

The Role of Yoga Intervention in the Treatment of Allergic Rhinitis: A Narrative Review and Proposed Model

Ripudaman Singh Chauhan^{1*}, Rajesh S.K²

¹Ph.D. Scholar, Division of Yoga and Life Sciences, Swami Vivekananda Yoga Anusandhana Samsthana, 19, Eknath Bhavan, Gavipuram Circle, K.G. Nagar, Bangalore, India, ²Associate Professor, Division of Yoga and Physical Sciences, Swami Vivekananda Yoga Anusandhana Samsthana, 19, Eknath Bhavan, Gavipuram Circle, K.G. Nagar, Bangalore, India,

ABSTRACT

Allergic Rhinitis (AR) is an IgE (immunoglobulin-E) mediated inflammatory condition of upper respiratory tract; main clinical features involve runny nose, sneezing, nasal obstruction, itching and watery eyes. AR is a global problem and has large variations in incidences, currently affects up to 20% - 40% of the population worldwide. It may not be a life-threatening disease per se but indisposition from the condition can be severe and has the potential to adversely affect the daily functioning of life. Classical yoga literature indicates that, components of yoga have been used to treat numerous inflammatory conditions including upper respiratory tract. A few yoga intervention studies reported improvement in lung capacity, Nasal air flow and symptoms of allergic rhinitis. This review examined various anti-inflammatory pathways mediated through Yoga that include downregulation of pro-inflammatory cytokines and upregulation of anti-inflammatory cytokines. The hypothalamic-pituitary-adrenal (HPA) axis and vagal efferent stimulation has been reported to mediate anti-inflammatory effect. A significant reduction is also reported in other inflammatory biomarkers like- TNF-alpha, nuclear factor kappa B (NF-κB), plasma CRP and Cortisol level. *Neti*, a yogic nasal cleansing technique, reported beneficial effect on AR by direct physical cleansing of thick mucus, allergens, and inflammatory mediator from nasal mucosa resulting in improved ciliary beat frequency. We do not find any study showing effect of yoga on neurogenic inflammation. In summary, Integrated Yoga Therapy may have beneficial effect in reducing symptoms and improving quality of life for patients with allergic rhinitis. Yoga may reduce inflammation through mediating neuro-endocrino-immunological network. Future studies are needed to explore the mechanism how yoga might modulate immune inflammation cascade and neurogenic inflammation at the cellular level in relevance to allergic rhinitis; the effects of *kriyas* (yogic cleansing techniques) also need to be evaluated in early and late phase of AR. So the proposed model could guide future research.

Keywords Inflammatory mediators, *Shuddhi Kriya*, *Neti*, Yoga, Allergic Rhinitis

INTRODUCTION

Allergic Rhinitis (AR) is an IgE (immunoglobulin-E) mediated inflammatory condition of upper airways (Hellings & Fokkens, 2006). The main clinical features involve a runny nose, sneezing, nasal congestion, nasal itching and epiphora (watery eyes) (Varshney & Varshney, 2015; Di, Lou, Ye, Miao, & Zhao, 2016). Further, additional symptoms may be sniffing, post nasal drip, impaired sense of smell and mouth breathing (Ng et al., 2000). AR is a global problem and has large variations in incidences, currently affects up to 20%-40% of the population worldwide (Solé et al., 2015; Settupane & Charnock, 2007). Europe has estimated 23% (Bauchau & Durham, 2004), and 11.03% of the Delhi population (excluding those having asthma) in India suffer from allergic rhinitis (Gaur et al., 2006).

Though not life threatening, AR symptoms are often distressing, adversely affecting the job, quality of life, and placing a burden on individuals and society (Schatz, 2007; Canonica et al., 2007). The total direct medical cost of allergic rhinitis is approximately \$3.4 billion in US (Meltzer & Bukstein, 2011). Association of allergic rhinitis with asthma adds to its financial burden (Nathan, 2007). AR is highly prevalent and significantly affects the quality of life through its symptoms and comorbidities. AR has a close association with Asthma (Dara, 2017), rhinosinusitis and atopic dermatitis (Tan & Corren, 2011). Our search yielded few studies on the effect of yoga on allergic rhinitis (Chanta, A. et al., 2019; Chellaa et al., 2019). A study concluded that AR contributes 3.6 days of absenteeism per annum and unproductive 2.3 hour per workday when experiencing symptoms (Lambert, 2006). AR symptoms may lead to both physical and mental complications. In children, it adversely affects the quality of life, sleep, and school performance and may progress to asthma causing a significant burden on his life (Meltzer et al., 2009). Immunological inflammation in AR is critically involved neural pathways thus it can impact psychological health or vice versa (Mandhane et al., 2011). Psychoneuroimmunology and medical genetics research suggest that CNS (central nervous system)

*Correspondence: Ripudaman Singh Chauhan
E-mail: drripudaman84@gmail.com

Received May 19, 2020; Accepted Aug 7, 2020; Published Aug 31, 2020

doi: <http://dx.doi.org/10.5667/CellMed.2020.0025>

©2020 by CellMed Orthocellular Medicine Pharmaceutical Association

This is an open access article under the CC BY-NC license.

(<http://creativecommons.org/licenses/by-nc/3.0/>)

may get affected by biochemical changes taking place due to allergic reactions (Marshall et al., 2002). Pharmacological treatments for AR include the use of oral intranasal H1-antihistamines, intranasal corticosteroids, and leukotriene receptor antagonists either alone or in combination (Brozek et al., 2017). Immunotherapy also shows a significant reduction in symptom scores and medication use (Mueller, 2013).

Yoga intervention-based studies had documented efficacy on upper and lower respiratory tract conditions like Allergic rhinitis (Chanta A. et al., 2019), Rhinosinusitis, Asthma and bronchitis (Shankarappa et al., 2012; Rao et al., 2014). However, there are shreds of evidence of the effectiveness of yoga intervention on conditions that coexist with Allergic Rhinitis like Asthma (Cramer et al., 2014) and rhino-sinusitis (Rastogi, 2007), Sleep difficulty (Mustian et al., 2013; Fang & Li, 2015), etc.

Yoga is a holistic way of life, which leads to biopsychosocial and spiritual homeostasis. The root of the word yoga, is *yuj* which had Sanskrit origin, which means to bind or join (Distasio, 2008). Even though the primary goal of yoga is self-realization, recent studies highlight the therapeutic application of yoga for non-communicable diseases (Taneja, 2014). Traditionally, two schools of yoga are widely practiced: *Raja* Yoga and *Hatha* Yoga. The practical steps of *Raja* Yoga were highlighted in the form of 196 aphorisms in *Patanjali* Yoga sutras. *Raja* Yoga emphasizes more on mental purification. The *Hatha* yoga branch focuses on physical postures and breathing. Further *Hatha* Yoga School gives importance to cleansing practices called *Kriyas*. In the Yogic tradition of India, *Hatha* yoga is a considerable apparatus to prevent and overcome various disease conditions (Muktibodhanand, 1998). Sage Swatmaram in a classical text *Hatha Yoga Pradipika* (H.Y.P.) and sage Gherand in *Gherand Samhita* explains about *Shatkarmas* (six cleansing techniques) they are as follows *Dhauti* (cleansing of digestive tract), *Basti* (colon cleansing), *Neti* (Nasal cleansing), *Trataka* (eye cleansing), *Nauli* (abdominal muscle movement) and *Kapalbhati* (skull cleansing) (Muktibodhanand, 1998). Yogic scriptures highlight that diseases caused by an excess of mucus can be managed by *Dhauti* karma (Muktibodhanand, 1998). And most of the disease, which manifests above the throat can be managed by *Neti-kriya*. There are many yogic practices that are traditionally exercised to reduce symptoms of AR.

The emerging evidence has shown yoga as a potential alternative or complementary treatment for AR (Chanta, A. et al., 2019; Chellaa et al., 2019). Based on the recent trend in yoga, it is essential to scrutinize the application of yoga as a potential add-on therapy for AR. Hence the narrative review intended to comprehend the possible mechanisms of action of yoga in AR, the limitations of prevalent literature and direction for the future study. This review is aimed at finding the mechanism with that yoga may interfere in the pathophysiology of AR.

METHODS

Search Strategy

The research team performed an electronic literature search using the search terms yoga and "allergic rhinitis," "inflammation," "anti-inflammatory," "cytokine," "vagal tone", "parasympathetic nervous system", "Nasal irrigation", "Neti" in the following databases: Pubmed, Google Scholar. Experimental papers, case studies, review studies revealing the effect of yoga on inflammation, sympathovagal balance, inflammatory or pro-inflammatory mediators and effect of

nasal irrigation were included. In addition, classical yoga text *Hatha Yoga Pradipika* and *Patanjali* Yoga Sutra were hand-searched.

Clinical Efficacy and Effectiveness of Yoga for the management of Allergic Rhinitis

A recent study has shown the effectiveness of three months of *Hatha* yoga-based intervention among Allergic rhinitis patients. The study evaluated the resistance level of both the upper and lower respiratory tract using a rhinomanometer and spirometer. The results highlighted a significant decrease in Nasal Airway Resistance, an increase in forced expiratory volume (FEV1) & % residual standard deviation (%RSD). Further standard questionnaires for Allergic rhinitis were assessed. The scores of "Sino-Nasal outcome test (SNOT)" and "Short form-12(SF-12)" were found significantly improved (Chellaa et al., 2019). That signifies that yoga not only increases lung capacity but also reduces nasal congestion to AR patients. Further, eight-week Yoga-based intervention program, consisting of yoga warm-up, Asanas, Pranayama, Relaxation and Meditation sessions for 60 minutes three days a week has shown significant improvement in Peak Nasal Inspiratory Flow Rate and increased secretion of interleukin (IL)-2 in the nasal discharge (Chanta A. et al., 2019). This signifies that Yoga practice may improve the cytokine level along with symptom score and nasal airflow.

MECHANISMS BY WHICH YOGA MAY MODERATE THE CLINICAL SYMPTOMS OF ALLERGIC RHINITIS

1. Overview of Possible Anti-Inflammatory Mechanisms of Yoga

Recent research has elucidated some of the mechanisms underpinning the anti-inflammatory effects of yoga practices that may have an impact on reducing symptoms of allergic rhinitis (Sarubin et al., 2014). Several physiological pathways seem to mediate the anti-inflammatory effects of Yoga include – regulation of inflammatory cytokine, Hypothalamus-Pituitary-Adrenal (HPA) axis, plasma CRP level, plasma GABA level, Vagus stimulation and clearing of the nasal pathway from annoying substances through yogic cleansing techniques.

1.1. Yoga and Inflammatory cytokine

Allergic rhinitis occurs in two phases i.e. early and late; the early phase starts with the degradation of mast cells and releases histamine and tryptase resulting in localized inflammation, sneezing, itching, and rhinorrhoea, on the exposure of potential allergen to the nasal mucosa (Mandhane et al., 2011; Y. Min, 2010). Late phase caused by migration of eosinophil, mast cells, T-cells and other inflammatory cells to the nasal mucosa. These cells produce cytokines, and eosinophil produces oxygen-free radicals and hydrogen peroxide result in epithelial damage and nasal congestion (Y. Min, 2010).

Yoga-based 6-month long clinical trials on moderate asthma cases found a significant reduction in blood eosinophil count, which plays a key role in AR (Kant, 2014). Interleukin-10 (IL-10), a potent immunosuppressant, reduces inflammation in two ways; indirectly by preventing antigen-specific T-cell activation and directly by inhibiting IL-2 production from a monocyte, macrophages, Langerhans cells and dendritic cells thereby controls the expansion of T-cells (De Vries, 1995). Yoga-Based intervention for three months on 38 individuals observes an increase in anti-inflammatory cytokine IL-10, in

addition study found a reduction in Pro-inflammatory Cytokine IL-12 (Cahn et al., 2017). Further, yoga intervention found to have reduced activity of the pro-inflammatory transcription factor Nuclear Factor Kappa B (NF- κ B) and increased activity of the anti-inflammatory glucocorticoid receptor among breast cancer survivors (Bower et al., 2014). Furthermore, yoga-based study with 86 subjects found a reduction in Serum Interleukin-6 and Tumor Necrosis Factor [TNF]- α level in 10 days (Yadav et al., 2012). Thereby yoga has shown as a potential intervention that modulates the anti-inflammatory effect.

1.2. Yoga and HPA axis

Research has shown that the HPA axis is associated with an acute allergic inflammatory condition, and increased cytokine level activates in AR (Buske-Kirschbaum et al., 2010). Yoga has shown to be modulating the HPA axis in a number of human studies. A recent study on eight weeks of Yoga training on female patients with multiple sclerosis results shows a significant difference in serum ACTH and cortisol levels in comparison to controls (Moghadasli & Najafi, 2017). Further, a 15-day yoga-based breathing technique has shown a reduction in serum ACTH and cortisol reduction among substance abusers (Vedamurthachar et al., 2006). Furthermore, yoga intervention study on enhancement of sleep physiological, indicates higher efficiency of the HPA axis (Vera et al., 2009). The involvement of the HPA axis in the anti-inflammatory effects of Yoga was further supported by changes in levels of Salivary cortisol and Serum cortisol in yoga-based clinical trials (Michalsen et al., 2005; Raghavendra et al., 2009; Vedamurthachar et al., 2006; Yadav et al., 2012). The reduction in inflammation, mediated through the HPA axis (Ross & Thomas, 2010) may reduce nasal congestion.

1.3. Yoga and C-reactive protein (CRP) levels

CRP is a potent biomarker for inflammation, rising rapidly in inflammatory conditions (Marnell et al., 2005). Previous ten days of a yoga intervention study showed a significant reduction in plasma CRP level along with other inflammatory markers like IL-6 and TNF- α (Yadav et al., 2012). Further, 12-week Yoga intervention study on COPD patients found a marked reduction in CRP level (Arora et al., 2013). Furthermore, a study has reported that yoga reduces plasma CRP levels in patients with heart disease (Pullen et al., 2008).

1.4. Yoga and Gamma-aminobutyric acid (GABA) level

An animal study reported that GABA down regulates both T-cell autoimmunity and antigen-presenting cell (APC) activity by reducing the proliferation of reactive T cells. Thus, GABA can reduce T-cell to mediate the inflammation (Tian et al., 2011). A pilot study with 19 subjects suggests 60-minute yoga intervention enhances GABA level up to 27%, while no change observed in control (Streeter et al., 2007). A randomized control trial on 34 subjects demonstrated an increased level of thalamic GABA following 12 weeks of Yoga intervention in comparison to walking among healthy individuals (Streeter et al., 2010). Further, 12 week-long controlled intervention on MDD (Major depressive disorder) subjects reported improved GABA levels following the practice of *yogasanas* and *pranayama* (Streeter et al., 2018).

1.5. Role of Yoga on Psychological Stress and Immune mechanism

Psychological stress is another important factor that aggravates inflammation it can be objectively documented by CRP and cortisol level (Almadi et al., 2013). Biochemical changes

during the allergen challenge in AR is also characterized by tiredness, malaise, irritability, and possibly neurocognitive deficits (Skoner, 2001). Evidence suggests that both stress and anxiety promote priming and hyper responsiveness to produce allergens in AR patients (Kiecolt-Glaser et al., 2009). A review on neuro inflammation suggests that neuropeptides like substance P may be released along with other inflammatory mediators and mast cells; in response to sensory nerve stimulation due to psychological stress (Black, 2002). Psychological stress kindles neuro-endocrine, sympathetic and immune response resulting in activation of the HPA axis and regulation of inflammatory mediators (Powell et al., 2013). Psychological stress has proven the role to stir up inflammation (Powell et al., 2013). Yoga has proven its role in reducing psychological stress in many clinical trials through various mechanisms. A Yoga study found increased brain alpha waves activities and serum cortisol levels following *asana*, *pranayama* and *soham* meditation (Kamei et al., 2000). A clinical trial on students concluded, regular practice of yoga practices may maintain physiological parameters and biomarkers of stress (Serum IFN- γ and cortisol level) following stress condition (Gopal et al., 2011). A 12-week yoga intervention study on chronic back pain sufferers revealed a significant rise in BDNF level in comparison to control (Lee et al., 2014). Yoga and meditation are capable of shifting brain execution, neurotropic and inflammatory pathways. Three-fold increase in BDNF (brain-derived neurotrophic factor) level and significant improvement in CAR (cortisol awakening response) following yoga and meditation program, suggesting an improvement in psychological parameters and rhythmicity of adrenocortical activity (Cahn et al., 2017). *Pranayama* (yogic breathing) decreases hyperventilation; this results in normalization of CO₂ level, and reduction of bronchospasm and breathlessness. Additionally, *Pranayama* improves immunological parameters and reduces anxiety (Sankar & Das, 2018).

1.6. Yoga and Neurogenic Inflammation

When nerve endings come in contact with cytotoxins released by inflammatory cells (Eosinophil & Mast cells) it leads to excitation of the both afferent and efferent nerve pathways this makes to secrete neuropeptides, including Substance P and Neurokinin A, (Togias, 2000). In response to these neuropeptides, adjacent mast cells release histamine. Histamine, in turn, evokes neuropeptide release, this exhibits a bidirectional link (Rosa & Fantozzi, 2013), and this is called neurogenic inflammation. It results in plasma extravasation and glandular secretion (Tai & Baraniuk, 2002). The sensation of pain and stiffness also developed due to the involvement of nasal sensory nerves (Tai & Baraniuk, 2002). A recent study in pediatric settings with mind-body therapy to evaluate its effect on neuropeptides (calcitonin gene-related peptide (CGRP) and vasoactive intestinal polypeptide (VIP)), could not find any significant difference, possibly due to inadequate sample size (Gershan et al., 2015). We do not find any yoga intervention study to evaluate its role in modulating neuropeptides. Yoga reduces cells of inflammation (Kant, 2014) those are responsible for cytokine secretion thereby initiates a cascade of Neurogenic Inflammation, so it has been proposed that the practice of yoga reduces neurogenic inflammation; however, no direct experimental confirmation is currently available.

1.7. The cholinergic anti-inflammatory pathway

Inhibition of pro-inflammatory cytokines and systemic inflammation through efferent vagal is termed as "The cholinergic anti-inflammatory pathway" (Czura & Tracey,

2013). Electrical stimulation of vagus nerve may suppress both local and systemic inflammation (Martelli et al., 2014). A clinical trial with an objective to assess the role of yoga on autonomic nervous system found the well-balanced beneficial activity of vagal efferent among the yoga groups (Muralikrishnan et al., 2012). Researchers reported that relaxation by Iyengar Yoga practice increases cardiac vagal modulation in healthy yoga practitioners (Khattab et al., 2007). This provides an insight on physiological mechanism for immunomodulation through the motor branches of the vagus nerve, and CNS control of peripheral inflammatory responses.

2. Yoga and Hyper-responsiveness in AR

Hyper-responsiveness of airways is closely related to an IgE mediated allergic inflammatory condition (Sears et al., 1991). Chronic exposure to allergens in AR can lead to hyper-responsiveness of the nasal mucosa (Baraniuk & Kim, 2007). Airway hyper-responsiveness also may be due to airway inflammation, airway remodeling and abnormalities of smooth muscles and neural control (Berend et al., 2008). Neurotrophins, such as the NGF (Nerve Growth Factor) are the mediators of neural hyper-responsiveness (Togias, 2000). Yoga has a calming effect on the mind, the devotional sessions that help to harness the emotional upsurges are particularly useful in eliminating emotional stresses (Nagendra & Nagarathna, 1986). Yogic *Suddhi Kriya* like *Neti* clear nasal pathway from allergens and other annoying substances (Rabone & Saraswati, 1999) that can reduce the number of inflammatory cells and cytokine levels in the nasal mucosa which may result in lessening of hyper-responsiveness. This signifies that yoga induces a greater degree of physiological relaxation and reduces hyper-responsiveness.

3. Effect of Yogic *Shuddhi Kriyas* in reducing allergen and inflammatory mediators

Roots of nasal irrigation are in ancient yogic purification technique involves *Neti Kriya* (nasal cleansing), there are two types of *Neti*; *JalaNeti*, i.e nasal irrigation with lukewarm saline water and *Sutra Neti*, i.e cleaning of the nasal path with a thread or catheter. *Neti* removes foreign bodies like allergens and dust from the nasal passage (Muktibodhanand, 1998). There are sufficient studies available that show the positive effect of nasal irrigation on nasal symptom scores (Tomooka et al., 2000; Rabone & Saraswati, 1999). A recent review study suggests that *JalaNeti* (yogic nasal cleansing techniques) and Pranayama (Yogic breathing) have a therapeutic effect for people suffering from AR including asthma (Agnihotri, et al., 2016). A 10-week long clinical trial with the daily practice of saline nasal spray significantly reduced symptoms of nasal symptoms and episodes of rhinitis (Tano&Tano, 2004). *JalaNeti* helps in preventing upper respiratory tract diseases equally in adults and children (Meera et al., 2019). Nasal lavage with isotonic seawater shown significant improvement in mucociliary clearance, Nasal Peak Expiratory Flow (NPEF) and nasal symptoms such as obstruction, posterior secretions, itching, irritation and sneezing (Holmström, et al., 1997). A single case study reported the beneficial results of *Sutra Neti* in his snoring and sleep apnoea condition (Ramalingam & Smith, 1990). A review study found saline nasal irrigation a safe procedure for both adults and children. It is helpful in flushing and moisturizing the nasal cavity also promotes mucociliary clearance (Papsin, & McTavish, 2003). A clinical trial with thirty allergic rhinitis patients underwent saline nasal irrigation and heated water vapor at 43 and 41°C, at different points of time, results revealed that saline nasal irrigation significantly reduces histamine concentration from nasal secretion (Georgitis,

1994). Another clinical trial on pediatric subjects for 12 weeks reported a significant reduction in AR symptoms and Eosinophil count (Chen et al., 2014).

3.1. Mechanism of action for *Neti*

The mechanism of action of *JalaNeti* or nasal irrigation can be understood in four ways.

1. Direct physical cleansing by flushing out thick mucus, crusts, debris, allergens, air pollutants (Blake & McTavish, 2003; Rabone & Saraswati, 1999).
2. The removal of inflammatory mediators (Georgitis, 1994; Chen et al., 2014).
3. Better mucociliary clearance by improving ciliary beat frequency (Holmström et al., 1997).
4. Desensitization of Nasal Mucosa - Yogic cleansing techniques *Kriyas* may desensitize the vagal end receptors by systematic exposure to nonspecific graded irritants followed by deep relaxation (Nagendra & Nagarathna, 1986).

4. A Proposed Model for the Mechanism of Yoga therapy in Allergic Rhinitis

Given the multifaceted discussion on pathways in allergic inflammation, it is hypothesized that yoga might exert anti-inflammatory actions in allergic rhinitis in the following ways: The local effect by improving mucociliary clearance, reducing inflammatory cytokines and inflammatory cells in the nasal mucosa. Further, the general effect mediated through the HPA axis, Efferent vagal stimulation, CRP level, and GABA. Yoga has shown improvement on Lung capacity and nasal airflow in AR patients. If yoga can be shown to have these actions on modulating cytokines and other pathways potentially mediating inflammation, then these modulations would be expected to be correlated with improvements in clinical signs and symptoms, including a reduction in rhinorrhea, sneezing and nasal obstruction. This review integrates current approaches and scientific evidence to illustrate how practicing traditional factors of yoga helps in the management of Allergic Rhinitis.

CONCLUSION

Yoga has recently emerged as having health benefits in allergic and other chronic conditions, yet yoga has not been systematically evaluated as therapy for AR. Evidence support that yoga reduces inflammation by modulating inflammatory mediators in some studies for conditions other than allergic rhinitis. Further, pieces of evidence support that yoga reduces nasal congestion, improves lung capacity, improve nasal airflow and symptom score in allergic rhinitis cases. Few studies reported *Netikriya* (yogic nasal cleansing) and a similar technique, saline nasal irrigation was effective in reducing symptoms of allergic rhinitis. Role of yoga in modulating neuropeptides like SP, CGRP, and VIP, and Neurotrophins NGF and BDNF had to be studied as they are shown to contribute in the early and late phases of AR respectively. Therefore, it is suggested in our proposed model that, yoga may downregulate certain inflammatory and pro-inflammatory cytokines. Furthermore, yoga up-regulates anti-inflammatory interleukins. Yoga, a mind-body therapy, embraces a holistic model of health and well-being. Yoga not only focuses on cardinal symptoms of AR but may also reduce psychological stress and sleep difficulty. Yoga may also reduce the hyper-responsiveness of nasal airway by improving sympathovagal balance. The delimitations of the present review include restricting the search to open online databases, which might narrow the access

to substantial research work done in the domain. Furthermore, the prevailing review is constrained to the narrative in nature, and statistical accountability was not presented. Current review highlights the importance of integrating yoga-based interventions as add-on therapy for AR. Further, there is a need for large scale, long-term effect, systematic study with augmented methodological designs to comprehend the potential neurobiological mechanisms of yoga-based intervention in patients with Allergic Rhinitis is needed.

CONFLICT OF INTEREST

Authors declared that there was no conflict of interest.

ACKNOWLEDGEMENT

None

REFERENCES

- Agnihotri S, Kant S, Kumar S, Mishra RK, Mishra SK. Impact of yoga on biochemical profile of asthmatics: A randomized controlled study. *International journal of yoga*. 2014;7(1):17.
- Almadi T, Cathers I, Chow CM. Associations among work-related stress, cortisol, inflammation, and metabolic syndrome. *Psychophysiology*. 2013;50(9):821-30.
- Arora S, Guleria R, Kumar G, Yadav SL, Mohan A. Efficacy of yoga on inflammatory markers, dyspnea, and quality of life in COPD. *Chest*. 2013;144(4):787A.
- Baraniuk JN, Kim D. Nasonasal reflexes, the nasal cycle, and sneeze. *Current allergy and asthma reports*. 2007;7(2):105-11.
- Bauchau V, Durham SR. Prevalence and rate of diagnosis of allergic rhinitis in Europe. *European Respiratory Journal*. 2004;24(5):758-64.
- Black PH. Stress and the inflammatory response: a review of neurogenic inflammation. *Brain, behavior, and immunity*. 2002;16(6):622-53.
- Bower JE, Greendale G, Crosswell AD, Garet D, Sternlieb B, Ganz PA, Irwin MR, Olmstead R, Arevalo J, Cole SW. Yoga reduces inflammatory signaling in fatigued breast cancer survivors: a randomized controlled trial. *Psychoneuroendocrinology*. 2014;43:20-9.
- Brożek JL, Bousquet J, Agache I, Agarwal A, Bachert C, Bosnic-Anticevich S, Brignardello-Petersen R, Canonica GW, Casale T, Chavannes NH, de Sousa JC. Allergic Rhinitis and its Impact on Asthma (ARIA) guidelines—2016 revision. *Journal of Allergy and Clinical Immunology*. 2017;140(4):950-8.
- Buske-Kirschbaum A, Ebrecht M, Hellhammer DH. Blunted HPA axis responsiveness to stress in atopic patients is associated with the acuity and severeness of allergic inflammation. *Brain, behavior, and immunity*. 2010;24(8):1347-53.
- Cahn BR, Goodman MS, Peterson CT, Maturi R, Mills PJ. Yoga, meditation and mind-body health: increased BDNF, cortisol awakening response, and altered inflammatory marker expression after a 3-month yoga and meditation retreat. *Frontiers in human neuroscience*. 2017;11:315.
- Canonica GW, Bousquet J, Mullol J, Scadding GK, Virchow JC. A survey of the burden of allergic rhinitis in Europe. *Allergy*. 2007;62:17-25.
- Chanta A, Klaewsongkram J, Mickleborough TD, Tongtako W. Effect of Hatha yoga training on rhinitis symptoms and cytokines in allergic rhinitis patients. *Asian Pacific journal of allergy and immunology*. 2019.
- Chellaa R, Soumya MS, Inbaraj G, Nayar R, Saidha PK, Menezes VH, Rajeeva HN. Impact of hatha yoga on the airway resistances in healthy individuals and allergic rhinitis patients. *Indian Journal of Otolaryngology and Head & Neck Surgery*. 2019;71(3):1748-56.
- Chen JR, Jin L, Li XY. The effectiveness of nasal saline irrigation (seawater) in treatment of allergic rhinitis in children. *International journal of pediatric otorhinolaryngology*. 2014;78(7):1115-8.
- Cramer H, Posadzki P, Dobos G, Langhorst J. Yoga for asthma: a systematic review and meta-analysis. *Annals of Allergy, Asthma & Immunology*. 2014;112(6):503-10.
- Dara PK, Meena HM, Kumari P, Sharma BS, Sharma P, Dara G. Allergic Rhinitis and Bronchial Asthma Comorbidity: A Cross Sectional Questionnaire Study in Children (6-18 Years) of Urban and Rural Jaipur (India). *Journal of Medical science and clinical research*. 2017; 5(7):24417-24421
- deVries JE. Immunosuppressive and anti-inflammatory properties of interleukin 10. *Annals of medicine*. 1995;27(5):537-41.
- Di R, Lou X, Ye L, Miao J, Zhao Y. Prevalence of allergic rhinitis and its effect on the quality of life of middle school students. *Int J ClinExp Med*. 2016;9(8):15772-9.
- DiStasio SA. Integrating yoga into cancer care. *Clinical Journal of Oncology Nursing*. 2008;12(1).
- Fang R, Li X. A regular yoga intervention for staff nurse sleep quality and work stress: a randomised controlled trial. *Journal of clinical nursing*. 2015;24(23-24):3374-9.
- Gaur SN, Gupta K, Rajpal S, Singh AB, Rohatgi A. Prevalence of bronchial asthma and allergic rhinitis among urban and rural adult population of Delhi. *Indian J Allergy Asthma Immunol*. 2006;20(2):90-7.
- Georgitis JW. Nasal hyperthermia and simple irrigation for perennial rhinitis: changes in inflammatory mediators. *Chest*. 1994;106(5):1487-92.
- Gershan LA, Durham PL, Skidmore J, Shimizu J, Cady RJ, Sheng X, Maloney CG. The role of salivary neuropeptides in pediatrics: Potential biomarkers for integrated therapies. *European journal of integrative medicine*. 2015;7(4):372-7.
- Gopal A, Mondal S, Gandhi A, Arora S, Bhattacharjee J. Effect of integrated yoga practices on immune responses in examination stress—A preliminary study. *International journal of yoga*. 2011;4(1):26.

- Hellings PW, Fokkens WJ. Allergic rhinitis and its impact on otorhinolaryngology. *Allergy*. 2006;61(6):656-64.
- Holmström M, Rosén G, Wåhlander L. Effect of nasal lavage on nasal symptoms and physiology in wood industry workers. *Rhinology*. 1997;35:108-12.
- Kamei T, Toriumi Y, Kimura H, Kumano H, Ohno S, Kimura K. Decrease in serum cortisol during yoga exercise is correlated with alpha wave activation. *Perceptual and motor skills*. 2000;90(3):1027-32.
- Khattab K, Khattab AA, Ortak J, Richardt G, Bonnemeier H. Iyengar yoga increases cardiac parasympathetic nervous modulation among healthy yoga practitioners. *Evidence-Based Complementary and Alternative Medicine*. 2007;4(4):511-7.
- Kiecolt-Glaser JK, Heffner KL, Glaser R, Malarkey WB, Porter K, Atkinson C, Laskowski B, Lemeshow S, Marshall GD. How stress and anxiety can alter immediate and late phase skin test responses in allergic rhinitis. *Psychoneuroendocrinology*. 2009;34(5):670-80.
- Lamb CE, Ratner PH, Johnson CE, Ambegaonkar AJ, Joshi AV, Day D, Sampson N, Eng B. Economic impact of workplace productivity losses due to allergic rhinitis compared with select medical conditions in the United States from an employer perspective. *Current medical research and opinion*. 2006;22(6):1203-10.
- Lee M, Moon W, Kim J. Effect of yoga on pain, brain-derived neurotrophic factor, and serotonin in premenopausal women with chronic low back pain. *Evidence-Based Complementary and Alternative Medicine*. 2014;2014.
- Mandhane SN, Shah JH, Thennati R. Allergic rhinitis: an update on disease, present treatments and future prospects. *International immunopharmacology*. 2011;11(11):1646-62.
- Marnell L, Mold C, Du Clos TW. C-reactive protein: ligands, receptors and role in inflammation. *Clinical immunology*. 2005;117(2):104-11.
- Marshall PS, O'Hara C, Steinberg P. Effects of seasonal allergic rhinitis on fatigue levels and mood. *Psychosomatic Medicine*. 2002;64(4):684-91.
- Martelli D, McKinley MJ, McAllen RM. The cholinergic anti-inflammatory pathway: a critical review. *Autonomic Neuroscience*. 2014;182:65-9.
- Meera S, Rani MV, Sreedhar C, Robin DT. A review on the therapeutic effects of *NetiKriya* with special reference to *JalaNeti*. *Journal of Ayurveda and integrative medicine*. 2019;11(2):185-189.
- Meltzer EO, Blaiss MS, Derebery MJ, Mahr TA, Gordon BR, Sheth KK, Simmons AL, Wingertzahn MA, Boyle JM. Burden of allergic rhinitis: results from the Pediatric Allergies in America survey. *Journal of Allergy and Clinical Immunology*. 2009;124(3):S43-70.
- Meltzer EO, Bukstein DA. The economic impact of allergic rhinitis and current guidelines for treatment. *Annals of Allergy, Asthma & Immunology*. 2011;106(2):S12-6.
- Michalsen A, Grossman P, Acil A, Langhorst J, Lüdtke R, Esch T, Stefano G, Dobos G. Rapid stress reduction and anxiolysis among distressed women as a consequence of a three-month intensive yoga program. *Medical Science Monitor*. 2005;11(12):CR555-61.
- Min YG. The pathophysiology, diagnosis and treatment of allergic rhinitis. *Allergy, asthma & immunology research*. 2010;2(2):65-76.
- Mueller RS. Allergen-specific immunotherapy. *Veterinary allergy*. 2013;20:85-9.
- Muktibodhananand, S. *Hath Yoga Pradipika*. (Bihar, India: Yoga Publication Trust),1998.
- Muralikrishnan K, Balakrishnan B, Balasubramanian K, Visnegarawla F. Measurement of the effect of Isha Yoga on cardiac autonomic nervous system using short-term heart rate variability. *Journal of Ayurveda and Integrative medicine*. 2012;3(2):91.
- Mustian KM, Sprod LK, Janelins M, Peppone LJ, Palesh OG, Chandwani K, Reddy PS, Melnik MK, Heckler C, Morrow GR. Multicenter, randomized controlled trial of yoga for sleep quality among cancer survivors. *Journal of Clinical Oncology*. 2013;31(26):3233.
- Nagendra HR, Nagarathna R. An integrated approach of yoga therapy for bronchial asthma: a 3–54-month prospective study. *Journal of asthma*. 1986;23(3):123-37.
- Najafi P, Moghadasi M. The effect of yoga training on enhancement of Adrenocorticotrophic hormone (ACTH) and cortisol levels in female patients with multiple sclerosis. *Complementary therapies in clinical practice*. 2017;26:21-5.
- Nathan RA. The burden of allergic rhinitis. *Allergy and asthma proceedings*. 2007;28(1):3-9.
- Ng ML, Warlow RS, Chrishanthan N, Ellis C, Walls R. Preliminary criteria for the definition of allergic rhinitis: a systematic evaluation of clinical parameters in a disease cohort (I). *Clinical and experimental allergy: journal of the British Society for Allergy and Clinical Immunology*. 2000;30(9):1314-31.
- Papsin B, McTavish A. Saline nasal irrigation: Its role as an adjunct treatment. *Canadian Family Physician*. 2003;49(2):168-73.
- Pavlov VA, Tracey KJ. The cholinergic anti-inflammatory pathway. *Brain, behavior, and immunity*. 2005;19(6):493-9.
- Pullen PR, Nagamia SH, Mehta PK, Thompson WR, Benardot D, Hammoud R, Parrott JM, Sola S, Khan BV. Effects of yoga on inflammation and exercise capacity in patients with chronic heart failure. *Journal of cardiac failure*. 2008;14(5):407-13.
- Rabone SJ, Saraswati SB. Acceptance and effects of nasal lavage in volunteer woodworkers. *Occupational medicine*. 1999;49(6):365-9.
- Raghavendra RM, Vadiraja HS, Nagarathna R, Nagendra HR, Rekha M, Vanitha N, Gopinath KS, Srinath BS, Vishweshwara MS, Madhavi YS, Ajaikumar BS. Effects of a yoga program on

- cortisol rhythm and mood states in early breast cancer patients undergoing adjuvant radiotherapy: a randomized controlled trial. *Integrative cancer therapies*. 2009;8(1):37-46.
- Ramalingam KK, Smith MC. Simple treatment for snoring also a means of prediction of uvulopalatopharyngoplasty success?. *The Journal of Laryngology & Otology*. 1990;104(5):428-9.
- Rao YC, Kadam A, Jagannathan A, Babina N, Rao R, Nagendra HR. Efficacy of naturopathy and yoga in bronchial asthma. *Indian J Physiol Pharmacol*. 2014;58(3):233-9.
- Rastogi S. JalaNeti Application in acute rhino sinusitis. *Indian Journal of Traditional Knowledge*. 2007; 6:324-327.
- Rosa AC, Fantozzi R. The role of histamine in neurogenic inflammation. *British journal of pharmacology*. 2013;170(1):38-45.
- Ross A, Thomas S. The health benefits of yoga and exercise: a review of comparison studies. *The journal of alternative and complementary medicine*. 2010;16(1):3-12.
- Sankar J, Das RR. Asthma—a disease of how we breathe: role of breathing exercises and pranayam. *The Indian Journal of Pediatrics*. 2018;85(10):905-10.
- Sarubin N, Nothdurfter C, Schüle C, Lieb M, Uhr M, Born C, Zimmermann R, Bühner M, Konopka K, Rupprecht R, Baghai TC. The influence of Hatha yoga as an add-on treatment in major depression on hypothalamic–pituitary–adrenal-axis activity: A randomized trial. *Journal of psychiatric research*. 2014;53:76-83.
- Schatz M. A survey of the burden of allergic rhinitis in the USA. *Allergy*. 2007;62:9-16.
- Sears MR, Burrows B, Flannery EM, Herbison GP, Hewitt CJ, Holdaway AM. Relation between airway responsiveness and serum IgE in children with asthma and in apparently normal children. *New England Journal of Medicine*. 1991;325(15):1067-71.
- Settipane RA, Charnock DR. Epidemiology of rhinitis: allergic and nonallergic. *Clinical allergy and immunology*. 2007;19:23-34.
- Shankarappa V, Prashanth P, Annamalai N, Varunmalhotra. The short term effect of pranayama on the lung parameters. *Journal of clinical and Diagnostic Research*. 2012;6(1):27-30.
- Skoner DP. Allergic rhinitis: definition, epidemiology, pathophysiology, detection, and diagnosis. *Journal of allergy and clinical immunology*. 2001;108(1):S2-8.
- Solé D, RosárioFilho NA, Sarinho ES, Camelo-Nunes IC, Barreto BA, Medeiros ML, Franco JM, Camargos PA, Mallol J, Gurgel R, De Andrade DM. Prevalence of asthma and allergic diseases in adolescents: nine-year follow-up study (2003-2012). *Jornal de Pediatria (Versão em Português)*. 2015;91(1):30-5.
- Streeter CC, Gerbarg PL, Nielsen GH, Brown RP, Jensen JE, Silveri MM. Effects of yoga on thalamic gamma-aminobutyric acid, mood and depression: Analysis of two randomized controlled trials. *Neuropsychiatry (London)*. 2018;8(6):1923.
- Streeter CC, Jensen JE, Perlmutter RM, Cabral HJ, Tian H, Terhune DB, Ciraulo DA, Renshaw PF. Yoga Asana sessions increase brain GABA levels: a pilot study. *The journal of alternative and complementary medicine*. 2007;13(4):419-26.
- Streeter CC, Whitfield TH, Owen L, Rein T, Karri SK, Yakhkind A, Perlmutter R, Prescott A, Renshaw PF, Ciraulo DA, Jensen JE. Effects of yoga versus walking on mood, anxiety, and brain GABA levels: a randomized controlled MRS study. *The Journal of Alternative and Complementary Medicine*. 2010;16(11):1145-52.
- Tai CF, Baraniuk JN. Upper airway neurogenic mechanisms. *Current opinion in allergy and clinical immunology*. 2002;2(1):11-9.
- Tan RA, Corren J. The relationship of rhinitis and asthma, sinusitis, food allergy, and eczema. *Immunology and Allergy Clinics*. 2011;31(3):481-91.
- Taneja DK. Yoga and health. *Indian journal of community medicine: official publication of Indian Association of Preventive & Social Medicine*. 2014;39(2):68.
- Tano L, Tano K. A daily nasal spray with saline prevents symptoms of rhinitis. *Acta oto-laryngol*. 2004;124(9):1059-62.
- Tian J, Yong J, Dang H, Kaufman DL. Oral GABA treatment downregulates inflammatory responses in a mouse model of rheumatoid arthritis. *Autoimmunity*. 2011;44(6):465-70.
- Togias A. Unique mechanistic features of allergic rhinitis. *Journal of allergy and clinical immunology*. 2000;105(6):S599-604.
- Tomooka LT, Murphy C, Davidson TM. Clinical study and literature review of nasal irrigation. *The Laryngoscope*. 2000;110(7):1189-93.
- Varshney J, Varshney H. Allergic rhinitis: An overview. *Indian Journal of Otolaryngology and Head & Neck Surgery*. 2015;67(2):143-9.
- Vedamurthachar A, Janakiramaiah N, Hegde JM, Shetty TK, Subbakrishna DK, Sureshbabu SV, Gangadhar BN. Antidepressant efficacy and hormonal effects of Sudarshana Kriya Yoga (SKY) in alcohol dependent individuals. *Journal of affective disorders*. 2006;94(1-3):249-53.
- Vera FM, Manzanique JM, Maldonado EF, Carranque GA, Rodriguez FM, Blanca MJ, Morell M. Subjective sleep quality and hormonal modulation in long-term yoga practitioners. *Biological psychology*. 2009;81(3):164-8.
- Yadav RK, Magan D, Mehta N, Sharma R, Mahapatra SC. Efficacy of a short-term yoga-based lifestyle intervention in reducing stress and inflammation: preliminary results. *The journal of alternative and complementary medicine*. 2012;18(7):662-7.