

# Yoga, immunity and COVID-19: A scoping review

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## ABSTRACT

Yoga is recognized and practiced for different levels of prevention since antiquity. The current scoping review aimed to identify and document the evidence reporting the effect of yoga interventions on immunity against COVID-19 infection. Three databases—PubMed, Cochrane, and Google Scholar, were searched to identify eligible studies. Articles published in English after 2010 and assessing the impact of any form of yoga (such as yogasanas, meditations, or pranayamas) on immunological markers were included in the review. The studies without information of the intervention on immunity markers, and experience sharing reviews were excluded. The search yielded 45 eligible articles with majority of the studies being published from the USA and India. Most of the studies were randomized controlled trials, enrolling the adult population with a specific focus on diseases like HIV, cancer, and heart failure. It was observed that a variety of yoga interventions along with meditation and pranayama, in different combinations were used by the authors. However, all these studies unanimously reported improvement in immunological profile (indicated by improved biochemical markers) of an individual (irrespective of disease state and type) with yoga. Moreover, the beneficial effects of these traditional Indian interventions were also found to have a positive impact on overall physical and physiological wellbeing and quality of life. Findings from the existing literature indicate that the practice of yoga has the potential to strengthen cell-mediated immunity and hence could be used as an effective preventive measure against COVID-19 where immunity plays a critical role.

**Keywords:** COVID-19, immunity, meditation, pranayama, review, yoga

## Introduction

With the World Health Organization (WHO) recognizing COVID-19 (SARS-CoV-2) pandemic as one of the worst global health crises ever, the entire world is exploring interventions to reduce the devastating health consequences of the pandemic. Ranging from hand washing, social distancing, lockdown to pharmacological and non-pharmacological interventions all are being tested for their efficiency in limiting the catastrophic effects of the pandemic. COVID-19 infection and its association with immune reactions have received lot of scientific attention since

starting of the pandemic. It is known that SARS-CoV-2 infection triggers cytokinin storm, leading to various clinical manifestations such as lymphocyte dysfunction, lymphopenia, septic shock, and multiorgan failure.<sup>[1]</sup> Altered levels of plasma cytokines and chemokines in the patients suffering from COVID-19 have been reported by many.<sup>[2-17]</sup>

Yogasanas and meditations - ancient mind-body practices though originated from the Indian subcontinent are now increasingly gaining popularity across other parts of the world for their proven clinical and non-clinical health benefits.<sup>[18]</sup> The imperative impact of yogasanas and meditation on the immune system in presence of chronic and acute stressors is widely studied under various disease conditions.<sup>[19]</sup> Pieces of evidence from randomized controlled trials (RCTs) indicated cell-mediated and mucosal immunity-enhancing effects of yogasanas and meditations in diseased as well as healthy individuals.<sup>[20]</sup> It exerts positive effects through down-regulation of inflammatory markers where

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specific exercises of yogasanas and meditations are known to improve respiratory health and immunity, both are needed for protection against COVID-19. Current scoping review aims to map all the available practices of Yoga for its potential impact on immune system that might pave a way for an alternative preventive and management strategy for COVID-19, having its higher utilities at primary care and resource-poor settings.

## Methods

The following methodological framework was used to conduct the review: (1) Identification of review question, (2) Developing of review objectives, (3) Setting eligibility criteria, (4) Developing search strategy and identification of search sources, (5) Screening records and data extraction, and (6) Evidence synthesis.

### Search strategy

Comprehensive search was conducted using PubMed, Google Scholar and, the Cochrane databases, with publication date limits of last 10 years. We searched databases using a combination of intervention-related terms (mind–body intervention OR yoga OR meditation OR pranayama) and immunity-related terms. Supplementary searches were also conducted in clinicaltrials.gov. The detailed search strategy for individual databases was as follows: PubMed and Cochrane - ((yoga [MeSH] OR pranayama OR breathing exercise OR asan OR yoga posture OR yoga position OR yoga Therapy)) AND TOPIC: ((“immunity” [MeSH] OR Immun\* OR immune response OR immune function OR infection)) AND TITLE: ((yoga OR Pranayama OR breathing exercise OR asan OR yoga posture OR yoga position OR yoga Therapy OR Cytokines OR telomers OR immune response OR immune function OR infection OR immunity OR immun)); Google scholar - (“Yoga” or “Pranayama”) and (“Immunity” or “immune response” or “immune function” or “infection” or “inflammation” or “cytokines” or “telomers”).

### Study selection and data extraction

After the initial literature search, two researchers independently screened studies for eligibility and relevance. The discrepancies were resolved through mutual discussion or with the opinion of a third reviewer. Studies were considered to be eligible if they presented interventional studies/reviews that adopted at least one yoga or meditation-based intervention technique for its effect on physiological/biochemical markers of immunity. Studies were identified as ineligible if they were: (a) case reports, (b) protocols, or (c) unpublished articles. Authors independently screened the articles based on titles and abstracts and eligible articles were further evaluated using full-text assessment. Disagreements between reviewers about eligibility were resolved through discussion.

### Data extraction and data synthesis

Data extraction was completed using a predefined tool and an excel matrix. The matrix was filled by two reviewers where the same electronic data collection tool was used to avoid the error.

Information regarding authors, country, study duration, type of intervention, and outcomes were extracted from individual studies.

## Results

After excluding duplicates, 366 articles (PubMed 105, Cochrane 122, and Google Scholar 139 articles) were assessed for its eligibility from three different databases and 45 articles<sup>[21-65]</sup> [Figure 1, Tables 1 and 2] were included in the final scoping review.

### Characteristics of studies

Out of 45 included articles, 22 were RCTs; 4 each were cohort, systematic review and meta-analysis (SRMA), and systematic review (SR) only; 3 were Non-RCTs; 1 was review of meta-analysis; and 7 were other reviews including narrative, scoping, descriptive and others. Majority of the studies were reported from the USA (40%) followed by India (31%); and from China (4%) and Iran (4%). Scattered reports were also published from the countries such as Australia, Brazil, Germany, Japan, Korea, Hong Kong, Ireland, Singapore, Taiwan and Thailand [Table 1]. The impact of yoga-based interventions on immunity markers was studied in various diseased and healthy populations. Fourteen studies (31%) included cancer patients among which 6 (13%) included breast cancer; 13 (29%) included healthy persons; 5 (11%) were from mental diseases including depression and stress/PTSD; and 4 (9%) were from HIV. Similarly, other medical conditions observed were Heart Failure, Irritable Bowel Disease (IBD), Multiple Sclerosis, Chest Injury, Rhinitis, Arthritis, and Asthma. Three studies assessed Telomere stability; 2 studies included the pregnant women and one study assessed the impact of yoga intervention on COVID-19 disease.

### Sample size and population characteristics

The sample sizes of the individual studies varied widely, ranging from 16 to 260 participants. The quantitative data used for meta-analysis ranged from 124 to 2219 [Table 1]. Information regarding the age of the population was mentioned in 34% of the articles and it ranged from 18 to 60 years. Apart from a study involving HIV-infected children, no other studies enrolled participants from the pediatric age group.

### Intervention details

Intervention protocols and duration of therapy varied substantially among all the studies [Table 3]. Longest intervention duration was recorded as 120 min (2 h) of yoga practice (3-5 times a week for nearly 1-6 months). In contrast, the lowest duration was intervention sessions once per week for nearly 3 weeks with 90 min of yoga practice. Some protocols also had an element of home-based practice. The intervention included various types of yoga such as general yoga (22.50%), integrated yoga with pranayama ( $n = 12$ ; 27%), meditation ( $n = 20$ ; 45%), Hatha yoga (13%), with few using Bikram, Hot, Iyengar, Ashtanga and Laughter yoga;

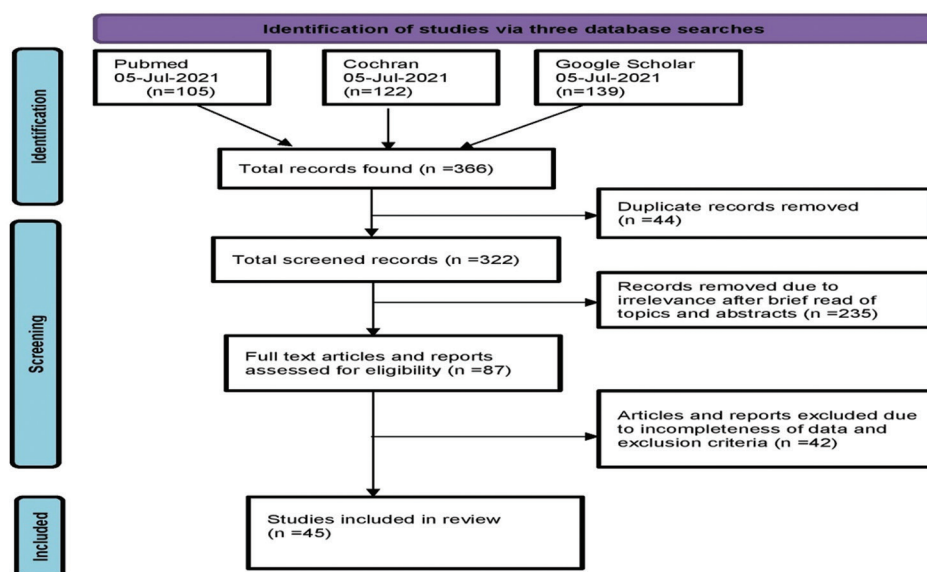


Figure 1: PRISMA chart

and Sudhi, Dhurvini along with a combination of prayer and counseling.

### Outcome measures

As depicted in Table 2, it was found that 48.8% of the studies analyzed their outcome based on cytokines (CRP = 20.9%, IL6 = 39.5%, TNF alpha = 30.2%, IL10 = 11.6%), 11.6% studies focused on serum immunoglobins whereas 20.9% studies also checked immunological markers such as CD-3 (2.3%), CD8 (6.9%), CD38 (2.3%) and CD4 (9.3%), and 13.9% studies also emphasized on cortisol. However, only 6.9% of studies screened NK kappa B and 4.6% NK cells.

Approximately 16% of studies portrayed the evidence based on physical examination that included parameters like pain, fatigue, sleep, heart rate, and  $VO_2$ . On the other hand, 21% of the studies assessed psychological and cognitive parameters as well. For pain-related findings, physical function tests were conducted using Health Assessment Questionnaires-Disability Index (HAQ-DI), Berg Balance Scale (BBS) six-minute walk test (6MWT), physiologic measures of alertness, modified Fatigue Impact Scale (MFIS), tender joints or swollen joints count, Disease Activity Score 28 (DAS-28) and Short Form (SF-36) health-related quality of life.

### Key findings

The results suggested that the practice of hatha yoga and allied activities enhance the inflammatory profile of diseased as well as healthy individuals. The evidence synthesis from various studies also illustrated profound improvement in the physical functioning of the subjects enrolled in the studies. Studies highlighted that yoga improves various aspects of quality of life and physiological distress. Yoga and meditation practice for 3 months have attributed a positive impact on brain-derived neurotrophic factor (BDNF)

signaling, chimeric antigen receptor (CAR), and various pro-inflammatory markers. The hatha yoga also showed reduction in fasting circulating insulin, cholesterol as well as CD31+/CD42b-EMPs. Yoga practice decreased lipid peroxidation, serum nitrous oxide as well as F2-isoprostane. Yoga intervention also up-regulated genes of immunoglobulin-related transcriptomes and down-regulated transcripts including pro-inflammatory cytokines and activation-related immediate-early genes. Apart from this, it also reduces the activity of cAMP response element-binding protein (CREB) family transcription factors, and also, it promotes NFkB expression and reduces HIF-1 activity. In addition, it plays a significant role in minimizing the aberrant expression of various hormones, chemokines, and tumor signaling pathways. Studies have also outlined the role of yoga in maintaining telomeric length, maintaining genomic integrity, and promoting cellular longevity.

Yoga was intervened as a stand-alone or in combination of Yogic asanas, Pranayama (breathing exercises), chanting, relaxation and/or meditation targeting diseased, elderly, adult, pregnant, and general population [Table 3]. It is evident as an adjuvant to conventional treatment by increasing specific salutogenic as well as pathogenic bio-physiological markers. The findings document the changes in (1) the subjective well-being indicators, (2) the physiological, and most importantly, and (3) biological markers. The intervention brought about the changes in general as well as disease-specific quality of life (QoL), balance (related to elderly and stroke patients), physical mobility, mood and fatigue indicators including reduction in psychological distress and post-operative distress. Similarly, in physiological markers, the changes in cardio-pulmonary outputs such as  $FEV_1$ ,  $VO_2$ , peak- $VO_2$ ,  $\%VO_{2max}$ , kcal expenditure, heart rate and respiratory rate as well as lipid profiles (especially increasing the healthy and decreasing the unhealthy lipids), the cognitive and alertness were documented. However, in some studies, non-significant pieces of evidence are also documented.

**Table 1: Details of the included studies (publication year, country, sample and type of article)**

Article title	Authors	Publication Year	Country	Sample	Type of article
Yoga into Cancer Care: A Review of the Evidence-based Research	Agarwal RP <i>et al.</i>	2018	USA	10,660	Systematic review
Enhancement of cancer stem cell susceptibility to conventional treatments through complementary yoga therapy: possible cellular and molecular mechanisms	Bhargav H <i>et al.</i>	2012	India		Narrative Review
Identification of potential salivary response biomarkers in subjects practicing yogic breathing	Balasubramanian S <i>et al.</i>	2015	USA	20	Randomized controlled trial
Yogic meditation reverses NF- $\kappa$ B and IRF-related transcriptome dynamics in leukocytes of family dementia caregivers in a randomized controlled trial	Black D S <i>et al.</i>	2013	USA	45	Randomized controlled trial
Mind-body therapies and control of inflammatory biology: A descriptive review	Bower J E <i>et al.</i>	2016	USA	3 studies	Descriptive Review
Yoga reduces inflammatory signaling in fatigued breast cancer survivors: a randomized controlled trial	Bower J E <i>et al.</i>	2014	USA	31	Randomized controlled trial
Yoga, Meditation and Mind-Body Health: Increased BDNF, Cortisol Awakening Response, and Altered Inflammatory Marker Expression after a 3-Month Yoga and Meditation Retreat	Cahn B R <i>et al.</i>	2017	USA	38	One Group Before-after Intervention
Effect of Hatha yoga training on rhinitis symptoms and cytokines in allergic rhinitis patients	Chanta A <i>et al.</i>	2019	Thailand	27	Randomized controlled trial
Effects of 8-Week Hatha Yoga Training on Metabolic and Inflammatory Markers in Healthy, Female Chinese Subjects: A Randomized Clinical Trial	Chen N <i>et al.</i>	2016	China	30	Randomized controlled trial
Effects of prenatal yoga on women's stress and immune function across pregnancy: A randomized controlled trial	Chen P J <i>et al.</i>	2017	Taiwan	94	Randomized controlled trial
Yoga for symptom management in oncology: A review of the evidence base and future directions for research	Danhauer S C <i>et al.</i>	2019	USA	29 studies	Descriptive Review
Review of yoga therapy during cancer treatment	Danhauer S C <i>et al.</i>	2017	USA	1022; Yoga=504; control=518	Scoping Review
Yoga stretching for improving salivary immune function and mental stress in middle-aged and older adults	Eda N <i>et al.</i>	2018	Japan	23	Clinical Trial
Yoga and immune system functioning: a systematic review of randomized controlled trials	Falkenberg R I <i>et al.</i>	2018	Germany	yoga- group of 12-96, for control 13-90	Systematic review
Toward identifying the effects of the specific components of Mindfulness-Based Stress Reduction on biologic and emotional outcomes among older adults	Gallegos A M <i>et al.</i>	2013	USA	100	Post-test only intervention
Effect of Structured Physical Activity on Inflammation and Immune Activation Profile of Antiretroviral Therapy-Experienced Children Living With HIV	Gopalan B P <i>et al.</i>	2020	India	72	Retrospective Cohort
Preliminary indications of the effect of a brief yoga intervention on markers of inflammation and DNA methylation in chronically stressed women	Harkess K N <i>et al.</i>	2016	Australia	144	Randomized controlled trial
Exercise therapy for fatigue in multiple sclerosis	Heine M <i>et al.</i>	2015	Iran, Ireland, Portland, Slovenia	124	Systematic review
Feasibility study of online yoga for symptom management in patients with myeloproliferative neoplasms.	Huberty J <i>et al.</i>	2017	USA	260	Randomized controlled trial
Exercise training, circulating cytokine levels and immune function in cancer survivors: A meta-analysis	Khosravi N <i>et al.</i>	2019	Iran	27 studies	Meta-analysis
Yoga's impact on inflammation, mood, and fatigue in breast cancer survivors: a randomized controlled trial	Kiecolt-Glaser J K <i>et al.</i>	2014	USA	200	Randomized controlled trial
Acute Physiologic Effects of Performing Yoga in The Heat on Energy Expenditure, Range of Motion, and Inflammatory Biomarkers	Lambert B S <i>et al.</i>	2020	USA	16	Non-RCT
Regular Yoga Practice Improves Antioxidant Status, Immune Function, and Stress Hormone Releases in Young Healthy People: A Randomized, Double-Blind, Controlled Pilot Study	Lim S A <i>et al.</i>	2015	Korea	25	Randomized controlled trial
The effects of mind-body therapies on the immune system: meta-analysis	Morgan N <i>et al.</i>	2014	USA	2219	Meta-analysis

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Table 1: Contd...

Article title	Authors	Publication Year	Country	Sample	Type of article
A Perspective on Yoga as a Preventive Strategy for Coronavirus Disease 2019	Nagarathna R <i>et al.</i>	2020	India	9 studies	Descriptive Review
Effect of Integrated Yoga (IY) on psychological states and CD4 counts of HIV-1 infected patients: A randomized controlled pilot study	Naoroibam R <i>et al.</i>	2016	India	44	Randomized controlled trial
Benefits of Yoga on IL-6: Findings from a Randomized Controlled Trial of Yoga for Depression	Nugent N R <i>et al.</i>	2019	USA	122	Randomized controlled trial
A randomized, single-blind, trial of yoga therapy as an adjunct to SSRI treatment for adolescent depression patients: variations in serum cytokine and neurotrophin levels	Pallavi P	2014	India	50	Randomized controlled trial
Effect of yoga intervention on biochemical, oxidative stress markers, inflammatory markers and sleep quality among subjects with type 2 diabetes in South India: Results from the SATYAM project	Viswanathan V <i>et al.</i>	2021	India	300	Randomized controlled trial
Benefits of yoga for African American heart failure patients	Pullen P R <i>et al.</i>	2010	USA	40	Randomized controlled trial
Effect of yoga module on pro-inflammatory and anti-inflammatory cytokines in industrial workers of lonavla: a randomized controlled trial	Rajbhoj P H <i>et al.</i>	2015	India	48	Randomized controlled trial
Influence of yoga on mood states, distress, quality of life and immune outcomes in early stage breast cancer patients undergoing surgery	Rao R M <i>et al.</i>	2008	India	98	Randomized controlled trial
Effects of an integrated yoga program on mood, perceived stress, quality of life and immune measures in HIV patients: a pilot study	Rao R <i>et al.</i>	2012	USA	70	Randomized controlled trial
Adjunctive yoga vs. health education for persistent major depression: a randomized controlled trial	Uebelacker L A <i>et al.</i>	2017	USA	122	Randomized controlled trial
Effect of Yoga on Sleep Quality and Neuroendocrine Immune Response in Metastatic Breast Cancer Patients	Rao R M <i>et al.</i>	2017	India	91	Prospective
Implication of Asana, Pranayama and Meditation on Telomere Stability	Rathore M <i>et al.</i>	2018	India	12 studies	Scoping Review
Oxidative Stress Induced Damage to Paternal Genome and Impact of Meditation and Yoga - Can it Reduce Incidence of Childhood Cancer?	Dada R <i>et al.</i>	2016	India	56 Studies	Prospective
Breathing exercises for adults with asthma	Santino T A <i>et al.</i>	2020	Brazil	2880	Systematic review
Effect of yoga training on inflammatory cytokines and C-reactive protein in employees of small-scale industries	Shete S U <i>et al.</i>	2017	India	48	Prospective
Yogic breathing when compared to attention control reduces the levels of pro-inflammatory biomarkers in saliva: a pilot randomized controlled trial	Twal W O <i>et al.</i>	2016	USA	20	Randomized controlled trial
Yoga for Treating Rheumatoid Arthritis: A Systematic Review and Meta-Analysis	Ye X <i>et al.</i>	2020	India	840	Systematic review and meta-analysis
Yoga-An Alternative Form of Therapy in Patients with Blunt Chest Trauma: A Randomized Controlled Trial	Gunjiganvi M <i>et al.</i>	2021	India	89	Randomized controlled trial
Mindfulness-based interventions: an overall review	Zhang D <i>et al.</i>	2021	Hongkong	-	Overall Review
Immunological and Psychological Efficacy of Meditation/ Yoga Intervention Among People Living With HIV (PLWH): A Systematic Review and Meta-analyses of 19 Randomized Controlled Trials	Jiang T <i>et al.</i>	2021	China	1300	Systematic review and meta-analysis
Changes Induced by Mind-Body Intervention Including Epigenetic Marks and Its Effects on Diabetes	Yang H J <i>et al.</i>	2021	Korea/ Singapore	15 meta-analyses	Review of Meta-analyses

The effect on immunity-related biological markers were summed up and listed in Table 2. The reduction was documented in CRP, IL-1  $\beta$  and the similar pro-inflammatory biomarkers whereas increase in IL-6 (%), IL-10, TNF- $\alpha$ , IFN-gamma

and other anti-inflammatory ones. Reduction in biomarkers of stem/tumor cell was documented as in interferon, ROS, DFI, telomeres stability and its length, oxidative DNA damage marker (8-OHdG). The immunity-related biomarkers included

**Table 2: Disease or health status, outcome measures and findings of the included studies**

First Author	Type of diseases/ Subjects involved	Outcome measures	Findings
Agarwal RP <i>et al.</i>	Breast cancer, Colorectal cancer, Leukemia, Lymphoma, Lung cancer, Pediatric cancer (unspecified), Prostate cancer, Hematopoietic stem cell transplant patients.	Telomere length Telomerase activity T-cell subsets Signalling pathways of inflammatory transcription genes Cytokines Nuclear factor kappa B, and cAMP response element binding protein	Yoga when integrated as adjuvant to conventional therapy proves effective
Bhargav H <i>et al.</i>	Cancer	Nuclear factor kappa-B (NF $\kappa$ B)	Brief daily yogic meditation may reverse the pattern of increased NF $\kappa$ B-related transcription of pro-inflammatory cytokines in leukocytes, and thereby reducing the hypoxia-inducible factor-1 (HIF-1), on which cancer stem cells (CSCs) are dependent for survival, growth, and maintenance.
Balasubramanian S <i>et al.</i>	Not mentioned (possibly healthy)	22 salivary proteins associated with immune response, stress and cancer.	Yogic breathing (YB) could alter salivary biomarkers associated with cancer, inflammation, and stress.
Black D S <i>et al.</i>	Family dementia caregivers	Gene Expression Profiling and Analysis	The results portraits that Kirtan Kriya Meditation (KKM) or Relaxing Music (RM) listening KKM treatment found to differentially express. 68 genes (19 up-regulated (immunoglobulin-related transcripts), 49 down-regulated (transcripts included pro-inflammatory cytokines and activation-related immediate-early genes) Promoter-based bioinformatic analysis implicated reduced NF- $\kappa$ B signalling and Increased activity of IRF1 in structuring those effects.
Bower J E <i>et al.</i>	Breast cancer and Heart failure (age=32-88 yrs)	Tissue necrotizing factor (TNF) Soluble IL-2 receptor (sIL-2R) C-reactive protein (CRP) Interleukin-6 (IL-6) Tissue necrotizing factor receptor II (TNFRII) IL-1 receptor antagonist (IL-1Ra)	Alterations in inflammatory gene expression were identified even after relatively short (6 week) interventions Reduced proinflammatory gene expression in the monocyte population. Change in production of proinflammatory cytokines observed as early as 8 weeks after intervention onset. TNFRII – (stable in yoga vs. increase in controls)
Bower JE <i>et al.</i>	stage 0-II breast cancer survivors	Nuclear factor kappa-B (NF $\kappa$ B) Anti-inflammatory glucocorticoid receptor Activity of cAMP response element-binding protein (CREB) sTNF-RII CRP IL-6 Diurnal cortisol	Reduced activity of the pro-inflammatory transcription factor NF- $\kappa$ B Increased activity of the anti-inflammatory glucocorticoid receptor Reduced activity of CREB family transcription factors Plasma levels of sTNF-RII remained stable in the yoga group, whereas levels of this marker increased in the health education group Non-significant trend was observed for the interleukin 1 receptor antagonist No significant changes in CRP, IL-6, or diurnal cortisol measures were observed
Cahn B R <i>et al.</i>	Healthy individuals	Psychometric measures, brain-derived neurotrophic factor (BDNF) Circadian salivary cortisol levels Pro- and anti-inflammatory cytokines.	Positively impact BDNF signaling, CAR, and immunological markers as well as improve subjective well-being. Significant improvements in both HPA axis functioning as exemplified by the CAR as well as neuroimmunologic functioning Increased BDNF levels and Alterations in cytokines were due to the intensive meditation practice involved in this retreat. Plasma level of the anti-inflammatory cytokine Interleukin-10 was increased and the pro-inflammatory cytokine Interleukin-12 was reduced after the retreat. Plasma levels of other pro-inflammatory cytokines, including Interferon Gamma (IFN- $\gamma$ ), Tumor Necrosis Factor (TNF- $\alpha$ ), Interleukin-1 $\beta$ (IL-1 $\beta$ ), Interleukin-6 (IL-6), and Interleukin-8 (IL-8) were increased after the retreat.

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**Table 2: Contd...**

First Author	Type of diseases/ Subjects involved	Outcome measures	Findings
Chanta A <i>et al.</i>	Allergic rhinitis (mean age=34.8)	Body weight Body fat BMIResting heart rate BP In addition, pre- and post-study trial rhinitis symptoms, PNIF Nasal blood flow Nasal secretions for cytokine analysis were evaluated	Hatha yoga training had beneficial effects in allergic rhinitis by improved clinical allergic rhinitis and cytokine profiles. The YOG group had increased peak nasal inspiratory flow (PNIF) Significantly decreased rhinitis symptoms and nasal blood flow (NBF) compared to pre-test. Significantly higher nasal secretion of interleukin (IL)-2 than the control group.
Chen N <i>et al.</i>	healthy, lean, and female Chinese subjects. (Age=18-45)	Primary outcome measure: plasma insulin level Secondary outcomes (1) other clinical biomarkers (i.e., glucose, TG, HDL-cholesterol, LDL-cholesterol, and total cholesterol); (2) Endothelial microparticles (EMPs); and (3) plasma cytokines and cytokines from culture whole blood ex vivo.	Improvement in markers related to metabolic syndrome, including reduced fasting circulating insulin, cholesterol and LDL-cholesterol levels, and circulating CD31+/CD42b-EMPs Reduced Toll-like receptor 2 (TLR2, a type of EMP) responses from whole blood culture.
Chen P J <i>et al.</i>	Pregnant women of 16-36 weeks of gestation	Salivary cortisol and immunoglobulin A levels	The intervention group had lower salivary cortisol and higher immunoglobulin Prenatal yoga significantly reduced pregnant women's stress and enhanced their immune function.
Danhauer S C <i>et al.</i>	Cancer	Mobility Flexibility Physical activity Mental, physical Spiritual health	The research has demonstrated that yoga interventions can improve psychological distress, QoL, physical function, and some biological outcomes among adults receiving cancer treatment.
Danhauer SC <i>et al.</i>	Any cancer among adults and children	Anxiety, depression and stress QoL Sleep and fatigue	Improvement in psychological outputs (anxiety, depression, stress) Partial studies suggest improvement in QoL Partial supports that yoga ameliorates sleep and fatigue
Eda N <i>et al.</i>	Elderly individuals aged 60.4±10.4 years	Secretory Immunoglobulin A (SIgA, a mucosal first line immunity) Cortisol Testosterone Profile of Mood States (POMS) score- a measure of stress	The SIgA concentration and secretion rate were significantly higher after yoga. The cortisol concentration and secretion rate both were lower whereas testosterone secretion rate was higher after yoga. Yoga stretching reduces stress and enhances mucosal immune function in elderly women. The participants' mental state did not change significantly after rest. The POMS significantly lower after yoga stretching than before.
Falkenberg R I <i>et al.</i>	Heart failure patients, Inflammatory bowel disease Risk of chronic inflammation Breast cancer	IL-1-beta, IL-4, IL-6, IL-8, IL-10, IL-12, sIL-2r TNF-alpha and soluble TNF-receptor II (sTNFrII) CRP IFN-gamma Circulating endothelial microparticles (EMPs) NK-kappaB cAMP responsive element binding (CREB)- a nuclear protein Glucocorticoid receptor (GR)	Yoga can downregulate pro-inflammatory parameters. There was significantly higher IgA levels in yoga group compared to controls Decrease in IFN-gamma during examination stress significantly less pronounced in yoga group compared to controls; No significant between group differences immediately postintervention, IgA, IL-4, IL-8, TNF-alpha, and Sil2r Significant increase in CD4+ cell count in yoga group compared to controls Significant decrease in IL-1-beta, IL-6, IL-10, IL12, INF-gamma and CRP in yoga group compared to controls
Gallegos A M <i>et al.</i>	Community-dwelling older adults of 50-70 years age group	Interleukin (IL)-6 and IGF-1 Keyhole limpet hemocyanin (KLH) Immunoglobulin (Ig) M and IgG) KLH-specific antibody responses were measured	Yoga Increased IGF-1 and reduced IgG response. Increased IGF-1 Informal meditation-Least evidence for unique effects Body scan-Reduced IgM and IgG response

*Contd...*

Table 2: Contd...

First Author	Type of diseases/ Subjects involved	Outcome measures	Findings
Gopalan B P <i>et al.</i>	HIV positive patients of 17-78 year age group	Measured in blood plasma Cytokines: TNF- $\alpha$ , IL-6, IFN $\gamma$ , and IL-10) and Immune activation (sCD163 and sCD14) Plasma lipopolysaccharide (LPS) concentration CD3+, CD8+, CD38 expression; and Gene Expression Profile	Reduction in levels of sCD14, tumor necrosis factor alpha, Interferon gamma, and interleukin-10 was observed among exercisers as compared with non-exercisers at Y2. CD38+expressing CD4+T cells were found to be lower among exercisers at Y2. The differences in levels of interleukin-6, sCD163, lipopolysaccharides, interleukin-2, and brain-derived neurotrophic factor were not significantly different among the 2 groups.
Harkess KN <i>et al.</i>	Adults with clinically confirmed Multiple sclerosis Age group above 65	Cytokines (IL-6 and TNF) High-sensitivity CRP DNA methylation patterns Protein and DNA methylation inflammatory candidate markers Stress measure	The Friedman test indicated that there was no evidence of a longitudinal difference in IL-6 or TNF across the three time points. A non-clinical chronically stressed community population, practicing a minimum of a once-weekly, hour-long yoga class, is associated with differential methylation patterns despite the waitlist control group reporting similar energy expenditure to the yoga group.
Heine M <i>et al.</i>	Fatigue in Multiple Sclerosis Age 8 to 16 years	Primary: [1] Fatigue, mood status, ambulatory functions [2] Berg Balance Scale (BBS) six minute walk test (6MWT), Multiple Sclerosis Impact Scale 29 version 2 (MSIS), and Modified Fatigue Impact Scale (MFIS) and Secondary - MSIS 29v2 psychological component, the Modified Fatigue Impact Scale (MFIS) and the 6-Minute Walk Test (6MWT). [3] Primary-cognitive measures focused on attention. Secondary: [1] Physiologic measures of alertness, Profile of Mood States, State-Trait Anxiety Inventory [2] Multi-Dimensional Fatigue Inventory (MFI), and Short Form (SF)-36 health-related quality of life.	Significant improvement for all 3 interventions for primary outcome. The subjects with MS participating in either a 6-month yoga class or exercise class showed significant improvement in measures of fatigue compared to a waiting-list control group. No relative improvement of cognitive function or mood was observed in either of the intervention groups. No improvement in spasticity after sports climbing and yoga intervention. A 17% increase was observed in selective attention performance after yoga intervention. Sports climbing reduced fatigue while yoga had no effect.
Huberty J <i>et al.</i>	Myeloproliferative neoplasms (MPNs) Age group of 18 years and above	CBC, TNF-a, IL-6) and to provide saliva samples (i.e., salivary cortisol)	
Khosravi N <i>et al.</i>		Cytokines	Exercise training reduced pro-inflammatory markers, specifically CRP and TNF. Prostate and breast cancer showed the greatest decrease in pro-inflammatory markers. Combination training was the most effective mode for reducing inflammation Exercise had minimal effects on anti-inflammatory cytokines and immune outcomes.
Kiecolt-Glaser J K <i>et al.</i>	Cancer	Lipopolysaccharide-stimulated production of proinflammatory cytokines interleukin-6 (IL-6), tumor necrosis factor alpha (TNF- $\alpha$ ), and interleukin-1 $\beta$ (IL-1 $\beta$ ), and scores on the Multidimensional Fatigue Symptom Inventory-Short Form (MFSI-SF), the vitality scale from the Medical Outcomes Study 36-item Short Form (SF-36), and the Center for Epidemiological Studies-Depression (CES-D) scale.	The study highlights that immediately post-treatment, fatigue was not lower but vitality was higher in the yoga group compared with the control group. At 3 months of post-treatment, fatigue was lower in the yoga group, vitality was higher, and IL-6, TNF- $\alpha$ , and IL-1 $\beta$ were lower for yoga participants compared with the control group. At 3 months of post-treatment, increasing yoga practice also led to a decrease in IL-6 and IL-1 $\beta$ production but not in TNF- $\alpha$ production.

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Table 2: Contd...

First Author	Type of diseases/ Subjects involved	Outcome measures	Findings
Lambert B S <i>et al.</i>	Healthy Adults 40±11 yr	VO <sub>2</sub> , peak VO <sub>2</sub> and %VO <sub>2</sub> max kcal expenditure Heart rate and respiratory rate upper body range of motion (ROM) Serum cytokine responses to acute exercise.	RER was observed to be reduced during the HY session compared to the RTY session. Significant reductions in carbohydrate oxidation and an increase in fat oxidation was observed during HY compared to RTY. No significant changes were observed for pre-to-post session measures of blood pressure for either the HY or RTY sessions. Pre- and post-exercise Range of Motion measurements show elicited similar acute increases in upper body ROM measures of which were primarily observed in the shoulder. A small increase in elbow extension was observed following the HY but not the RTY condition. For hip ROM, both the HY and RTY conditions yielded increases in ROM for hip flexion and abduction with no change detected in internal or external rotation. HY elicited a significantly greater increase in hip abduction ( Effect Size d=0.8, VL) and trended towards a greater increase in ROM for hip flexion. No post-exercise changes in serum TNF- $\alpha$ or IL-10 were observed under either condition. Serum IL-6 was significantly following HY only compared to the RTY group where no changes were observed.
Lim S A <i>et al.</i>	Healthy Age group of 27-76 yrs	The oxidative stress/antioxidant components, immune-related cytokines, and stress hormones were evaluated in serum or plasma.	The serum levels of nitric oxide, F <sub>2</sub> -isoprostane, and lipid peroxide were significantly decreased by yoga practice, Serum total glutathione (GSH) contents, activities of GSH-peroxidase, and GSH-s-transferase were remarkably increased in yoga practiced group when compared with the control group. Yoga practice also significantly increased immune-related cytokines, such as interleukin-12, and interferon- $\gamma$ , in serum and plasma levels of serotonin compared with the control group. Significantly reduced the plasma levels of adrenalin
Morgan N <i>et al.</i>	Age=29-51	CRP, IL-6, TNF-a, CD4 Lymphocytes, Salivary IgA, Total blood count	Stratified by clinical populations, the subgroup meta-analysis showed no significant difference in the pooled effect on IL-6 between studies in healthy people and those in the population with disease conditions. Meta-analysis of 3 studies showed a negligible to small effect on TNF-a. Meta-analysis of 7 studies showed a negligible to small effect on the number of CD4+* T lymphocytes. The study also reported a significant increase in salivary IgA compared to the control, and another study reported no significant difference in salivary IgA between groups, Decrease in neutrophils and increase in lymphocytes compared to the control group.
Nagarathna R <i>et al.</i>	Coronavirus disease	PEFR	There was a significant improvement in their PEFR by >20% within 30 min of the practice with successful relief from the episode. The patients reported reduction in panic and anxiety element, cutting the vicious cycle of aggravating bronchial obstruction.
Naoroibam R <i>et al.</i>	HIV	Anxiety, depression, and CD4 counts	Between-group comparison revealed a significant reduction in depression scores and significant increase in CD4 counts in the yoga group as compared to the control.
Nugent N R <i>et al.</i>	Depression (age up to 60 yrs)	Inflammatory markers (IL-6, CRP, and TNF $\alpha$ ), depression	IL-6, an inflammatory marker was observed to decrease over time in persistently depressed participants in the hatha yoga condition relative to health education control participants.
Pallavi P.	depression	Psychometric scores, cytokine and neurotrophin levels	The results support the beneficial effects of the yoga therapy on adolescent depression patients as an adjunct to standard care as reflected in changes in psychometric scores, cytokine and neurotrophin levels.

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Table 2: Contd...

First Author	Type of diseases/ Subjects involved	Outcome measures	Findings
Viswanathan V <i>et al.</i>	Type 2 Diabetes Mellitus	IL6, HsCRP, Inflammatory cytokine, Adiponectin, leptin levels	There was a marked reduction in leptin and IL-6 levels in the test group Adiponectin levels increased significantly in the test group compared to control. hsCRP levels showed slight reduction in the test group but did not reach statistical significance. Twelve weeks of Yoga practice had a positive impact on inflammatory cytokine response among subjects with T2DM.
Pullen P R <i>et al.</i>	Heart Failure Age group of 13-18 yrs	Peak exertion, flexibility, interleukin-6 (IL-6), C-reactive protein (CRP), and extracellular superoxide dismutase (EC-SOD)	Significant changes were observed in the YG, compared with those in the CG, for flexibility, treadmill time, VO2 peak, and the biomarkers (IL-6; CRP; and EC-SOD). Within the YG, pre-test to post-test scores for the total and physical subscales of the MLWHFQ were improved. Yoga therapy offered additional benefits to the standard medical care of predominantly AA HF patients by improving cardiovascular endurance, QoL, inflammatory markers, and flexibility.
Rajbhoj P H <i>et al.</i>	Industrial workers (Age=30-58 yrs)	Pro-inflammatory cytokine IL-1 $\beta$ and anti-inflammatory cytokine IL-10 were evaluated	The result of within group comparison revealed that the yoga group showed a significant decrease in IL-1 $\beta$ while significant increase in IL-10 No change was observed in control group. Further, the results between the groups The yoga group had significantly lower level of IL-1 $\beta$ and increase in IL-10 as compared to control group.
Rao RM <i>et al.</i>	stage II and III breast cancer	Serum immunoglobulins- IgG, IgA and IgM levels (g/L) Depression, anxiety and stress T lymphocyte subsets (CD4%, CD8% and natural killer (NK) cell % counts)	The results suggest possible benefits for yoga in reducing postoperative distress and preventing immune suppression following surgery. The results suggest a significant decrease in the state and trait of anxiety, depression, symptom severity, distress and improvement in quality of life in the yoga group as compared to the controls. There was also a significantly lesser decrease in CD 56% and lower levels of serum IgA in the yoga group as compared to controls following surgery.
Rao R <i>et al.</i>	HIV	Cytokines	The results suggest benefit with yoga in reducing psychological distress and improving quality of life in HIV seropositive patients.
Uebelacker L A <i>et al.</i>	Patients with elevated depression symptoms and on antidepressant medication	Primary outcome was depression symptom at 10 weeks Secondary outcomes included the assessment at 3 and 6 months Of depression symptoms, social and role functioning, general health perceptions, pain, and physical functioning.	At 10 weeks, there was no statistically significant difference between groups in depression symptoms ( $b = -0.82$ , $s.e. = 0.88$ , $P=0.36$ ) At 6 months, the yoga participants had lower levels of depression than HLW participants ( $b = -1.38$ , $s.e. = 0.57$ , $P=0.02$ ) After 6 months, 51% of yoga participants demonstrated a response ( $\geq 50\%$ reduction in depression symptoms) compared with 31% of HLW participants (odds ratio=2.31; $P=0.04$ ) Yoga participants showed significantly better social and role functioning and general health perceptions over time.
Rao R M <i>et al.</i>	Metastatic Breast Cancer Patients (age=49.2 $\pm$ 9.6 years)	Diurnal cortisol, and natural killer (NK) cell counts	There was a significant decrease in scales of symptom distress, sleep parameters, and improvement in quality of sleep and Insomnia Rating Scale sleep score following intervention. There was a decrease in morning waking cortisol in yoga group alone following intervention. A significant improvement in NK cell percent following intervention in yoga group compared to control group.

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Table 2: Contd...

First Author	Type of diseases/ Subjects involved	Outcome measures	Findings
Rathore M <i>et al.</i>	Telomere stability (30-70 yrs)	Most studies measure telomere length in peripheral blood mononuclear cells (PBMCs) by quantitative polymerase chain reaction. In this method, the average telomere length is estimated by comparing the amount of amplification product of telomere repeats (T) to that of a single-copy gene (S).	The results highlight the positive effects of yoga intervention on telomere length
Dada R <i>et al.</i>	fathers of retinoblastoma (RB) affected children	Semen samples were taken, Semen parameters, ROS, DNA extraction, 8OHdG and DFI	Levels of ROS were significantly reduced in tobacco users as well as in alcoholics after intervention. DFI reduced significantly after 6 months of yoga and meditation practice in all groups. The levels of oxidative DNA damage marker 8-OHdG were reduced significantly after 3 months and 6 months of practice. The results suggest that OS and ODD DNA may contribute to the development of childhood cancer. Increased MT DNA mutations and aberrant repair of MT and nuclear DNA due to highly truncated DNA repair mechanisms all contribute to sperm genome hypermutability and persistent oxidative DNA damage.
Santino T A <i>et al.</i>	Adults with Asthma	Primary - Quality of life. Secondary - asthma symptoms, hyperventilation symptoms and some lung function variables.	QoL improved favoring breathing exercise at 3 months and at 6 months, AQLQ showed 0.5 unit improvement with 1.5 OR.
Shete S U <i>et al.</i>	Adults of average health exposed to occupational hazards demonstrated	Serum IL-6, TNF- $\alpha$ , and hs-CRP, erum cholesterol, triglyceride, and HDL, LDL, VLDL	A yoga-based lifestyle intervention seems to be a highly promising as an alternative therapy. The results of within group comparison revealed highly significant changes in cholesterol, high-density lipoprotein, low-density lipoprotein (LDL), hs-CRP, IL-6, and TNF- $\alpha$ in experimental group. Comparison between experimental and control group revealed significant changes in cholesterol, LDL, IL-6, TNF- $\alpha$ , and hs-CRP .
Twal W O <i>et al.</i>	Age=30-58 yrs	Cytokines (IL-1 $\beta$ , IL-1RA, IL-6, IL-8, IL-10, IL-17, IP-10, MCP-1, MIP-1b, and TNF-alpha)	The levels of interleukin (IL)-1 $\beta$ , IL-8, and monocyte chemotactic protein -1 (MCP-1) were significantly reduced in YB group when compared to AC group. The level of reduction of IL-8 was significant at all time points tested, whereas IL-1 $\beta$ showed reduction at 15 and 20 min time points, and MCP-1 level was marginally different at 5-20 min. There were no significant differences between YB and AC groups in the salivary levels of IL-1RA, IL-6, IL-10, IL-17, IP-10, MIP-1b, and TNF- $\alpha$ .
Ye X <i>et al.</i>	Rheumatoid arthritis (RA) Age=18 and above	Pain Physical function, as measured using Health Assessment Questionnaires-Disability Index (HAQ-DI) Disease activity, as measured using Tender joints or Swollen joints count, Disease Activity Score 28 (DAS-28) Inflammatory cytokines, as measured using C-reactive Protein (CRP), Erythrocyte sedimentation rate (ESR), Interleukin-6 (IL-6), Tumor necrosis factor- $\alpha$ (TNF- $\alpha$ ). The minor outcome included: • Grip Strength.	Yoga may be beneficial for improving physical function, disease activity, and grip strength in patients with RA. No significant effect in improving pain, tender joints, swollen joints count, and inflammatory cytokines in patients suffering from RA.

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**Table 2: Contd...**

First Author	Type of diseases/ Subjects involved	Outcome measures	Findings
Gunjiganvi M <i>et al.</i>	Chest injury patient	Primary outcomes: pulmonary function tests (PFT) at 4 weeks of discharge Secondary outcomes: changes in quality of life (QoL), respiratory muscle strength and endurance, chest wall mobility, and levels of cytokines at 4 weeks	Significant improvements in PFT in the Yogatherapy group compared with physiotherapy; with an increase in forced vital capacity ( $P=0.02$ ) and forced expiratory volume ( $P=0.01$ ) Significant improvement in physical component of QoL, respiratory muscle endurance ( $P=0.003$ ) and axillary cirtometry ( $P=0.009$ ) in the Yogatherapy group No statistically significant difference in the trends of cytokine markers
Zhang D <i>et al.</i>	Patients and normal participants with stress Patients with cancer Effects on physical health, e.g., respiratory health (COPD, asthma), Anxiety and depression	Respiratory: FEV1 Cancer: CRF score Stress: effect size (Hedge's g) on cortisol level Anxiety and depression: effect size, SMD	(FEV1) (3 months: MD=0.1 L, 95% CI: 0.02-0.18; 6 months: MD=0.18 L, 95% CI: 0.1-0.26); Both insignificant; limited effects (needs further investigation) Significant change in CRF score; SMD = -0.51, 95%CI [-0.81-0.20] Stress: Overall effect of cortisol among healthy participants; moderately low ( $g=0.41$ ; $P=0.025$ ) Stress: Overall effect of cortisol among the participants in symptomatic stress: moderate ( $g=0.42$ , 95% CI: 0.27-0.57) Anxiety and depression; small to medium effects on both anxiety (SMD=0.39; CI: 0.22, 0.56; PI: 0.07, 0.70; $P<0.001$ , $I^2=18.90\%$ ) and depression (SMD=0.41; CI: 0.19, 0.64; PI: -0.05, 0.88; $P<0.001$ ; $I^2=33.43\%$ )
Jiang T <i>et al.</i>	Peoples living with human immunodeficiency virus (HIV)	CD4-T Cell counts stress, depression, and anxiety symptoms QoL	Improvement of CD4 T-cell counts (Cohen's $d=0.214$ , $P=0.027$ ) and maintained (0.427, $P=0.049$ ) Reduction of stress, depression, and anxiety symptoms (0.422, $P<0.001$ ; 0.506, $P<0.001$ , and 0.709, $P<0.001$ , respectively) Improved quality of life (0.67, $P<0.001$ )
Yang H J <i>et al.</i>	Experienced meditators vs. novice meditators; PTSD patients, Women reporting psychological distress	Changes in pro-inflammatory gene expressions Changes in epigenetic marks and differentially methylated areas (DMRs)	MBI (yoga and others e.g., tai chi, qigong, meditation) significantly reduced the CRP level, whereas IL-6 and TNF-alpha levels were not significantly altered It has been reported that yoga and mindfulness practice reduce the expression of pro-inflammatory genes in the blood cells Possibly decrease in methylation of the TNF-alpha gene promoter, an inflammation factor Positive correlation between methylation level of GPR31 and telomere length in meditator Negative correlation between methylation level of SERPINB9 and telomere length in meditator Negative correlation between methylation level of the inter-genic CpG island within the sub-telomeric region of chromosome 4 Short arm and telomere length in meditator No correlation between age and telomere length in meditators

less reduction in CD4 (mainly HIV), CD3, CD8 cells, and increase in IgA, IgG, IgM. In addition, cytokine levels such as IL-12 and interferon- $\gamma$  were also found to increase. Finally, the stress-related biomarkers were reduced, especially the oxidative stress/antioxidant components such as nitric oxide, F2-isoprostane, lipid peroxide and IFN-gamma. The interventions also showed a reduction in adrenaline that has critical role in stress and immune response. However, some studies could not show the significance in the effects.

## Discussion

A current scoping review was commenced to identify and document evidence-supported yoga and meditation-based interventions for improving immunity in various diseased and healthy populations. It aimed to provide a comprehensive list of

interventions that might be useful in COVID-19 management and prevention as the disease also has severe consequences in individuals with weakened immunity. The graphical summary as presented in Figure 2 showed that these alternative therapies are effective in improving the range of immunity biomarkers in Ataxia Telangiectasia and Rad 3 related (ATR), cancer, HIV, heart disease, and COVID-19.

Many studies have shown that viral attack affects one's immunity at first, where various biomarkers get either up or down-regulated. The human immune system might play a significant role in protecting an individual from getting COVID-19 infection.<sup>[20]</sup>

It is claimed that the clinical signs and symptoms of this COVID-19 are analogous to viral pneumonia,<sup>[66]</sup> where the maladjusted immune feedback mechanism might result in

**Table 3: Summary of major interventions of the included studies**

Author*	Details of intervention	Type of intervention
Agarwal RP <i>et al.</i> , Chanta A <i>et al.</i> , Chen N <i>et al.</i> , Lim SA <i>et al.</i> , Heine <i>et al.</i> , Morgan N <i>et al.</i> , Bhargav <i>et al.</i> (36)	3-20 weeks, 40-90 min, 1-3 times a week majorly Hatha yoga was practiced which mostly included mountain pose, standing sun pose, standing forward bend, lunge pose, push-up pose, lifted hip pose, upward facing dog pose, downward facing dog pose, warrior pose, triangle pose, modified dancer pose, eagle pose, seated twist pose, head to knee pose, bow pose, cat pose, child pose, supine twist pose, half bridge pose, half shoulder stand pose, and fish pose (Sukhasana/Vajrasana/Yogamudra/Paschimottanasana/ArdhaMatsyendrasana/Shavasana/Naukasana/Bhujangasana/Ardha-Shalabhasana/Chakrasana/Vrikasana/Sarvangasana) Pranayama: Adhama/Pranayama/Bhastrika/Ujjayi/Surya Bhedana/Chandra bhedana/Nadi Shodhana/Kapalbhati Buddhist meditation (25 MIN) Compassion meditation: compassion meditation (karuna for 12.5 min) MBSR	Yoga, Pranayama and Meditation
Twal WO <i>et al.</i> , Balasubramanian <i>et al.</i> (2)	Enrolled participants were randomized to one of two conditions: Yogic Breathing (YB) arm versus the Attention Control (AC) arm. The Yoga instructor taught each participant in the YB group how to perform YB, which consisted of a combination of 10 min of Om chanting (Pranava Pranayama) followed by 10 min of TMP as described previously. Briefly, the participants were taught to inhale through one nostril for two counts, hold the breath for eight counts, and exhale for four counts. Pranava Pranayama and Thirumoolar Pranayama (TMP)	Pranayama
Gallegos AM <i>et al.</i> , (1)	8-week MBSR program.	Meditation
Black DS <i>et al.</i> (1)	Kirtan Kriya Meditation (KKM) is a 12-minute yogic meditation chanting practice guided by an audio CD that is performed at the same time each and every day for a total of eight weeks. KKM progresses through 1 minute of silently focusing inwards on the mind and body in the present moment, then, 11 minutes of mudras or repetitive finger movements while chanting “Saa, Taa, Naa, Maa” that are chanted first aloud, gradually softening into a whisper, and then silently. The meditation practice was completed with deep breathing and the visualization of light.	Yoga and Meditation
Huberty <i>et al.</i> , Khosravi N <i>et al.</i> , Kiecolt-Glaser JK <i>et al.</i> , Pallavi <i>et al.</i> , Pratibha <i>et al.</i> , Bower JE <i>et al.</i> , Eda N <i>et al.</i> , Harkess KN <i>et al.</i> (8)	Ones -twice a week, 4-12 weeks, 60-90 min ( Hatha yoga classes)	Yoga
Bower JE <i>et al.</i> , Cahn BR <i>et al.</i> , Nagarathna R <i>et al.</i> (29)	The intervention includes 2 hour of sitting meditation practices, 1-2 h of yoga practice with a meditative component and 10 min to 1 h of chanting daily. Iyengar system to reduce fatigue, emphasized postures and breathing techniques, passive inversions (i.e., supported upside down postures in which the head is lower than the heart) and passive backbends (i.e., supported spinal extensions) (for description of all study postures) Prayer may include (Age 6-18 years: Vinayaka Remover of all obstacles; age 18-60 years: Maha-Mrityunjaya Remover of fear of death; and >60 years: Dhanvantari Lord of health. For every group, 4 activities were carried out-Loosening Exercises (Shithilikarana Vyayama); breathing exercises and asanas; Kriya (cleansing technique) and pranayama: and Meditation) Shoonya meditation (sitting practice focused on a state of “non-doing”), Samyama meditation (sitting practice with breath-focused open awareness) as well as diverse Hatha yoga (mindful movement/stretching) and Pranayama (focused breath control) practices. Forward and backward bending; Spinal twisting, Surya Namaskar Hand stretch, Tiger breathing (1 min), Chair Vakrasana (1 min); Kriya (cleansing techniques) and Pranayama: Nadishuddhi Pranayama (2 min) Kapalabhati Kriya (30 strokes - 1 min) A: Kapalabhati Kriya (30 strokes - 1 min), Abdominal breathing (1 min), Nadishuddhi Pranayama (2 min) Kapalabhati Kriya (30 strokes - 1 min), Abdominal breathing (1 min) Surya Anuloma Viloma Pranayama (1 min), Nadishuddhi Pranayama (2 min); Meditation: Sun meditation (2 min)	Yoga, pranayama, meditation and chanting

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Table 3: Contd...

Author*	Details of intervention	Type of intervention
Chen PJ <i>et al.</i> , Danhauer SC <i>et al.</i> , Pullen <i>et al.</i> , Falkenberg RI <i>et al.</i> (4)	Hatha yoga, Tibetan Yoga (TY), Movements, Breathing, Meditation, Relaxation with guided imagery; and Deep relaxation; as followings: a) 5-min warm-up phase including breathing exercises (pranayama), b) 40-min period of standing and/or seated yoga postures (asanas), and finally, c) 15-min relaxation phase. Min- 10-120 min; Weekly- 1-5 days; Weeks- 3-20 weeks	Yoga, pranayama and relaxation exercise
Gopalan BP <i>et al.</i> (1)	Running was practiced in the morning or evening depending on the weather condition for a minimum of 4 times per week for 20 to 45 min covering a distance of 3 to 10 km for each child depending on the age Practice of yoga asanas during the morning hours for a minimum of 4 times per week for 15 to 30 min Each yoga session consisted of the sun salute (Surya namaskara); the practice of various aligned postures or asanas (Svastikasana, Vajrasana, Trikonasana, Parsvakonasana, Simhasana, Paschimottanasana, Purvottanasana, Pawanmuktasana, Bhujangasana, and Uttanapadasana); controlled breathing (pranayama); and deep relaxation techniques All the practices (running and yoga) were done under supervision, and compliance was recorded All the study participants on an average completed 4 sessions per week during the study period	Running, yoga and pranayama
Herzog and Yam (1)	The experimental group was treated by laughter yoga by a trainer for 20 to 30 minutes under researcher's observation.	Laughter yoga
Naoroibam R <i>et al.</i> , Rajbhoj PH <i>et al.</i> , Lambert BS <i>et al.</i> , Nugent NR <i>et al.</i> , Rao <i>et al.</i> , Gunjiganvi M <i>et al.</i> (6)	One month training, 2-7 days a week, 45-80 min; as followings: Loosening practices (5 min)- hands, legs, neck and trunk. Suryanamaskar -5 min Breathing practices (15 min)- hands in and out, hand stretch breathing, ankle stretch breathing, sectional breathing, tiger breathing and bridge posture breathing; Relaxation techniques (5 min): deep relaxation technique, Quick relaxation technique; Pranayama (10 min): Anulom- Vilom, Bhramari, Ujjayi, Kapalabhati, Om Chanting Nadishuddhi, sitali and bhramari. Shavasana, Ardh-halasan (half plough Pose), Viparita karani (inverted pose), Matsyasana (fish pose), Naukasana (boat pose), Setubandhasana (bridge pose), Bhujangasana (cobra pose), Ardha shalabhasana (half locust pose), Shalabhasana (locust pose), Dhanurasana (bow pose), Vakrasana (twisted pose), Gomukhasana (cow face pose), Paschimatanasana (forward bending pose), Supta vajrasana (reclining adamant pose), Ushtrasana (camel pose), Chakrasana (wheel pose), Utkatasana (chair pose), Vrikshasana (tree pose), Tadasana (mountain pose), halfmoon pose, awkward pose, eagle pose, standing head to knee, standing bow pulling, Balancing stick pose, standing separate leg, triangle pose, standing separate leg head to knee, toe stand, corpse pose, bow pose, full locust pose, cobra pose, sit up, winding removing pose, fix firm pose, half tortoise pose, rabbit pose, head to knee stretching, spinal twist, rapid breathing For hot yoga: a heated (HY: 105°F, 40.5°C), humidity: 45% Yogtherapy (YTP) group was given Pranayama (breath control exercises) and Yogic asanas (Yoga postures) along with standard physiotherapy (CTP) for maximum of 1 hr daily upto 4 weeks after discharge of 4.3±2.0 days of length of stay; whereas CTP group was only given standard physiotherapy; in both groups of patients with blunt chest trauma.	Yoga and pranayam
Rao RM <i>et al.</i> (1)	Yoga: 20 min, pranayama: 10 min, meditation :30 min	Yoga, pranayama, meditation and chanting; and counselling
Rima D <i>et al.</i> (1)	Intervention program lasted for 2 hours each day and that was for 6 months, comprising theory and practice sessions. Generally, the program starts with an array of asanas consists of various postures and pranayama which consists of typical breathing exercise	Yoga and pranayama

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Table 3: Contd...

Author*	Details of intervention	Type of intervention
Shete SU <i>et al.</i> (1)	6 days a week for 3-6 months, Each yoga session comprised 1 h yoga training intervention, Bhujangasana, Shalabhasana, Makarasana, Supine, Uttanapadasana, Setubhandhasana, Pavanmuktasana, Matsyasana, Savasana, Kapalbhathi, Ujjayi, Nadishodhana, Bhramar, ardha halasana, halasan, viprita karani, naukasana, ardha shalabhasana, shalabhasana, vajrasanna, supta vajrasana, gomukh asan, Vakrasana, paschimatanasana, ustrasana, parvatasana chakrasana, tadasana, padahastasana, vrikshasana, utkatasana, veerbhadrasana, anulom vilom, bhramari, ujjayi, kapalbhathi. The yoga training duration was divided into three stages, that is, an adaptation stage with no maintenance time in asanas and pranayama without kumbhaka (3 weeks), a gradual advancement in yoga practice (6 weeks), and continuation stage (3 weeks).	Yoga and pranayama
Ye X <i>et al.</i> , (1)	Yoga (60-120 min), weekly (1-5), weeks (40 days-12 weeks), meditation (dmarks, nsaisd, prescription)	Yoga and meditation

\*Note: Figures in parentheses in Author column indicate the number of articles mentioned about the intervention

immunopathology and impaired pulmonary gas exchange.<sup>[20]</sup> It is proposed that the Covid-19 virus infects macrophages, thus presenting COVID-19 antigens to T cells. Further, this progression leads to T cell activation and differentiation, along with the production of cytokines associated with the different T cell subsets. This subsequently leads to a massive vent of cytokines for immune response intensification.<sup>[67]</sup> The secretion of a large amount of chemokines and cytokines is indorsed in infected cells in response to the COVID-19 infection.<sup>[68]</sup> In most cases, it is observed that systemic inflammatory and pulmonary responses associated with the COVID-19 are prompted by the innate immune system once it identifies the virus.<sup>[69]</sup>

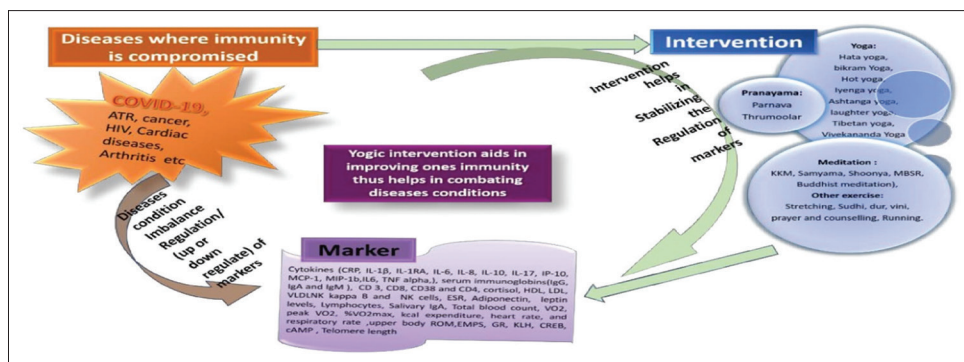
The cytokine storm marked by amplified lymphopenia, and reduced expression of IFN- $\gamma$  in CD4+ T-cells are found to be associated with a severe infection of COVID-19.<sup>[23,24]</sup> Decreased number of lymphocytes, cytotoxic T cells and CD proteins were also observed among COVID-19 patients.<sup>[13,70-77]</sup> All these pathophysiological changes indicate a vital role of the immune system in COVID-19 disease outcomes. Hence the positive impact of yoga intervention can be promoted as potential COVID management and control strategy.

Various mind and body therapies have been known to work as an adjunct treatment. Yogasana and meditation-subsets of mind-body therapies improve immunity and provide protection against respiratory tract infections (RTI). The imperative of yogasanas and meditation has a huge impact on the immune system even in presence of chronic and acute stressors are widely studied under various disease conditions. Specific exercises of yogasana and meditations are known to improve respiratory health and immunity; both are needed for protection against the current pandemic virus. There are many studies that highlight the result of yoga on communicable and acute condition diseases.<sup>[21]</sup> Our available findings also homogeneously rope that yoga practice may perhaps down-regulate pro-inflammatory markers. The results from the Meditation or Exercise for Preventing Acute Respiratory Illness Trials (MEPARI) have pointed out that training in meditation evoked curtailing in a

global acute respiratory infection (ARI) severity as compared to that of exercise or the wait-list control or physiotherapy control participants.<sup>[78,79]</sup>

Increased C-reactive protein (CRP) and high-sensitivity CRP is reported in the majority of COVID-19 patients. The elevation of other inflammatory cytokines and chemokines, IL-2R, IL-6, IL-8, IL-10, and TNF- $\alpha$ , was found especially in severe cases compared to mildly affected individuals.<sup>[80]</sup> However, an RCT was carried out by Gunjiganvi M *et al.*<sup>[23]</sup> showed that there was no significant change in cytokine markers but in pulmonary function tests (PFTs) was found to improve among the Yogotherapy group compared to physiotherapy group.

Nagarathna R *et al.* have reported that yoga practice can be a preventive strategy for COVID-19. The authors conducted an RCT where it was found that the patients reported a reduction in panic and anxiety element, cutting the vicious cycle of aggravating bronchial obstruction with yoga. Moreover, there was a significant improvement in their PEFr by >20% within 30 min of yogic practice.<sup>[21]</sup> Significant improvements in pulmonary function tests (PFTs) including forced vital capacity and forced expiratory volume were observed in the Yogotherapy group compared with physiotherapy one, and in only meditation group.<sup>[23,81]</sup> CRF score (related to cancer), cortisol level, and anxiety and depression were also found reduced among the meditating group.<sup>[23]</sup> A meta-analysis of 1300 people living with HIV (PLHIV) revealed that mindfulness-based stress reduction (MBSR) intervention was found effective in increasing the number of CD4 T-cells and reducing stress, anxiety, and depression-related indicators.<sup>[30]</sup> Yoga, different Kriyas, and breathing exercises, in a systematic review, showed a significant reduction in CRP level, expression of pro-inflammatory genes, and possibly decrease the methylation of the TNF-alpha gene promoter, an inflammation factor.<sup>[31]</sup> Similar cytokines storms such as increased serum level of Th1, IFN- $\gamma$ , TNF- $\alpha$  among both MERS-CoV and SARS-COV patients was observed within 2 weeks of infection.<sup>[82,83]</sup> Even the online yoga intervention showed large effects on TNF- $\alpha$  reduction along with small



**Figure 2:** Summary of findings

effects on sleep, pain, and anxiety as well as a moderate effect on depression.<sup>[84]</sup>

Cumulatively, the results of the current evidence synthesis provide a surrogate indication that yoga, meditation, and pranayama might be a useful adjuvant therapy to COVID-19 patients where it improves condition of the diseased through immunomodulatory activities. Moreover, the beneficial effects of these traditional Indian interventions are not only limited to improved immunity but also have a positive impact on overall physical and physiological wellbeing and quality of life. So, in order to bring a control or subside the condition from deteriorating one needs to boost one's immunity for which yoga can be used as an adjunct therapy not only as curative measure but also as preventive measure. Having its better outputs in health prevention, promotion and disease control than cure, yoga interventions may be more applicable for family physicians and primary care professionals.

### Conclusion

Overall, our findings from the existing literature indicate that the practice of yoga, pranayama and meditation have the potential to strengthen cell-mediated immunity and it would turn out to be an effective preventive as well as a therapeutic measure against COVID-19.

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### Highlights of the review

Earlier what we knew

- Yoga, meditation and pranayama have positive impacts in prevention, control and cure of different communicable and non-communicable diseases.

What this review added

- Current evidence synthesis provides a surrogate indication that yoga, meditation and pranayama might be a useful adjuvant therapy to COVID-19 patients.

- These interventions may be easily implemented in low-resource settings such as primary care levels, even online and from distant modes with limited efficacies.

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### Conflicts of interest

There are no conflicts of interest.

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