nerve. The frequencies are picked up by the nerve endings in the ear, but they are also felt by other areas of the body. Placing a singing bowl on the chest can help relax the diaphragm where the vagus nerve passes to the abdominal cavity via the esophageal hiatus. Tuning forks can be used as well, but should never be placed directly on the head. Just listening to any consistent stable vibration can induce relaxation and positively impact the vagus nerve both directly and indirectly.

- **Spending Time in Nature**: all of nature has its own frequencies. The more our systems are exposed to these natural sounds and other natural frequencies, the more we become entrained by them. In Japan "forest bathing" (shinrin-yoku) is even prescribed by some doctors to reduce stress and anxiety.

Conclusion:
The devices that are used in clinical practice are still being researched as to how they function and the impact they have on the body depending on the application of frequency and intensity. Science is still learning in general how vagal nerve stimulation works, but there is an inherent value to be gained from experiential evidence and long-term observation. Sound frequencies are used and have been used for thousands of years around the world as forms of medicine.

Ultimately, there are many ways to stimulate the vagus nerve. Experimenting with several approaches, getting professional support when appropriate, and listening to how the body responds are essential for customizing treatments and practices that fit both the person and the condition(s) being treated. Even when disease or dysfunction are not present, consistent vagal toning helps to maintain physical, mental, emotional, and social balance, which are fundamental to overall health and well-being.