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Review Article

Role of Ayurveda and Yoga-Based lifestyle in the COVID-19 pandemic – A narrative review

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ABSTRACT

The COVID-19 pandemic has posed an immense challenge to health care systems around the globe in terms of limited health care facilities and proven medical therapeutics to address the symptoms of the infection. The current health care strategies are primarily focused on either the pathogen or the environmental factors. However, efforts towards strengthening the host immunity are important from public health perspective to prevent the spread of infection and downregulate the potency of the infectious agent. While a vaccine can induce specific immunity in the host, non-specific ways of improving overall host immunity are needed as well. This scenario has paved the way for the use of traditional Indian therapies such as Ayurveda and Yoga. This review aims at collating available evidence on *Ayurveda*, *Yoga*, and COVID-19. Further, it draws inferences from recent studies on *Yoga* and *Ayurveda* on immunity, respiratory health, and mental health respectively to approximate its probable role in prophylaxis and as an add-on management option for the current pandemic.

1. Introduction

The Coronavirus disease (COVID-19) pandemic has emerged as a major challenge, especially for the health care sector across the globe. Currently, as the number of positive cases of COVID-19 is outstripping existing healthcare facilities, an economically feasible therapeutic option can be immensely beneficial. Strategies that can improve immune surveillance and resilience in terms of reduction in inflammatory markers and improvement in the activity of the specific immune cells involved in the pathogenesis of COVID-19 are the need of the hour. Conti et al. suggested that reduction of inflammatory responses is a relevant strategy to reduce the severity of the COVID-19 disease, that could potentially reduce the number of cases requiring critical care [1]. The current health care strategies have primarily focussed on either the pathogen or on the environmental factors. However, the efforts towards strengthening the host immunity are important from public health perspective to prevent the spread of infection and downregulate the potency of the agent. While a vaccine can induce specific immunity to the host [2], non-specific ways of improving overall host immunity are equally necessary. Thus, traditional Indian systems of medicine such as *Ayurveda* and *Yoga* should be explored for their potential role in improving host immunity and reducing severity of the infection.

This review aims to consolidate the existing literature available on *Yoga* and *Ayurveda* for COVID-19. Further, it infers the ancilliary evidences for utlity of *Yoga* and *Ayurveda* in enhancing health in three major domains: 1) Immune system, 2) Respiratory system and 3) Mental health, that are more vulnerable during COVID-19 infection.

2. Understanding COVID-19

2.1. Ayurveda perspective

According to *Ayurveda* classics, the term *Janapadodhwamsa* (epidemic diseases) has been used to describe epidemics/pandemics which manifest due to polluted *Vāyu* (air), *Bhūmi* (land), *Jala* (water), and *Kāla* (vitiated seasons). These are considered to be

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consequences of *'Prajñaparādha'* (crime against wisdom) and *'Adharma'* (Unrighteousness) [3]. *Ayurveda* classics have described the concept of *Sukshmakrimi/bhūta* (organisms invisible to the naked eye). The term *Bhūtabiṣanga* (exogenous cause) has been used to describe diseases caused by them [3]. Fever due to *Bhūtabiṣanga* is similar to the conditions explained during the epidemics/pandemics. In the Ayurveda context of epidemic diseases, terms such as *Samsargaja* and *Upsargaja* have been used to indicate transmission from infected to the healthy through contact including exhaled air. The modes of spread in *Janapadodhwamsa* have been described as through *Gātrasamsparsa* (touch), *Niṣwāsa* (inhalation), *sahabhojana* (eating together), *sahāsana* (sleeping together), and *Sahagandhamālyānulepana* (use of infected articles) [4]. Interestingly, *Susŕuta* has also described a condition that mimics all symptoms of an influenza-like illness such as the current COVID-19 viz., *Jwara* (fever), *Swāsa* (difficulty in breathing), *Kāsa* (cough), *Siroruk* (head ache), *Pratisyāya* (common cold), *Gandhaajñana* (anosmia), *Bhrama* (giddiness/postural instability), and *Vamathu* (vomiting) [4].

Clinical symptoms reported by Huang et al. from heavily affected places of COVID-19 suggests that, 98% patients had mild to moderate fever (*Jwara*), 76% had cough (*Kāsa*), and 44% had myalgia (*Aṅgamarda*) and fatigue (*Tandrā*). Among those who developed pneumonia, 99% had fever (*Jwara*), 70% had fatigue (*Tandrā*), 59% dry cough (*Vātikakāsa*), 40% anorexia (*Aruci*), 35% had myalgia (*Aṅgamarda*),31% had dyspnea (*Swāsa*), and 27% had sputum production (*Kaphajakāsa*) [5]. Considering all these factors, COVID-19 can be considered as a *Kapha-vātasamsargajajwara* (a febrile condition with predominance of *kapha* and *vāta*) [3] with *Pitta* association [3] in the initial stages. At advanced stages it acquires the status of overt *Sannipātajwara* (a febrile condition with predominance of all *Tridoṣaḥ* viz., *Vāta Pitta* and *Kapha*-a disease involving all *Tridoṣaḥ* in its pathophysiology) which has been described in *Ayurveda* as difficult to cure) [3].

2.2. Yoga perspective

Yoga therapy emphasises on modulation of host factors such as regulation and moderation of the lifestyle factors [6]. Host immunity is downregulated due to altered lifestyle patterns such as consumption of unwholesome food, physical inactivity, improper sleep—wake cycle, increase in workload, stress, and addictions [7,8]. This results in fragility of the immune resilience that results in the host succumbing to the virus. Thus, the aim of *Ayurveda* and *Yoga* therapeutics is to enhance host immunity and reduce the extent of infection and inflammation in the body by balancing body humors and lifestyle factors.

3. Potential role of Ayurveda and Yoga in COVID-19 infection: current evidence base

To understand the role, we have categorized our literature search into three domains which are commonly involved in COVID-19 infection: 1) Immune system, 2) Respiratory System and 3) Mental Health.

3.1. COVID-19 infection current evidence base

3.1.1. Ayurveda

Using the key words '*Ayurveda*' and 'COVID' in search engine PubMed till 20th December 2020. We found 218 articles; out of these 63 dealt with *Ayurveda* and COVID-19. From these 63—45 articles were reviews, letters to editor, or concept papers and 18 articles were experimental studies. Those 18 studies included: 1 double blind Randomized controlled trial (RCT), 1 uncontrolled RCT on Influenza like illness, 1 prospective open label interventional clinical trial, 2 case studies and 13 were Insilico/docking studies. Insilico/Docking studies were conducted on *Āyurveda* herbs such as *Asparagus racemosus*, *Tinospora cordifolia*, *Nigella sativa*, *Withania somnifera*, *Andrographis paniculate*, and *Zingiber*. Much of the data on anti-viral properties of medicinal herbs come from Insilico and in-vitro studies. Molecular docking studies suggest that curcumin and nimbin withaferin A, piperine, mangiferin, thebaine, berberine, and andrographolide have significant binding affinity towards spike glycoproteins of SARS-CoV-2 and ACE2 receptor and may be useful as a therapeutic and/or prophylactic agent for restricting viral attachment to the host cells. Resveratrol, quercetin, luteolin, naringenin, zingiberene, and gallic acid have significant binding affinity towards the ACE2 receptor only and therefore may be used for ACE2-mediated attachment inhibition of SARS-CoV-2 [9]. Study with *Asparagus racemosus* (Willd.) found Asparoside-C, Asparoside-D, and Asparoside −F were most effective against NSP15 Endoribonuclease and spike receptor-binding domain [10]. Further studies demonstrated Berberine, a chemical constituent of *T. cordifolia* can regulate 3CLpro protein's function due to its easy inhibition and thus can control viral replication [11]. Among twenty-five phytocomponents of *N. sativa*; alpha-spinasterol, beta-sitosterol, campesterol, taraxerol and 24-methylene-cycloartanol showed best binding affinity against N-terminal RNA binding domain of nucleocapsid protein and papain-like protease of SARS-CoV-2 [12]. Docking study with *Withania somnifera* (*Ashwagandha*) found four constituents; Withanoside II, Withanoside IV, Withanoside V and Sitoindoside IX exhibited potential inhibition against main protein (Mpro) of SARS-CoV-2 [13]. Similar observations were observed with Andrographolide from Andrographis paniculate exhibited potential inhibition against main protein (Mpro) of SARS-CoV-2 [14]. In another docking study 6 gingesulphonic acid which is present in Sunthi (*Zingiber officinale* Roscoe) showed higher binding energy and inhibition to protein molecule of SARS-CoV-2 compared to hydroxychloroquine and quinine [15]. In a prospective clinical study comprising *Daśmūlakaṭtrayādi kaṣāya* and *Guḍūcyādi kvātha* tablets as add ons to standard care showed a faster recovery from breathlessness with reduced ageusia accelerating recovery in terms of reduction of symptoms and duration of hospital stay [16].

3.1.2. Yoga

Using the key words "*Yoga*" or "meditation", "COVID", "corona virus", "SARS" in PubMed search engine, we found 29 articles till December 2020. Out of these, 18 articles were on *Yoga* and COVID-19, which included: 9 review articles discussing the role of Yoga in the pandemic [17—25], 4 letters to editor and short communications [26—29], 2 research protocols of randomized controlled trials, (first one to study the efficacy of online *Sudarshan Kriya Yoga* (SKY) for frontline hospital staff) [30] and the other to examine the effect of meditation app on anxiety and wellbeing [31], 2 cross-sectional observational studies [32,33], 2 articles on cancer care during pandemic [34,35], 1 on modifications in tele-training and tele-assessment in alternative therapies for multiple sclerosis during COVID-19 pandemic [36]. From these 18 articles, 3 articles exclusively focused on the role of *Yoga* in elderly [23,27,28] and 2 were related to maternal health during the pandemic times [22,24]. Only 4 articles discussed specific *Yoga* modules for COVID-19 [17,18,26,27].

We would like to provide the contextual summary of the available reviews primarily focusing on *Yoga* for COVID-19. A study exploring the patterns of physical activity across genders during the pandemic revealed a significant increase in women opting

Yoga along with reduction in walking and marching outdoors [33]. *Yoga* has been considered as one of the home-based activities that can be utilized to improve mental wellbeing amidst the pandemic [25]. Nagendra et al. emphasized on homeostasis at body as well as mind and provided philosophical relevance of *Pancha-koshas* (five sheaths of existence) and *Viparyaya vritti* (false/misinterpretation of a subject) of Patanjali's *Pancha vrittis* (mental afflictions) and *Pratipaksha bhavana* (contrary mental attitude recommended in yogic literature) to the current scenario in addition to the evidences suggesting role of *Yoga* as an add-on in reducing severity of infections and inflammation [19]. In the same context, Nagarathna et al. discussed the challenges posed by the pandemic and the potential areas where *Yoga* could play its role in prevention and management of COVID-19 such as stress management, improving the respiratory functions and immunity [17]. Another review aimed that highlighting the traditional knowledge from *Ayurveda* and *Yoga* to formulate local and systemic prophylactic and therapeutic measures in accordance to the known disease course of the SARS coronavirus 2 (SARS-CoV-2) [20]. Bushell et al. lucidly discussed the probable mechanisms of action of *Yoga* and meditation in combating the current pandemic. The local and systemic anti-inflammatory actions of *Yoga* have been discussed and further warranted an urgent need to investigate these mechanisms in order to validate and potentiate the use of *Yoga* and meditation as an adjunct therapy for management of COVID-19 [21].

3.1.3. Ongoing trials

Clinical Trial Registry of India (CTRI) has 122 registered trials on COVID-19. Of which, 42 trials were on modern medicine and 67 were registered on traditional systems of medicine. Of 67 trials, 45 were on *Ayurveda*, 14 on Homeopathy, 8 on *Yoga/Siddha/Unani*. Thirty-one trials included traditional system of medicine as prophylaxis and the other 36 trials as therapy for mild to moderate cases of COVID-19 [37]. However, results from these registered trials are still awaited.

3.2. Immune system

3.2.1. Ayurveda and immunity

Every individual possesses inherent strength which opposes the manifestation and prevents the re-occurrence of disease. This innate strength is called *Vyādhikṣhamatva* in *Ayurveda*. Genetic, epigenetic and lifestyle of an individual determine this innate strength. *Ojus* (essence of seven tissue elements) is the chief contributor in sustaining *Vyādhikṣhamatva*. *Ayurveda* concept of immunity is classified as *Sahaja* (constitutional), *Kālaja* (chronobiologic) or *Yuktikrta* (acquired strength) [38]. Optimum immunity plays a vital role in preventing/minimizing the chances of infection in pandemic like situations. *Ayurvedic* approach towards promoting immunity includes the use of *Rasāyana* that comprises of proper daily regimens, seasonal regimens and consumption of medicinal herbs that enhance tissue regeneration. Among *Rasāyana* specially *Kāmya Rasāyana* is taken to increase the longevity and intelligence and *Ajsrika rasāyana* taken on the daily basis helps in optimizing the immune system [4]. Herbs such as *Tinospora cordifolia*, *Embelia officinale*, *Bacopa monnieri*, *Curcuma longa*, *Ocimum tenuiflorum*, *Terminalia chebula*, *W. somnifera* and *Asparagus racemosus* are potential immunomodulators [39]. Regular use of these herbs either alone or in form of preparations such as *Chavyanprash* and *Bramha rasāyana* helps in immune strengthening and serve as an effective prophylaxis in the management of SARS-COV-2 infection. *Swarna bindu prashana* (SBP) improves the immunity in infants and children [40].

3.2.2. Yoga and immunity

Out of the literature available on *Yoga* for COVID-19, there are no experimental studies that have demonstrated improvement in immune parameters of patients with COVID-19. However, there are ancillary evidences that point towards probable role of add-on Yoga therapy in increasing the anti-inflammatory neuro-hormonal substances and thereby reducing in the severity of infection. A RCT compared the effects of 8-week *Yoga* program and matched moderate intensity exercise and no intervention on the acute respiratory illness severity in individuals above 50 years of age during single flu season. Mean global severity [measured on Wisconsin Upper Respiratory Symptom Survey (WURSS-24)] was lesser in meditation group than the exercise group and was significantly lower when compared to control group [41]. Another study demonstrated that regular practice of integrated *Yoga* program (joint loosening, sun salutations, breathing practices, *Prānayāma* and relaxation techniques) for a month could boost the immunity and psychological health in patients with HIV [42,43]. *Yoga* has also been found beneficial as an adjunct to anti-tuberculosis treatment (ATT) in patients with pulmonary tuberculosis by reducing the symptom scores, sputum conversion on microscopy, improvement in the lung capacity, and radiographic pictures [44].

A number of RCTs reported the efficacy of *Yoga* in regulating inflammatory markers. A recent systematic review of 15 RCTs revealed that the practice of *Yoga* significantly decreased pro-inflammatory markers such as Interleukins: (IL)-6, IL-1β and Tumor Necrosis Factor (TNF-α) and increased the levels of anti-inflammatory markers such as IL-10 and IL-12 [45]. Further, Davidson et al. (2003) demonstrated an increase in antibody titer in response to influenza vaccine in the subjects who practiced 8-week meditation program as compared to the control non-meditators [46]. Studies have also demonstrated higher levels of circulating CD3+, CD4-and CD8+, B lymphocytes and Natural Killer cells (NK cells) in the meditators and Yoga practitioners as compared to no-practitioners [47–49]. *Sudarshan kriya* (SK), a yogic breathing which includes *Ujjāyi* and *Bhastrika* practices has been found to lower blood lactate levels, enhance antioxidant defence [50] and improve NK cell counts [51]. Also, studies have reported that practice of *Yoga* for 4–12 weeks can improve anti-oxidant status of an individual by improving the levels of glutathione and superoxide dismutase [52,53]. These evidences suggest the role of *Yoga* in reducing the severity of infections by regulating the immune responses.

3.3. Respiratory System

3.3.1. Ayurveda and respiratory health

SARS-CoV-2 enters the host via the respiratory tract, airway and alveolar epithelial cells, vascular endothelial cells and alveolar macrophages are among their first targets of viral entry. These cells are the initial targets for early infection and subsequent replication due to their expression of ACE2. Observations emulating the disease course of COVID-19, suggesting that the lung is the primary tropism of SARS-CoV-2. From *Ayurvedic* point of view, the primary site of the disease is *Prānavaha srotas*, which includes both upper and lower respiratory tracts. *Āyurveda* mentions several interventions that can improve the innate immunological responses of respiratory epithelium and thus may prevent the virus transmission to lungs. The daily regimen measures such as *Uṣha pāna* (drinking water retained in copper vessel), gargling, nasal installation and consuming hot food and water may be beneficial in maintaining the respiratory health that plays a key role in host defense mechanism against viral infections [54–56]. Medicated hot water (*Saḍaṅga pāniya*) may help in improving digestion and balancing of *vāta* and *kapha dosha* which play a major in manifestation of respiratory conditions such as rhinitis, cough, and breathlessness [38].

AYUSH *kvātha* [57], a Government of India initiative, is an herbal concoction of household spices consisting of holy basil, cinnamon, ginger and black pepper along with jaggery/raisins and lemon juice that may help in restoring the respiratory health. All the ingredients in AYUSH *kvātha* pacify *Kapha* and *Vāta*, they possess *Kāsahara*, *Svāsahara*, *Depana*, *Pāchana*, *Jvaragna* and *Kṛimigna* properties [58]. *Sodana* (bio-cleansing) in form of *Ritu sȯdana* (seasonal bio-cleasing) and *Rasāyana* (immune modulators) for the maintenance of respiratory health. Several in-vitro, animal and human clinical studies have demonstrated the immunomodulatory effects of the *Rasāyana* drugs such as *Aswagandha* (*W. somnifera*), *Gudūci* (*Tinospora cordifoloia*) and *Āmalaki* (*Emblica officinale*) [39]. Recent studies on *Aswagandha* have reported significant increase in immunoglobulins viz. IgA, IgG and IgM [59]. *Gudūci* has been found to exert a variety of immunomodulatory effects such as stimulation of phagocytic functions, macrophage and mitogenic activity, antibody responses, synthesis of interleukins, and humoral and cell-mediated immunity, both in-vitro and in-vivo respectively [60]. Another study on *Āmalaki rasāyana* (AR) has suggested that it possesses an immunostimulant and cytoprotective activity [61].

3.3.2. Yoga and respiratory health

Currently, there are no experimental studies that demonstrated improvement in lung functions in patients with COVID-19. We have aimed at drawing evidences from synonymous non-infectious conditions with respiratory distress. Consistent practice of yogic breathing techniques (*Prānayāma*) improves lung functions and capacity by strengthening the inspiratory and expiratory muscles [62]. In a controlled study, the practice of *Bhastrika* (Bellow's breath) *Prānayāma* significantly increased the maximum inspiratory and expiratory pressures in comparison to the stretching exercises in the elderly participants [63]. A randomised, double-blind, placebo-controlled, crossover trial demonstrated improvement in mean forced expiratory volume in 1-s (FEV1), peak expiratory flow rate, symptom score, and inhaler use (over the past 3 days) in 18 patients with mild asthma after the practice of slow deep *yogic* breathing. The breathing was practiced for 15 min, twice a day, for two consecutive weeks [64]. Similar improvements have been reported in trials involving patients with moderate to severe asthma and Chronic Obstructive Pulmonary Disease (COPD) [65,66]. Chair based *Yoga* breathing practices have been found useful in acute airway obstruction in patients with bronchial asthma [17]. Soni et al. also reported an improvement in TLCO (Transfer factor of Lung for Carbon Monoxide) diffusion capacity inpatients in the *Yoga* arm. TLCO improved from 17.61 ± 4.55 to 19.08 ± 5.09 ml/mmHg/min in patients with mild COPD and from 14.99 ± 4.02 to17.35 ± 3.97 ml/mmHg/min in patients with moderate COPD, as compared to the control group who were on conventional therapy alone [67]. A study assessed blood oxygen saturation before, during and after two Yoga breathing techniques; high frequency Yoga breathing (*Kapālabhāti*) and breath awareness in 29 healthy young male volunteers. A significant increase in oxygen saturation was noted after high frequency Yoga breathing for 33-min [68]. Another study examining the effect of Humming breath (*BhrāmariPrānayāma*) reported improvement in sinus ventilation and 15-fold increase in nasal nitric oxide (NO) levels (involved in host defence functions) [69].

3.4. Mental health

3.4.1. Ayurveda and mental health

During the current pandemic, Rajkumar et al. reported that 28% of the screened subjects (general public and healthcare professionals) reported stress, symptoms of anxiety, and depression [70]. A meta-analysis of 300 studies concluded that chronic stressors reduce both cell mediated and humoral immunity of the host [7]. On the other hand, reduction in stress hormones, psychological stress, anxiety, and depression are associated with better functioning of the immune system. This emphasizes the need for addressing mental health issues during the current pandemic. Both physical and psychological disorders have the capacity to exert mutual effects on each other. Conditions such as fever can exert its effect over mind and can lead to psychological manifestations on other hand psychological conditions can lead the physical manifestations (ca.vi 6/7). *Swāsthya* (health) in *Ayurveda* includes mental well-being in the form of *Prasanna* (healthy), *Atma* (soul), *Manah* (mind), and *Indriyāh* (senses) [4]. Caraka has advocated *Achara rasāyana* (code of behavioral conduct) for perfect mental, physical, social, spiritual health of human beings. It includes moral, ethical, and benevolent conduct: truth, nonviolence, personal and public cleanliness, mental and personal hygiene, devotion, compassion, and a *yogic* lifestyle [3].

A study suggested that individual who strongly follows *Achara rasāyana* were good at academics, enjoying good physical and mental health and friendly reputation among peers [71]. Further acharyas advocated intake of *Medhya rasāyana* (psychotropic Ayurvedic pharmacological interventions) for maintenance of mental health. *Medhya rasāyana* include drugs which help in cognition enhancement and act as brain tonics or rejuvenators e.g., *Mandūkaparni (Centella asicatica), Yaṣtimadhu (Glycerrhiza glabra), Gudūci (Tinospora cordifilia)* and *Sankhapuṣpi (Clitoria ternacia)* [3]. These drugs promote *Dhi* (Intellect) *Dhrti* (power of self-control), and *Smṛti* (memory). Further, *M. rasāyanas* balance *Manodoṣas* (humours that control the mind) viz., *R*ajas (speed) and *T*amas (indolence) thereby regulating and promoting healthy mental functions [72]. Another study revealed that consumption of *Aswagandha* 600 mg/day for 12 weeks led to overall improvement in the general wellbeing, sleep quality and mental alertness of healthy subjects [73]. Meta-analysis on *C. asicatica* suggested improvement in alertness and reduction in anger outbursts [74]. Similarly, a study on *Sankhapuṣpi* demonstrated its memory-enhancing, anxiolytic, antidepressant, and memory-enhancing activity [75]. Hence psychotropic *Ayurvedic* pharmacological interventions may benefit in managing stress, anxiety and depression.

3.4.2. Yoga and mental health

Mental health plays a pivotal role in regulation of proper immune responses and homeostasis.

However, mental health has taken a greater toll in all the sections of the society due to the COVID-19 pandemic [18]. This has resulted in increased incidences of anxiety and depression, leaving the vulnerable population such as healthcare workers at the risk of Post Traumatic Stress Disorder (PTSD) [29]. *Yoga* has been included as one of the home-based activities to improve mental health during the current pandemic [25]. There are evidences on the efficacy of *Yoga* in previous similar natural disasters [76,77]. There are two studies that have reported improvement in mental health during the current pandemic period. A cross sectional study has reported that higher percentage of non-practitioners (33%) of *Sudarshan kriya Yoga* (SKY) have reported anxiety and negative effects on their mental health that SKY practitioners (17.7%) during the current pandemic [32]. Another, pre-post single group study investigated the effect of tele-*yoga* intervention on perceived stress. To meet the norms of social distancing during the present pandemic, a tele-*yoga* module was designed and was offered to the general public during the national lockdown period. The participants were assessed on perceived stress scale (PSS-10), *Yoga*

Performance Assessment (YPA) and Visual Analog Scale (VAS) at the baseline and after a 4-week *Yoga* program. Their YPA scores indicated that *Yoga* practices were learnt properly and efficiently. At the end of 4-weeks, a significant reduction in perceived stress on PSS-10 and improvement in wellbeing on VAS was noted, suggesting usefulness of the tele-*yoga* module in reducing stress and improving mental wellbeing [26].

Prodigious amount of evidence suggests usefulness of *Yoga* to induce mental tranquillity and equilibrium. *Yoga* is known to regulate hypothalamo-pituitary-adrenal (HPA) axis and bring balance in the autonomic nervous system functions. Practicing *Yoga* increases the Gamma Amino Butyric Acid (GABA) levels and reduces the levels of cortisol (stress hormone) and catecholamines leading to reduction in stress, anxiety, and depression [78,79]. Further, a systematic review that studied 7 RCTs with 240 participants with major depressive disorder reported positive effects of *Yoga* beyond placebo concluded that *Yoga* interventions were comparable to other evidence-based conventional interventions [80]. Similarly, systematic review including RCTs on anxiety disorders and individuals with elevated levels of anxiety revealed that *Yoga* is safe and effective for elevated levels of anxiety, however future studies to conclude its efficacy for anxiety disorders are required. Recent systematic reviews studying the effects of *Yoga* in stress in healthy individuals and healthcare workers suggested positive effects of *Yoga* on reducing stress [81,82].

4. Discussion

4.1. Critical analysis of literature

As narrated above, current available literature in *Yoga* and *Ayurveda* has lucid theoretical framework that could be used as foundation for the experimental studies to examine their effects for COVID-19 infection in the domains of improving immunity, reducing respiratory distress, and improving mental health. Recommendations and probable usefulness of *Yoga* and *Ayurveda* in COVID-19 in the existent literature have been extrapolated from its effects on other similar conditions such as acute upper respiratory infections, obstructive lung disorders, and so on. Though some case-studies and small pilot experimental studies have been published, experimental studies with robust methodology and validated intervention protocols on humans are lacking and are warranted in future. Scientific rigour should be followed to ascertain the efficacy of such interventions.

4.2. Probable mechanisms of action

4.2.1. Ayurveda

With a view point of prevention and improving the host defence mechanism when the contact of the pathogen with the host is unavoidable the above narrated measures helps to overcome/minimize the severity of the infection. *Rasāyana dravyas* may stimulate humoral immunity in terms of antibody production and cell-mediated immunity in terms of delayed-type hypersensitivity [39]. They may diminish the release of TNFα, IL-1, inhibit NF-kB, increase B cell proliferation, and act by chain breaking and scavenging of free radicles [83]. Study has suggested that *Svarṇa bindhu prāśana* may enhance differentiation immature dendritic cells into mature dendritic cells through expression of CD83 and CD86 which may effectively strengthen the immune system [40]. Copper impregnated water has been found to have antimicrobial, antioxidant, anti-carcinogenic, and anti-inflammatory properties [54]. Mouth rinsing with warm liquids and medicated oil may help in excretion of toxic heavy metals by saliva, may activate salivary enzymes, thus detoxifying the entire body [55]. Nasal installation of medicated oils and vegetable oils such as sesame oil may act as protective layer and trap virus particles thereby preventing direct contact and binding of virus onto the surface of nasal mucosa [56]. Ingredients of AYUSH *kvātha* possess antiviral, anti-inflammatory and antioxidant properties. Active constituents of these drugs like eugenol, linoleic acid in holy basil, cinnamaldehyde in cinnamon, gingerols, shogaols in ginger and piperine in pepper scan have been found to downregulate the proinflammatory pathways thereby decreasing INF-γ, IL-4 and exerting anti-atherosclerotic, anti-coagulative, and anti-platelet activity [57].

4.2.2. Yoga

Yogic practices (particularly *Prānayāma* and meditation) have exhibited significant immunomodulatory effects such as increase in production of immunoglobulins, activation of phagocytic functions, enhancement in humoral and cell-mediated immunity [46–48,51]. It has also been found to reduce inflammatory cytokines such as IL-6, IL-1b, TNF-a (which are part of the 'cytokine storm' reported in COVID-19), along with that it also shows to improvement in the levels of anti-inflammatory cytokines (IL-10 and IL-12) and anti-oxidant status of individuals [41,48,49]. *Yoga* induces neuro-hormonal modulation via HPA axis resulting in reduction of cortisol levels and balance in sympathetic and parasympathetic nervous system. Further, the practice of *Yoga* increases GABA levels stimulating the vagus nerve resulting in parasympathetic predominance and optimization of proper immune responses [78,84]. Psychological stress, anxiety and deterioration of sleep quality have increased during the pandemic [18]. These symptoms may be downregulated by the promotive effects of *Yoga* on melatonin secretion [85]. Melatonin is a known anti-oxidant that plays an important role in improving sleep quality and ameliorating stress and anxiety. *Yogic* breathing techniques have also been found useful in improving lung functions in conditions with respiratory distress such as COPD and bronchial asthma [65,66], suggesting a probable role in reducing respiratory distress in patients with COVID-19 infection.

The available literature points towards potential role of *Ayurveda* and *Yoga* in the prevention of COVID-19 infection, reduction in the intensity of the symptoms, of infection in those afflicted, as well as improving pulmonary function, quality of life, and mental wellbeing in the rehabilitative phase post-COVID.

4.3. Limitations of current literature review

This narrative review has not been systematised according to the PRISMA guidelines of reporting studies due to scanty literature available on the effect of *Yoga and Ayurveda* for COVID-19. The above suggestions have been drawn based on the efficacy of *yogic* practices and *Ayurvedic* drugs as preventive and therapeutic measures in condition bearing similar clinical features.

4.4. Future directions

Collaborative multi-centric trials to evaluate the safety, feasibility and, efficacy of *Ayurveda* and *Yoga* lifestyle interventions in treating various stages and severity of the COVID-19 infection are the need of the hour. This will enable recommendation of specific *Ayurveda* and *Yoga* protocols for each stage of the illness.

5. Conclusion

Though conclusive evidences on role of *Yoga* and *Ayurveda* on COVID-19 are lacking. The available ancillary evidences point towards the potential role of *Yoga* and *Ayurveda* in preventing and mitigating the infection through modulating our immune system,

strengthening respiratory system, and mental health respectively. This suggests an urgent need for conducting systematic clinical trials to investigate the add-on efficacy of *Yoga* and *Ayurveda* lifestyle interventions with current conventional treatment approaches.

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Conflict of interest

None.

Author contributions

Chikkanna Umesh: Conceptualisation, Investigation, Data curation, Writing-original draft, Visualization. Kishore Kumar Ramakrishna: Conceptualisation, Methodology, Validation, Data curation, Writing- review & editing, Visualization, Supervision. Nishitha Jasti: Conceptualisation, Investigation, Data curation, Writing-original draft, Visualization. Hemant Bhargav: Conceptualisation, Methodology, Validation, Data curation, Writing-review & editing, Visualization, Supervision. Shivarama Varambally: Conceptualisation, Validation, Writing- review & editing, Visualization, Supervision.

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