CHAPTER 3: REVIEW OF SCIENTIFIC LITERATURE

3.1 INTRODUCTION

Yoga, derived from the Sanskrit root 'Yuj' meaning to bind or join, is a holistic approach to life promoting bio-psychosocial and spiritual homeostasis (Distasio, 2008). While its primary objective is self-realization, recent studies have also illuminated its therapeutic potential for non-communicable diseases (Taneja, 2014). Traditionally, *yoga* is practiced in two main schools: *Raja Yoga*, with its mental purification techniques outlined in Patanjali's *Yoga Sutras* through 196 aphorisms, and *Hatha Yoga*, which emphasizes physical postures and breathing. Notably, *Hatha Yoga* emphasizes cleansing practices known as *Kriyas*, which are integral in preventing and managing various diseases (Muktibodhanand, 1998). Sage Swatmaram in the *Hatha Yoga Pradipika* (H.Y.P.) and *Sage Gherand* in the *Gherand Samhita* detail six *Shatkarmas* (cleansing techniques): *Dhauti* (digestive tract cleansing), *Basti* (colon cleansing), *Neti* (nasal cleansing), *Trataka* (eye cleansing), *Nauli* (abdominal muscle movement), and *Kapalbhati* (skull cleansing). These practices are particularly effective in managing diseases related to excess mucus, as highlighted in yogic scriptures (Muktibodhanand, 1998). For instance, diseases manifesting above the throat are often managed by *Neti-kriya.*

Given the prevalence of Allergic Rhinitis (AR) and its impact, various *yogic* practices have traditionally been employed to alleviate its symptoms. Recent research, including studies by Chanta et al. (2019) and Chellaa et al. (2019), indicates *yoga's* potential as an alternative or complementary treatment for AR. With the growing trend of incorporating *yoga* into healthcare, it is crucial to examine its application as a potential adjunct therapy for AR. This review aims to understand the potential mechanisms through which *yoga* can influence and manage AR, bridging traditional practices with contemporary healthcare approaches.

3.2 METHODS

To comprehensively explore the effects of *yoga* on allergic rhinitis and its associated physiological aspects, an electronic literature search was conducted. The search terms included "*yoga*" in conjunction with "allergic rhinitis," "inflammation," "anti-inflammatory," "cytokine," "vagal tone," "parasympathetic nervous system," "Nasal irrigation," and "*Neti*." The databases utilized for this search were PubMed and Google Scholar. The scope of the search encompassed experimental papers, case studies, and review studies that focused on the impact of *yoga* on inflammation, the sympathovagal balance, and the modulation of inflammatory or pro-inflammatory mediators, as well as the effects of nasal irrigation.

3.3 POSSIBLE ANTI-INFLAMMATORY MECHANISMS OF *YOGA*

The potential anti-inflammatory mechanisms of *yoga*, which may alleviate the clinical symptoms of allergic rhinitis, have been increasingly illuminated in recent research. Sarubin et al. (2014) highlight several physiological pathways that *yoga* impacts, which contribute to its anti-inflammatory effects. These include the regulation of inflammatory cytokines, modulation of the Hypothalamus-Pituitary-Adrenal (HPA) axis, alteration of plasma CRP levels, and changes in plasma GABA levels. Additionally, *yoga*'s stimulation of the vagus nerve and the clearing of nasal passages from irritants through *yogic* cleansing techniques are also critical in mitigating the symptoms of allergic rhinitis. These findings suggest a multifaceted approach by which *yoga* practices can influence and potentially moderate the inflammatory responses associated with allergic rhinitis.

3.3.1 *Yoga* and Inflammatory Cytokines

Allergic rhinitis typically manifests in two phases: the early phase and the late phase. The early phase is characterized by the degradation of mast cells, which release histamine and tryptase,

leading to localized inflammation, sneezing, itching, and rhinorrhea upon exposure to potential allergens on the nasal mucosa (Mandhane et al., 2011; Y. Min, 2010). The late phase is driven by the migration of eosinophils, mast cells, T-cells, and other inflammatory cells to the nasal mucosa. These cells secrete cytokines, and the eosinophils produce oxygen-free radicals and hydrogen peroxide, resulting in epithelial damage and nasal congestion (Y. Min, 2010). Significant findings have emerged from *yoga*-based clinical trials. For instance, a 6-month long study on moderate asthma cases revealed a substantial reduction in blood eosinophil count, a critical factor in allergic rhinitis (Kant, 2014). Interleukin-10 (IL-10), a powerful immunosuppressant, mitigates inflammation in two ways: indirectly by hindering antigen-specific T-cell activation and directly by inhibiting IL-2 production from monocytes, macrophages, Langerhans cells, and dendritic cells, thereby controlling the expansion of T-cells (De Vries, 1995). A three-month *yoga*-based intervention involving 38 individuals indicated an increase in the anti-inflammatory cytokine IL-10. This study also observed a decrease in the pro-inflammatory cytokine IL-12 (Cahn et al., 2017). Additionally, *yoga* interventions have been shown to reduce the activity of the pro-inflammatory transcription factor Nuclear Factor Kappa B (NF-κB) and increase the activity of the anti-inflammatory glucocorticoid receptor among breast cancer survivors (Bower et al., 2014). Furthermore, a *yoga*-based study with 86 subjects reported a decrease in Serum Interleukin-6 and Tumor Necrosis Factor [TNF]-α levels within 10 days (Yadav et al., 2012). These findings collectively underscore *yoga's* potential as an intervention that effectively modulates anti-inflammatory effects.

3.3.2 *Yoga* and the HPA Axis

The Hypothalamus-Pituitary-Adrenal (HPA) axis, known for its role in acute allergic inflammatory conditions, is implicated in the increased cytokine levels observed in allergic

rhinitis (AR) (Buske-Kirschbaum et al., 2010). A growing body of research indicates that *yoga* practices can modulate the HPA axis. For instance, a recent study involving eight weeks of *yoga* training for female patients with multiple sclerosis showed significant differences in serum Adrenocorticotropic Hormone (ACTH) and cortisol levels compared to a control group (Moghadasi & Najafi, 2017). Additionally, a 15-day intervention involving *yoga*-based breathing techniques led to reductions in serum ACTH and cortisol levels among substance abusers (Vedamurthachar et al., 2006). Moreover, a study focusing on the enhancement of sleep physiology through *yoga* indicated an increased efficiency of the HPA axis (Vera et al., 2009). This connection between *yoga* and the HPA axis is further supported by changes in salivary and serum cortisol levels observed in various *yoga*-based clinical trials (Michalsen et al., 2005; Raghavendra et al., 2009; Vedamurthachar et al., 2006; Yadav et al., 2012). These findings suggest that the anti-inflammatory effects facilitated by *yoga*, potentially through the modulation of the HPA axis (Ross & Thomas, 2010), may contribute to the reduction of nasal congestion associated with AR.

3.3.3 *Yoga* and C-Reactive Protein (CRP) Levels

C-Reactive Protein (CRP) is recognized as a significant biomarker for inflammation, known to rise rapidly in response to inflammatory conditions (Marnell et al., 2005). In the realm of *yoga* research, a ten-day intervention study by Yadav et al. (2012) demonstrated a notable reduction in plasma CRP levels, along with other inflammatory markers such as IL-6 and TNF-α. Expanding on these findings, a 12-week *yoga* intervention study focusing on patients with Chronic Obstructive Pulmonary Disease (COPD) reported a marked reduction in CRP levels (Arora et al., 2013). Moreover, Pullen et al. (2008) also found that *yoga* significantly reduced plasma CRP levels in patients with heart disease. These studies collectively indicate that *yoga* can effectively

lower CRP levels, underscoring its potential role in mitigating inflammatory responses in various health conditions.

3.3.4 *Yoga* and Gamma-Aminobutyric Acid (GABA) Levels

Gamma-Aminobutyric acid (GABA), a neurotransmitter, plays a crucial role in reducing inflammation, particularly T-cell mediated inflammation. This is evidenced by an animal study which showed that GABA downregulates both T-cell autoimmunity and antigen-presenting cell (APC) activity by diminishing the proliferation of reactive T cells (Tian et al., 2011). In human studies, the effects of *yoga* on GABA levels have been similarly promising. A pilot study involving 19 participants found that a 60-minute *yoga* session enhanced GABA levels by up to 27%, whereas no significant changes were observed in the control group (Streeter et al., 2007). Additionally, a randomized control trial with 34 subjects demonstrated an increase in thalamic GABA levels following a 12-week *yoga* intervention, in comparison to a control group that engaged in walking (Streeter et al., 2010). Furthermore, a controlled 12-week intervention on subjects with Major Depressive Disorder (MDD) reported improved GABA levels following the practice of *yogasanas* and *pranayama* (Streeter et al., 2018). These studies collectively suggest that *yoga* may enhance GABA levels, thereby contributing to its potential anti-inflammatory effects, which could be beneficial in managing conditions like allergic rhinitis.

3.3.5 *Yoga* on Psychological Stress and Immune Mechanism

Psychological stress is a significant factor in aggravating inflammation, as evidenced by objective markers such as C-Reactive Protein (CRP) and cortisol levels (Almadi et al., 2013). Biochemical changes during allergen exposure in allergic rhinitis (AR) are often characterized by symptoms like tiredness, malaise, irritability, and potential neurocognitive deficits (Skoner, 2001). Research indicates that stress and anxiety can exacerbate the sensitivity and reactivity to

allergens in AR patients (Kiecolt-Glaser et al., 2009). A review by Black (2002) on neuroinflammation suggests that psychological stress may trigger the release of neuropeptides like substance P, along with other inflammatory mediators and mast cells, in response to sensory nerve stimulation.

The link between psychological stress and inflammation is further established by studies showing that stress activates neuro-endocrine, sympathetic, and immune responses, leading to the activation of the Hypothalamus-Pituitary-Adrenal (HPA) axis and the regulation of inflammatory mediators (Powell et al., 2013). In this context, *yoga* has demonstrated its efficacy in reducing psychological stress in numerous clinical trials. A study by Kamei et al. (2000) found that *yoga* practices, including *asanas, pranayama*, and *soham* meditation, increased brain alpha wave activity and serum cortisol levels. Similarly, Gopal et al. (2011) concluded that regular *yoga* practice could maintain physiological parameters and biomarkers of stress, such as serum IFN-γ and cortisol levels, even under stressful conditions.

Yoga interventions have also shown promise in addressing chronic conditions like back pain. A 12-week *yoga* intervention in patients with chronic back pain led to a significant increase in Brain-Derived Neurotrophic Factor (BDNF) levels compared to controls (Lee et al., 2014). Furthermore, *yoga* and meditation have been found to influence brain functionality, neurotropic pathways, and inflammatory responses. Cahn et al. (2017) reported a threefold increase in BDNF levels and significant improvements in the cortisol awakening response (CAR) following a *yoga* and meditation program, indicating an enhancement in psychological parameters and the rhythmicity of adrenocortical activity. Pranayama, or *yogic* breathing, has been shown to decrease hyperventilation, leading to normalized CO2 levels and a reduction in bronchospasm and breathlessness. It also improves immunological parameters and reduces anxiety (Sankar &

Das, 2018). These findings collectively underscore *yoga's* potential as a therapeutic tool in managing psychological stress and related immune responses

3.3.6 *Yoga* and Neurogenic Inflammation

Neurogenic inflammation arises when nerve endings are stimulated by cytotoxins released by inflammatory cells like eosinophils and mast cells. This contact leads to the excitation of both afferent and efferent nerve pathways, prompting the secretion of neuropeptides, including Substance P and Neurokinin A (Togias, 2000). These neuropeptides then cause adjacent mast cells to release histamine, which further evokes neuropeptide release, creating a bidirectional link (Rosa & Fantozzi, 2013). Such interactions result in plasma extravasation and glandular secretion (Tai & Baraniuk, 2002), and can also contribute to sensations of pain and stiffness due to the involvement of nasal sensory nerves. While a recent pediatric study investigating mind-body therapy's effect on neuropeptides (such as calcitonin gene-related peptide (CGRP) and vasoactive intestinal polypeptide (VIP)) did not find significant differences, possibly due to an inadequate sample size (Gershan et al., 2015), the role of *yoga* in modulating neuropeptides is yet to be extensively studied. However, research has shown that *yoga* reduces inflammatory cell activity (Kant, 2014), which is responsible for cytokine secretion and the initiation of neurogenic inflammation. It is thus proposed that *yoga* practice could reduce neurogenic inflammation, although direct experimental evidence to support this claim is currently lacking.

3.3.7 The Cholinergic Anti-Inflammatory Pathway

The cholinergic anti-inflammatory pathway is defined by the inhibition of pro-inflammatory cytokines and systemic inflammation through efferent vagal nerve activity (Czura & Tracey, 2013). It has been observed that electrical stimulation of the vagus nerve can suppress both local and systemic inflammation (Martelli et al., 2014). In the context of *yoga*, a clinical trial aimed at

assessing its impact on the autonomic nervous system found a well-balanced and beneficial activity of the vagal efferent pathways among *yoga* practitioners (Muralikrishnan et al., 2012). Further supporting this, researchers reported that relaxation induced by *Iyengar Yoga* practice increases cardiac vagal modulation in healthy individuals (Khattab et al., 2007). These findings offer insights into the physiological mechanisms behind immunomodulation, potentially through the motor branches of the vagus nerve and the central nervous system's control of peripheral inflammatory responses.

3.4 *YOGA* AND HYPER-RESPONSIVENESS IN ALLERGIC RHINITIS

Airway hyper-responsiveness, a hallmark of IgE-mediated allergic inflammatory conditions like Allergic Rhinitis (AR), is closely linked to chronic exposure to allergens, leading to the sensitization of the nasal mucosa (Baraniuk & Kim, 2007; Sears et al., 1991). This hyper-responsiveness can also stem from airway inflammation, airway remodeling, and anomalies in smooth muscle and neural control (Berend et al., 2008). Neurotrophins, particularly Nerve Growth Factor (NGF), are known mediators of neural hyper-responsiveness (Togias, 2000). *Yoga,* renowned for its calming effects on the mind, particularly through devotional sessions that help manage emotional turbulence, can be instrumental in mitigating emotional stress (Nagendra & Nagarathna, 1986). Specifically, *yogic* Shuddhi Kriyas like *Neti* cleanse the nasal pathways of allergens and other irritants (Rabone & Saraswati, 1999), potentially reducing the presence of inflammatory cells and cytokine levels in the nasal mucosa, thereby lessening hyper-responsiveness. These insights suggest that *yoga* not only promotes physiological relaxation but also plays a role in reducing hyper-responsiveness in AR.

3.5 SHUDDHI KRIYAS ROLE IN MITIGATING ALLERGENS AND INFLAMMATION

The practice of nasal irrigation, rooted in the ancient *yogic* purification technique of *Neti Kriya,* encompasses two methods: *Jala Neti,* which involves nasal irrigation with lukewarm saline water, and *Sutra Neti,* which uses a thread or catheter for nasal cleansing. *Neti* effectively removes foreign bodies like allergens and dust from the nasal passage (Muktibodhanand, 1998). Several studies demonstrate the positive effects of nasal irrigation on nasal symptom scores (Tomooka et al., 2000; Rabone & Saraswati, 1999). A recent review by Agnihotri et al. (2016) suggests that *Jala Neti* and *Pranayama* (*Yogic* breathing) offer therapeutic benefits for individuals suffering from allergic rhinitis, including asthma.

In a 10-week clinical trial, daily use of saline nasal spray significantly reduced nasal symptoms and episodes of rhinitis (Tano & Tano, 2004). *Jala Neti* has been shown to prevent upper respiratory tract diseases in both adults and children (Meera et al., 2019). Additionally, nasal lavage with isotonic seawater significantly improves mucociliary clearance, Nasal Peak Expiratory Flow (NPEF), and nasal symptoms such as obstruction, posterior secretions, itching, irritation, and sneezing (Holmström et al., 1997). A case study reported that *Sutra Neti* benefited a patient's snoring and sleep apnea (Ramalingam & Smith, 1990). Papsin and McTavish (2003) found saline nasal irrigation to be a safe procedure for both adults and children, aiding in flushing and moisturizing the nasal cavity and promoting mucociliary clearance. In a clinical trial involving thirty allergic rhinitis patients, saline nasal irrigation and heated water vapor at 43°C and 41°C significantly reduced histamine concentration in nasal secretions (Georgitis, 1994). Another trial with pediatric subjects over 12 weeks showed a significant reduction in AR symptoms and eosinophil count (Chen et al., 2014). These findings collectively indicate the

efficacy of *Shuddhi Kriyas,* particularly nasal irrigation techniques, in reducing allergens and inflammatory mediators in allergic rhinitis.

3.5.1 Mechanism of Action for *Neti*

The mechanism of action for *Jala Neti,* or nasal irrigation, can be conceptualized through four key processes:

Direct Physical Cleansing: This process involves flushing out thick mucus, crusts, debris, allergens, and air pollutants from the nasal passages, thereby facilitating clearer nasal pathways (Blake & McTavish, 2003; Rabone & Saraswati, 1999).

Removal of Inflammatory Mediators: Studies have shown that nasal irrigation effectively removes inflammatory mediators, contributing to reduced inflammation in the nasal mucosa (Georgitis, 1994; Chen et al., 2014).

Enhancement of Mucociliary Clearance: *Jala Neti* aids in improving the mucociliary clearance by enhancing the ciliary beat frequency within the nasal passages, which is essential for maintaining nasal hygiene (Holmström et al., 1997).

Desensitization of Nasal Mucosa: *Yogic* cleansing techniques, or *Kriyas*, may lead to the desensitization of the vagal end receptors. This is achieved through systematic exposure to nonspecific graded irritants, followed by deep relaxation, which helps in reducing hypersensitivity of the nasal mucosa (Nagendra & Nagarathna, 1986).

Collectively, these mechanisms underscore the multifaceted benefits of *Jala Neti* in managing conditions like allergic rhinitis, highlighting its role in physical cleansing, anti-inflammatory action, improved nasal hygiene, and desensitization of the nasal mucosa.

3.6 PROPOSED *YOGA* THERAPY MODEL FOR ALLERGIC RHINITIS

Considering the various pathways involved in allergic inflammation, it is hypothesized that *yoga* might exert its anti-inflammatory effects on allergic rhinitis through several mechanisms:

Local Effects: *Yoga* is thought to improve mucociliary clearance, reduce inflammatory cytokines, and decrease the presence of inflammatory cells in the nasal mucosa. This local action directly targets the nasal passages, potentially alleviating some of the primary symptoms of allergic rhinitis.

Systemic Effects: The practice of *yoga* may also produce systemic effects mediated through the Hypothalamus-Pituitary-Adrenal (HPA) axis, efferent vagal stimulation, C-reactive Protein (CRP) levels, and Gamma-Aminobutyric Acid (GABA) regulation. These broader physiological changes can contribute to the overall reduction of inflammatory responses in the body.

Improvements in Respiratory Function: Studies have demonstrated that *yoga* can enhance lung capacity and nasal airflow in patients with allergic rhinitis. This improvement in respiratory function is pivotal in managing the condition effectively.

If *yoga* can indeed modulate cytokines and other pathways involved in mediating inflammation, these alterations are likely to correlate with improvements in clinical signs and symptoms. This includes a reduction in rhinorrhea, sneezing, and nasal obstruction. Such a model suggests that *yoga* therapy, with its multifaceted approach, could be a viable complementary treatment in managing allergic rhinitis, offering both local and systemic benefits.

3.7 *YOGA* FOR MANAGING ALLERGIC RHINITIS

Recent studies have demonstrated the efficacy of *yoga* in managing Allergic Rhinitis (AR). A study involving a three-month *Hatha yoga*-based intervention showed notable improvements in patients with AR. Using a rhinomanometer and spirometer, the study assessed the resistance in

both the upper and lower respiratory tracts. The results indicated a significant decrease in Nasal Airway Resistance, an increase in forced expiratory volume (FEV1), and a reduction in % residual standard deviation (%RSD). Additionally, standard questionnaires like the "Sino-Nasal Outcome Test (SNOT)" and "Short Form-12 (SF-12)" revealed considerable improvements (Chellaa et al., 2019). These findings suggest that *yoga* not only enhances lung capacity but also alleviates nasal congestion in AR patients. Further evidence of *yoga's* benefits is seen in another study featuring an eight-week *yoga*-based program. This intervention, which included *yoga* warm-ups, *Asanas, Pranayama*, Relaxation, and Meditation for 60 minutes, three days a week, led to significant improvements in Peak Nasal Inspiratory Flow Rate and increased interleukin (IL)-2 secretion in the nasal discharge (Chanta A. et al., 2019). These outcomes highlight *yoga's* potential to improve cytokine levels, symptom scores, and nasal airflow, further affirming its role as a valuable therapeutic tool in the management of Allergic Rhinitis.

3.8 CONCLUSION

Yoga, increasingly recognized for its health benefits in allergic and chronic conditions, has yet to be systematically evaluated as a therapy specifically for Allergic Rhinitis (AR). Existing evidence suggests that *yoga* can modulate inflammatory mediators, which has been observed in conditions other than AR. Additionally, there is support for *yoga's* ability to reduce nasal congestion, enhance lung capacity, and improve both nasal airflow and symptom scores in AR cases. Notably, practices like *Neti Kriya* (yogic nasal cleansing) and similar techniques, such as saline nasal irrigation, have been effective in alleviating AR symptoms.

The role of *yoga* in modulating neuropeptides like Substance P (SP), Calcitonin Gene-Related Peptide (CGRP), Vasoactive Intestinal Polypeptide (VIP), and neurotrophins like Nerve Growth Factor (NGF) and Brain-Derived Neurotrophic Factor (BDNF), needs further exploration, as

they contribute significantly to both early and late phases of AR. Our proposed model suggests that *yoga* may downregulate inflammatory and pro-inflammatory cytokines while upregulating anti-inflammatory interleukins. Embracing a holistic health model, *yoga* addresses not just the cardinal symptoms of AR but may also alleviate psychological stress and sleep difficulties. Additionally, *yoga* could potentially reduce nasal airway hyper-responsiveness by improving the sympathovagal balance.

This review's limitations include a focus on open online databases, which may have restricted access to extensive research in the field. Moreover, the narrative nature of this review did not incorporate statistical analyses. Despite these limitations, this review underscores the potential value of integrating *yoga*-based interventions as adjunct therapy for AR. However, there is a pressing need for large-scale, long-term systematic studies with robust methodological designs to fully understand the neurobiological mechanisms underlying *yoga*'s effects on patients with Allergic Rhinitis.