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Original research article

Taming the Vagus is the key to alleviate body dysfunction: A Narrative Review

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Abstract

Background: Very often the Combating effects of vagal tone regulated by its afferents, to reduce stress and inflammation have been published in literature under the disguise of the old traditional breathing exercises and their effects on the different systems of the body. This review is an effort to establish literature evidence supporting the paradigm shift from classroom teaching to clinical application about the physiology of the tenth cranial nerve, whose power has been underestimated by the human.

Data Source and Search Strategy: The electronic database of PUBMED/MEDLINE, Wiley online Library, Scopus and related articles was searched for available literature on key words vagus nerve and prolonged expiration, breathing techniques, immunity, yoga, pranayama and dysfunction. After reviewing the literature by different authors, a brief review was conceptualized from the same.

Discussion and Conclusion: The role of vagus nerve is thus intriguing considering its vast connectivity and multiple projections leading to modulation of the different body functions. The parasympathetic-sympathetic balance resetting mechanisms executed through the feedforward and feedback vagal neural networks have shown to produce such biological effects which have alleviated several body dysfunctions. Moreover, regular practice have also shown to have long term effects on the body.

Keywords: Vagus nerve, prolonged expiration, breathing techniques, immunity, yoga, pranayama, dysfunction

1. Introduction

It is not long before that one has heard in their physiology classes about the neural control of breathing as a medical student. The inflation stretch reflex conveyed via the myelinated tenth cranial nerve to the apneustic centre, leading to inhibition of the inspiration and thus promoting prolonged expiration is a well-known fact being studied in isolation. And at the other edge of the paradigm, standing secluded from this basic knowledge are the beneficial effects of contemporary sciences, Yogic Sciences, breathing exercises that prevail and are reported in literature very often. Time and now many authors have revealed the mysteries of Vagus and Breathing and its dramatic effect on the different systems of the body, however still oblivious. Since years Vagus has been recognised by several latin synonyms named vagrant or wanderer. Originating from the brainstem and the cerebellum, it connects the major organs of the body till the abdomen through 20% efferent and 80% afferents which help to complete the feedback mechanism conveying the disturbances in the resting state/homeostasis of the body to the brain and hence modulating several processes in the human body. It was German Scientist Otto Loewi who discovered that stimulating the vagus nerve causes slowing of the heart and later he accidently discovered the neurochemical transmitters in the heart released by the Vagus. He concocted the word Vagusstoff for this neurotransmitter, which is today recognised as acetylcholine: the first neurotransmitter accidently discovered by scientists (McCoy & Tan, 2014). The aim of this review is to re-establish through evidence, the ways of administration of tranquilizing action of this nerve and the propounded effect on the various systems of the body. Very often the Combating effects of vagal tone regulated by its afferents, to reduce stress and inflammation have been published in literature under the disguise of the old traditional breathing exercises and their effects on the different systems of the body. This review is an effort to establish literature evidence supporting the paradigm shift from classroom teaching to clinical application about the physiology of the tenth cranial nerve, whose power has been underestimated by the human.

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2. Data Source and Search Strategy

The electronic database of PUBMED/ MEDLINE, Wiley online Library, Scopus and related articles was searched for available literature on vagus nerve, slow breathing and pain and body dysfunction. After reviewing the literature by different authors a brief review was conceptualized from the same. All authors equally contributed in conceptualising and writing the manuscript.

3. Study Selection and Screening

The Included Studies were only full text articles or reviews from reputed organisations. Information was gathered in a spreadsheet shared by the authors and included articles chronologically from the past to present, discussing the different effects on the body and different systems.

4. Data Extraction and study quality assessment

The data was independently extracted by the investigators from the data base and reviewed to validate the articles. Brainstorming sessions amidst the authors helped to exclude the biasness, however there was no blinding of reviewers and journals. All the authors equally contributed in writing the review. The full text articles from reputed websites and journals were included, to ensure quality of the review and to present an unbiased, well documented clinical aspect through scientific evidences.

5. Study characteristics and Discussion

The primary aim of this narrative review is to re-establish through evidence, the ways of administration tranquilizing action of vagus nerve and the propounded effect on the various systems of the body.

5.1 Vagus nerve and musculoskeletal system

Chronic inflammatory conditions like RA and SLE have been observed to have an altered sympatho-parasympathetic balance in the body. Studies in animal modals have suggested that complete excision of vagus can exacerbate symptoms whereas cholinergic system activation can attenuate the effect. Moreover, it has been found that there is expression of the α7nACh receptors in these musculoskeletal disorders in the inflamed joint synovium. However, the efferent vagus nerve component can modulate the immune system and reduce the TNF and other cytokines released by the macrophages via the α7nACh receptors signalling which thus plays a significant role in controlling the inflammatory responses. (Bruchfeld *et al*., 2010; Koopman *et al*., 2016).

5.2 Vagus nerve and Cardiovascular and Respiratory system

One may propose to stop breathing but cannot stop the heart. This lead to an assumption that it is not possible to alter the heart rate voluntarily. The modulation of Heart rate with each breath i.e. increase during inhalation and decrease during exhalation is an aftermath of the vagal tone and is a parameter generally studied in CANS testing.

The Cardiac autonomic Nervous system testing (CANS) detects the abnormalities particularly in the parasympathetic activity by studying the Variability in the High Frequency range. A reduction in Heart Rate Variability is an independent indicator of Morbidity and Mortality and the dysfunction has been found to be inversely related to the inflammatory marker C-reactive protein and WBC counts and is also suggestive of inflammatory atherosclerosis. (Bruchfeld *et al*., 2010). A higher Heart Rate Variability indicates better conditioning of the hypothalamo-pituitary-adrenal axis leading to lower levels of stress and diseases.

Yoga Meditation in form of listening to relaxing music can affect the gene expression pathway in susceptible participants and thus the cardiac autonomic system. (Black *et al*., 2012). Also, the Inhalation: Exhalation Ratio which suggests slow breathing and longer expiratory phase is adopted during Yoga Practice while doing several effective pranayama which conveys state of relaxation to the higher centres, further enhancing the Vagus activity and culminating into accentuated unwinding. It is thus propounded that one can modulate the heart beat via this constant monitoring system established by the "great Wandering protector" through its afferent branches ascending all the way upto the medulla to integrate several systems, which not only control the heart rate and breathing but also via the mechanoreceptors in the airways convey the lumen size, the I:E and the pattern of breathing. (Gerritsen & Band, 2018). Thus, a slow deep breathing with prolonged expiration can induce a parasympathetic dominance via the vagus nerve. (Gerritsen & Band, 2018)

5.3 Vagus nerve and psychosocial component

In a study done by authors Barbara Fredrickson and Bethany Kok in the year 2010 (Kok *et al*., 2013a) they could establish the vagus nerve as a part of the feedback mechanism between emotions and physical health and also exhibited the psycho social component of the same. The authors have also tried to establish the importance of interpersonal relationships to have an effect of the vagal tone index. (Gerritsen & Band, 2018). Moreover, the production of the stressor hormones from the adrenal glands is also convey efficiently to the brain via this tenth cranial nerve. The afferents of this nerve are also

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connected to the limbic system and the prefrontal cortex which may play a vital role in the Cognition, positive emotion and self-esteem of an individual through the neurovisceral feedback and feedforward mechanism. (Conway *et al*., 2018; Gerritsen & Band, 2018; Kok *et al*., 2013)

5.4 Vagus nerve and the Gut

There is plethora of evidence which establishes relationship between the gastrointestinal system and the vagal activity. The gastrointestinal viscera including the liver also ends its signals and via the vagal afferents to the medulla where they are further amalgamated with those received from the other systems of the body. (Bonaz *et al*., 2016; Gerritsen & Band, 2018)

5.5 Vagus nerve and immune system

Not only does the vagal nerve substantiates evidence for having relation with the bones, joints, brain and gut but also is related to the immune system by affecting the regulation of the cytokines in the body and thus could in turn affect the former systems. (Gerritsen & Band, 2018; Koopman *et al*., 2016)

6. Implications

Artificially stimulating the vagus afferents have been found to help alleviate mood disorders in subjects with treatment resistant depression, in dementia and has also depicted similar effects on the CNS, heart, lungs and the production of inflammatory products and the pathway.(Aaronson *et al*., 2017; Conway *et al*., 2018) Vagus nerve approached transcutaneously through the auricles and neck region has also shown similar effects.

Stimulation of the vagus nerve by either self-administered prolonged breathing regularly can have long term effects on the vagal tone and through it can affect the cortical connection and the psychosomatic component of body dysfunctions by altering the autonomic balance towards parasympathetic dominance by neuro-immuno modulation and also alters the default setting in the neural networks including the HPAxis. The stretch receptors in the arterial walls also activate the vagus leading to reduction in the heart rate and blood pressure, and the sensitivity for this cardiovagal baroreflex can be increased by breathing at 6 breaths per minute (0.1 Hz) which is the recommended breath rate even for measuring the HRV variables at rest. (Black *et al*., 2012; Gerritsen & Band, 2018)

7. Conclusion

The role of vagus nerve is thus intriguing, considering its vast connectivity and multiple projections leading to modulation of the different body functions. The parasympathetic-sympathetic balance resetting mechanisms executed through the feedforward and feedback vagal neural networks have shown to produce such biological effects which have alleviated several body dysfunctions. Moreover, regular practice has also shown to have long term effects on the body.

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