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Impact of "Yoga Based Lifestyle Interventions" and its Implications on Health and Disease

Mrithunjay Rathore,[1] Meghnath Verma[2], Jessy Abraham,[3] Rima Dada,[4] Manoj Kumar,[5]

1- Additional Professor, Department of Anatomy, AIIMS Raipur, 492099(CG)
2- Research Officer, CCRYN-CMBIY, AIIMS, Raipur, 492099, (CG)
3-Additional Professor, Department of Biochemistry, AIIMS Raipur, 492099, (CG)
4-Professor, Laboratory for Molecular Reproduction and Genetics, Department of Anatomy, AIIMS, New Delhi-110029
5-Professor, Laboratory for Molecular Reproduction and Genetics, Department of Anatomy, AIIMS, New Delhi-110029

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Corresponding author-
Meghnath verma, Research officer, CCRYN, AIIMS, Raipur.

Email: megh.140@gmail.com

ABSTRACT:

Yoga and meditation address mind and body, affecting many molecular processes like metabolism, epigenetic, oxidative processes, and subjective well-being. In this review, we have compiled the results of various clinical trials that have looked into the effect of yoga-based intervention programs on gene expression changes in peripheral blood mononuclear cells (PBMCs). Most yoga-based interventions aided in the maintenance of genomic stability through maintenance of telomere length and showed improvement in innate immunity. However, there is a lack of randomization and variability in the duration of intervention programs across studies. So, future trials should focus more on rigorous methods and reporting adequate sample size and randomization.

Aim: To explores the effect of yoga on physical health through observable molecular changes in the form of differential gene expression and the molecular changes underpinning psycho physiological benefits.

Materials and Methods: we reviewed different types of Mind body interventions (MBIs) of various observable molecular changes in the form of differential gene expression.

Result and discussion: This review adds to the ever-growing literature on the effects of Yoga/MBIs on health and disease, specifically the changes in the regulation of gene expression levels.

Conclusion: our review article suggests that a comprehensive yoga program induces significant gene expression changes. By adopting a yoga and meditation-based lifestyle, we surely can slow down the pace of our biology or chronological age.

Keywords: Yoga, Meditation, Gene expression, Biochemical Markers.

INTRODUCTION

In the past two decades, mental health professionals have gained empirical support and recognition from mind-body interventions (MBIs). MBIs include but are not limited to practices like Yoga, Tai Chi, and Qigong, meditation, mindfulness, and breath regulation techniques[1] . They are relatively safe, with only a few adverse events reported in the literature.[2] MBIs produce varied psychophysiological effects in healthy and diseased populations, resulting in fewer emergency room visits and increased quality of life. Economically, this translates into an average of $2,360 per

person in emergency room visits alone or a health care savings of anywhere from $640 to as much as $25,500 per patient yearly.[3]

A growing body of evidence supports the belief that yogic exercises may be better in inducing health benefits through differential effects at the molecular level than other forms of MBIs and activities.[4] Yoga is an ancient mind-body practice that includes meditation, breathing, activities or postures, philosophy, cleansing, and deep relaxation. Yoga has traditionally been viewed as a relatively safe form of exercise that people of varying health statuses can practice and is therefore emerging fast as an effective complementary medicine discipline.[5] The most popular styles of yoga are Iyengar, Svaroopa, Viniyoga, Kripalu, Kundalini, and Himalayan. Randomized controlled trials of yoga-based interventions conducted on healthy and diseased populations suggest that irrespective of the style, yoga has beneficial effects on genome stability, stress, anxiety, depression, pain, and physical health, although the quality of trials limits conclusions.[6,7,8] Yoga aims at reducing the toxic buildup of reactive oxygen species and consequent damage from oxidative stress.[9] Yogic practices reduce inflammatory signaling through the pro-inflammatory NF-κB-related gene expression, a critical stress pathway activated by the sympathetic nervous system.[10,11,12] Studies have also shown a positive relationship between telomere health and yoga.[13] Both chronic inflammation and poor telomere health are associated with increased risk for cancer, neurodegenerative diseases, asthma, arthritis, cardiovascular diseases, and psychiatric disorders.[14,15,16,17] This review explores the effect of yoga on physical health through observable molecular changes in the form of differential gene expression and the molecular changes underpinning psychophysiological benefits. Different types of MBIs were analyzed along with yoga, for which evidence suggests similar beneficial effects on mental and physical health.[18] Finally, we will discuss the implications of various studies, their limitations, and suggestions for future studies.

METHODOLOGY

The data were independently collected from two authors' articles available in PubMed and Google scholar. The search keywords were"Yoga & Health" Mind Body therapies & Health" AND "Gene Expression" AND "Biomolecular Changes "AND "Bio Markers." The research was limited to human studies and articles published in English. Conference proceedings, editorials, comments, case reports, and books/chapters were not included. The results obtained were consolidated, and the duplicates deleted. The studies were then reviewed by reading the full texts of free available manuscripts, titles, and abstracts of paid articles. Studies that did not stratify the inclusion criteria were excluded.

We included studies of changes in Gene Expression" and "Biomolecular Changes observed through mind body interventions. There were no age range, health status, or ethnicity restrictions. Unpublished dissertations and conference papers were not considered.

Review Of Literature

Gene Expression Profiling in Practitioners of Sudarshan Kriya(SK):

SK, a type of pranayama,[19] has been shown to lower blood lactate levels and provide better antioxidant defense. In a pilot study, Sharma and colleagues[20] conducted a prospective controlled trial to explore the short-term impact of SK on subjective well-being in normal and diseased subjects.SK is a rhythmic breathing activity that has been shown to reduce stress and produces a sense of relaxation.[21]They hypothesized that the regular practice of SK should impact the expression of genes involved in reducing oxidative stress, DNA repair, cell cycle control, aging, and apoptosis. The authors compared gene expression patterns in 42 long-term practitioners of SK with controls who otherwise led a sedentary lifestyle with little physical exercise or formal stress management techniques. They found a better antioxidant status in SK practitioners at protein and RNA levels. While some genes involved in oxidative stress response like Glutathione-S-transferase, Antiapoptotic Cox-2, and HSP-70 showed a significant increase in expression, others like Glutathione peroxidase, Catalase, aging-related hTERT, and anti-apoptotic Bcl-2 showed an increasing trend in SK practitioners but were not statistically significant.

Qu et al.[22] were interested in rapid changes in gene expression immediately after a comprehensive yoga program. The intervention consisted of gentle yoga postures, breathing exercises, and meditation, termed SK and related practices (SK&P). The study had 10 participants who were self-proclaimed practitioners of SK &P for at least 1.5 months up to 5 years. In the first two days, participants practiced SK&P, guided by experienced teachers, for two hours. For the next two days, they had a walk-in nature (to control for the physical aspect of yoga in SK&P) followed by relaxing music (to control for the

relaxation aspect of meditation and breathing exercises in SK&P);this was done at the same time of the day on both days. Gene profiles were compared for each participant before and after each day of practice. Hierarchical clustering showed three-fold up-regulation of at least 111 genes after SK&P (54 upregulated and 57 downregulated) and 38 after the walk and relaxing music (15 upregulated and 23 downregulated). Fourteen genes were commonly affected by both interventions. Thirty-six percent of the genes that changed after walking and relaxing music also changed after SK&P, suggesting that the yoga routine has more benefits than just physical activity and relaxation. Although there were many significant gene expression changes, bioinformatics analysis (using different methods of gene ontology analysis) did not find any specific pathway affected in these participants; this could be because the participants were already routine practitioners of SK&P.

Gene Expression Profiling in Leukemia Patients performing *Pranayama:* Kumar and Balkrishna (2009)[23] studied the effects of pranayama on chronic lymphocytic leukemia patients using a sequence of seven breathing patterns which included *Bhastrika, KapalBhati, Bahaya, AnulomVilom, Bharamari, Udgeeth, and Pranav Pranayama*. A total of eight patients with chronic lymphocytic leukemia were recruited, some of whom practiced breathing techniques while others served as control. There was upregulation of nearly 15% of genes by two-fold or more in leukemia patients who practiced breathing techniques. These genes include those involved in delaying cell death and improving the immune system. However, the study did not give any further details.

Yoga maintains telomere health: Telomeres, located at the ends of all chromosomes, shorten rapidly with aging and age-related diseases, including cancer, cardiovascular disease, and diabetes. Telomere shortening results in cell aging and reduced life span, whereas telomere lengthening can increase a cell's longevity. A couple of studies have shown that yoga maintains telomere length. Smoking, exposure to pollution, lower physical activity, psychological stress, and an unhealthy diet significantly increase the oxidative burden and the rate of telomere shortening.

Carlson and his group administered a yoga and meditation program, supportive group therapy, and a one-day stress management seminar to 88 breast cancer survivors. The yoga group participated in weekly 90-minute yoga sessions for eight weeks. The yoga group also practiced yoga and meditation program at home. The supportive group participated in weekly 90-minute group therapy for three months. While telomere length in the intervention group was maintained, in control participants, there was a marked decrease in telomere length.[24]

In another study, Krishna et al. conducted a prospective case-control study involving Yoga practitioners aged 30-40 practicing yoga for at least two years. The control group included individuals whose age, gender, and body mass index (BMI) matched but led a sedentary lifestyle and did not have any medical problems. The leukocyte telomere length was shorter in the control group than in the yoga group ($p<0.001$). Further, telomere length positively correlated with total antioxidant status ($r=0.841$, $p<0.001$) and negatively correlated with malondialdehyde ($r=-0.931$, $p<0.001$) and homocysteine ($r=-0.756$, $p<0.001$).Greater oxidative stress is associated with higher malondialdehyde and homocysteine concentrations.

Researchers at the University of California, LA (USA) did a pilot study to examine the effects of brief daily yogic meditation on mental health, cognitive functioning, and immune cell telomerase activity in family dementia caregivers with mild depressive symptoms. Thirty-nine family dementia caregivers (mean age 60.3 years old were randomized to practice Kirtan Kriya or listen to relaxation music for 12 minutes per day for eight weeks). After completing the study period, the meditation group showed significantly lower depressive symptoms and remarkable improvement in mental health and cognitive functioning compared with the relaxation group. The meditation group showed a 43% increase in telomerase activity, while in the relaxation group, there was only a 3.7% increase in telomerase activity($p = 0.05$).[25] In another study, Rao and colleagues administered intensive three-week mind and body therapies in 38 men and 70 women (aged 18-90). While half of the intervention group showed more than double telomerase activity after the intervention, about one-fourth of the participants showed a two-fold telomerase activity.[25] Similarly, Jacobs and colleagues also found a significant increase in telomerase activity after yogic interventions. In their study, intervention participants (n=30) meditated for about six hours daily for three months compared to the control group (n=30) matched for age, sex, body mass index, and no prior meditation experience.[26]

However, Duraimani and colleagues[27] did not see any specific changes in the expression of telomerase-related genes in their pilot studies comprising Transcendental Meditation(TM)intervention in hypertensive adults. This type of meditation involves using a sound or mantra to settle the mind effortlessly. The effectiveness of the TM

technique practiced for 20 minutes twice a day while sitting with closed eyes was compared with the effect of extensive health education alone. After an intervention period of 16 weeks, both groups showed a similar increase in the expression of telomerase-related genes.

In one of our studies,[28] we evaluated the impact of cellular aging in apparently healthy individuals who practiced yoga. We also found a significant increase in telomerase activity ($p<0.05$) in the yoga intervention group. The intervention included a set of Asanas (physical postures), pranayama (breathing exercises), and Dhyana (Meditation) for approximately 90 minutes for 12 weeks. We also found similar results in another study where a 31-year-old man with class I obesity (body–mass index, 29.5 kg/m2) was started on yogic interventions. The patient performed a series of asanas, pranayama, and meditation for approximately 1 hour for three months. After the intervention period, telomerase activity increased, and a sustained reduction in oxidative stress markers, such as ROS and 8-oxoG, was seen compared to baseline levels.[29]

Similarly, Ornish et al.[30] also found a slight increase in telomerase activity (expressed as natural logarithms increased from 2.00 (SD 0.44) to 2.22 (SD 0.49; $p=0.031$)) from baseline with one-month comprehensive lifestyle changes. Lifestyle changes included gentle yoga-based stretching, breathing, meditation, imagery, and progressive relaxation for 60 min daily in the intervention group. After five years, the change in telomerase activity in samples of peripheral blood mononuclear cells (PBMCs) was negligible in the lifestyle intervention group (decreased from baseline by 0.25 units). In contrast, the decline was more visible in the control group, which fell by 1.08 units ($p=0.64$). Thus, it is reasonable to assume that the regulatory mechanisms involved in the maintenance of telomerase activity and telomere health are better modulated in the yoga intervention group.

Yoga (Meditation) Reverses NF-κB and IRF-Related Transcriptome in Leukocytes of Family Dementia Caregivers: Caregivers of dementia patients have increased expression of biological markers of inflammation and reduced expression of proteins involved in cellular immunity. While there is up-regulation of inflammation-related genes under the control of the transcription factor Nuclear Factor-κB (NF-κB), a complementary down-regulation of innate antiviral genes is targeted by Interferon Response Factors (IRF)occurs. Black and colleagues studied the gene expression of caregivers of frail or demented family members who participated in a yogic intervention program. Twenty-three caregivers were recruited for the study as an intervention group. They were asked to perform 12-minute Kirtan Kriya meditation practice guided by an audio recording every day for eight weeks. The method started with one minute of mind and body awareness, followed by chanting "birth, life, death, rebirth" in Sanskrit with hand gestures. It ended with breathing deeply and visualizing light. As controls, twenty caregivers were asked to listen to relaxing music with eyes closed for 12 min every day for eight weeks. The depression and mental health levels were measured with questionnaires before and after the intervention. The controls were gender, illness burden, and BMI matched. The authors found a significant reduction in depressive symptoms and improved mental health in the intervention group.

Contrary to the controls, the transcriptional profiling of PBMC showed 49 genes downregulated and 19 upregulated in the Kirtan Kriya Meditation group. These differentially expressed genes were further analyzed with the Transcription Element Listening System (TELiS), a bioinformatics algorithm used to identify transcription factors regulating gene expression amid a set of genes.[31] The analysis further confirmed the hypothesis that a decrease in pro-inflammatory gene expression (related to NF-κB) and an increase in IRF-1. So it can be assumed that Kirtan Kriya Meditation improved the immune system by reducing inflammation and enhancing defense against viruses.

In another small but significant study, Criswell and colleagues administered yoga therapy to forty-eight hypertensive, lonely older adults. The intervention group participated in an eight-week, 120-minute group session, a day-long retreat in the sixth or seventh week, and 30-minutes of daily home mindfulness practice: mindfulness-Based Stress Reduction, Downregulated C-Reactive Protein, and NF-κB-associated gene expression profile post-treatment.[32]

Yoga Reduces Inflammatory Signaling in Fatigued Breast Cancer Survivors: Inflammation is associated with cancer. Previous studies have found that breast cancer survivors with fatigue have higher levels of inflammation than non-fatigued breast cancer survivors.[33] Bower et al.[34]explored the effects of 3 months of Iyengar yoga on inflammatory processes in breast cancer survivors with fatigue. Sixteen people in the yoga group and 15 were included in the health education control group. The hypothesis was that Iyengar yoga (a form of Hatha yoga with an emphasis on precise alignment and breath control in each posture) would reduce inflammation-related gene

expression and decrease levels of circulating markers of inflammation. Instead of measuring cytokines directly, the authors chose downstream markers of pro-inflammatory cytokine activity, which can be measured more reliably than the cytokines that induce their production. Downstream markers included: soluble tumor necrosis factor receptor type II (sTNF-RII), amarker of TNF activity, IL-1ra, and CRP (markers of IL activity). These markers were measured from blood, while cortisol was measured from saliva immediately after waking, 30 minutes and eight hours after waking, and before bedtime. Genome-wide transcriptional profiling identified 282 upregulated and 153 downregulated genes after three months of yoga. A 15% gene expression change was considered statistically significant, unlike other studies that set 20% as a cutoff point. Most downregulated genes were related to type I interferon responses (i.e., cytokines released when a virus infects a cell), previously associated with fatigue in cancer patients.

Similarly, behavioral measures of fatigue were significantly reduced after months of yoga and remained reduced at a 3-month follow-up.TELiS analysis found a significant decrease in transcription factor NF-κ. Anti-inflammatory glucocorticoid receptor and interferon regulatory factors (IRF) increased and reduced the activity of cAMP response element-binding protein (CREB) family transcription factors relative to controls. Though the increase in glucocorticoid receptors should repress the synthesis and release of cortisol, no significant changes in the cortisol levels in saliva were found. There was also a significant intervention effect on the sTNF-RII; plasma levels of sTNF-RII remained stable in the yoga group, whereas this marker increased in the health education group. There were no significant changes for IL-1ra and CRP.

Yoga reduces levels of oxidative stress markers: Yogic postures (asanas) and breathing techniques (pranayama) focus on airflow in the lungs, thus increasing their capacity, endurance, and efficiency. Poses include back-bending, opening the chest, and improving lung and heart functions.[35] Bhattacharya S et al.[36] evaluated blood oxygen saturation before, during, and after two different yoga breathing techniques in 30 healthy male volunteers and found a significant increase ($P<0.01$) in oxygen saturation with high-frequency yoga breathing. Del Rio and colleagues[37] conducted another similar study thatmeasured the impact of asanas and pranayama on blood oxygen saturation levels. They also found a significant increase in oxygenation in the pranayama group. The study was conducted on healthy male volunteers divided into yoga (n=34) and control groups (n=8). The group practiced yoga asanas, pranayama, and meditation for three months, and the control group followed a usual routine. Results showed an increase in total antioxidant status ($P<0.001$) and in glutathione peroxidase activity ($P<0.001$).The plasma concentration of malondialdehyde ($P<0.01$) and oxidized glutathione ($P<0.01$)decreased significantly after three months of yoga. They are markers for oxidative stress; therefore, their decrease suggests an improvement in oxidative stress.

Impact of Yoga-based interventions on Disease-Associate Molecular Phenotypes: Epel and colleagues[38] showed the effects of meditation and relaxation (6-day residential retreat on people who did not have experience with meditation) on disease-associated molecular phenotypes. They hypothesized that people on relaxation/retreats should have significantly lower stress levels and associated changes in gene expression. Therefore, they enrolled in an active control group that was not participating in meditation or relaxing programs. The intervention group included people new to meditation and who attended a 4-day intensive program of mantra meditation (4 h/day), yoga (3 h/day), lectures, and self-reflective exercises. Additionally, a group of regular meditators attended the same program. Psychological outcomes were depression, stress, vitality, and mindfulness: all of which improved for all groups after the intervention and remained positively changed at a 1-month follow-up. On follow-up after ten months, meditators had fewer depressive symptoms than the vacation group. So, meditation may have long-lasting psychological benefits than merely going on a holiday. The group also studied changes in gene expression patterns between the groups. Three hundred ninety genes changed expression in all three groups. All the study participants showed a lower expression of genes related to stress response, wound healing, and injury. In addition to these changes, regular meditators showed lower gene expression in protein synthesis, viral expression, and viral infectious cycle.

In contrast, the novice meditators had no specific gene expression changes. Regular meditators showed increased telomerase enzymatic activity and increased expression of several telomere maintenance pathway genes compared with controls. The regular meditator group started with a higher plasma Aβ42/Aβ40 ratio, which did not change from pre- to post-intervention. After four days, plasma Aβ40 levels significantly decreased in the novice meditator group, accompanied by a significant increase in the

Aβ42/Aβ40 ratio. A low plasma Aβ42/Aβ40 ratio is considered a risk factor for dementia[39], depression,[40] and mortality.[41] The vacation group had significantly more TNF- α than regular meditators. This level was also marginally higher than novice meditators. It could be due to an acute inflammatory response, possibly from sun exposure or exercise.

Effects of Lifestyle Modification on Telomerase Gene Expression*:* Lifestyle factors modulate aging and age-related diseases, affecting telomere length and telomerase activity. Duraimani and colleagues[42] compared the effectiveness of a TM and health education program with a program of extensive health education alone in hypertensive adults. Recent studies indicate that reducing oxidative stress lifestyle factors might also affect telomerase activity and telomere length. Various interventions have been studied to determine their influence on telomere health as indices for promoting health and longevity. There is strong evidence from recent studies that the regular practice of yogic postures stabilizes telomeres.

Ornish et al.[43] conducted a pilot study involving 35 individuals with localized prostate cancer to explore the relationship between comprehensive lifestyle changes and telomere length. They found that relative telomere length in PBMCs of patients increased approximately 10% from baseline in the lifestyle intervention group. In contrast, telomere length in the control group increased only by about 3%.

In another study, Krishna et al.[44] describe the effect of leukocyte telomere biology with homocysteine, malondialdehyde, and oxidative stress in yoga practitioners. It is a prospective case-control study involving 15 yoga practitioners aged 30-40 years with a minimum of two years of yoga practice (Yoga group) and matched sedentary healthy general population with no medical problems (Control group, n=18). Subjects with chronic hypertension, known cardiovascular disease, and other systemic diseases were excluded from the study. The yoga group practiced asana, pranayama, and meditation. The control group has a shorter leukocyte telomere length than the yoga group ($p<0.001$). The authors found higher levels of oxidative stress biomarkers, malondialdehyde (MDA), and homocysteine in the control group in comparison to the Yoga group ($p<0.001$). So, people who practice yoga regularly have lower systemic oxidative stress, and leukocyte telomere length is well-preserved compared to those who have a relatively sedentary lifestyle despite the lack of any medical disorders.

A study in our laboratory[45] analyzed the impact of Yoga and Meditation based lifestyle intervention on cellular aging and longevity in apparently healthy subjects. One of the endpoint markers was peripheral blood telomere length in addition to DNA damage marker 8-hydroxy-2′-deoxyguanosine (8-oxoG), oxidative stress markers ROS, and total antioxidant capacity. This prospective, open-label, single-arm exploratory study enrolled 96 healthy individuals to receive Yoga and Meditation based lifestyle intervention for a 12-week. Inclusion criteria were males or females aged 30-65 who led an unhealthy modern lifestyle. Participants who could not perform yogic exercises due to physical challenges were excluded. The program included sessions five days per week for 12 weeks. Each session included a set of Asanas (physical postures), pranayama (breathing exercises), and Dhyana (Meditation) for approximately 90 minutes. The asanas included loosening practices (warm-up) for 5 minutes, followed by *Shavasana, Uttanpadasana, Pawanmuktasana, Prone Makarasana, Bhujangasana, Salabhasana, Sitting Vakrasana, Ardha- Matsyendrasana, Vajrasana, Standing Tadasana, Vrikshasana, Ardhachakrasana* for 2 min each. The *asanas* were followed by 5 minutes of relaxation by performing *Shavasana* and 20 minutes of Pranayama or breathing exercises, *including Nadishodhana, Bhramri, Shikari, Shitali,* and *Brahmamudra*. Furthermore, there was a significant improvement in most of the biomarker levels assayed by the authors compared to the values at baseline. The mean levels of 8-oxoG and ROS were significantly lower ($p<0.01$ and $p<0.0001$, respectively). There was no significant difference in telomere length though an upregulation in telomerase activity occurred.

Yoga and Glaucoma: In Primary open-angle glaucoma, yoga and meditation lead to increase expression of DNA repair genes and decreases the levels of inflammatory cytokines such as Interleukin-6 (IL-6), Mitogen-activated protein kinase 10 (MAPK10), MAPK15, and upregulates the levels of anti-inflammatory cytokines such as IL-2 and IL-4.[46] The study revealed that 54 genes were upregulated, and 56 were downregulated post-yoga and meditation practice. Upregulated genes included (NGFR, TAZ, BNP, IL2, IL4, FGFR1, Metallothionein-I, and down-regulated genes had Neuregulin1, NFKBIA, RAR, CYP26A1, Bim, I-kB, EGFR, ERK7. Thus, differential expression positively impacted uveoscleral outflow, trabecular meshwork maintenance, synapse maturation, and anti-inflammatory and anti-apoptotic pathways.

***Yoga and Depression*:** Depression has reached epidemic

proportions and is associated with accelerated aging and the earlier onset of complex lifestyle diseases. A randomized controlled trial in our laboratory on cellular aging and transcription expression profiles in major depressive disorder (MDD) showed an increase in the expression of *CX3CL1*, *GPR50*, and *Rb1* in the yoga group relative to the control group.[47] Biological mechanisms of MDD may involve genes related to circadian rhythm, cell cycle regulation, neurodevelopment, and aging pathways. These findings indicate that yoga and meditation can slow the rate of accelerated cellular aging, decrease clinical severity and improve quality of life. Regular meditation and yoga ameliorate levels of oxidative stress by both regulating the expression of antioxidant genes, depending on the levels of free radicals, and also modifying the expression of genes [48]

***Yoga and infertility*:** Regular yoga practice causes an improvement in reproductive functions both in men and women by improving the overall integration of physiological systems. It also reduces urinary excretion of catecholamines, and aldosterone, decreases serum testosterone and luteinizing hormone levels, and increases cortisol excretion, indicating optimal changes in hormonal stress profiles.[49] At the molecular level, regular yoga and meditation decrease seminal oxidative stress and oxidative DNA damage in cases of unexplained male infertility. Oxidative DNA damage of sperm, accumulation of mutagenic oxidized DNA adducts, and genome-wide hypomethylation may be possible etiological factors in childhood cancers. Therefore, decreasing the DNA damage in sperm through yoga and meditation may positively impact the sperm epigenome and reduce the levels of mutagenic adducts, thereby reducing the incidence of congenital malformations and childhood cancers and impacting the lifelong health of offspring. A total of 131 fathers of children with retinoblastoma (non-familial sporadic heritable) and 50 controls (fathers of healthy children) were recruited at a tertiary center in India. Sperm parameters as per WHO 2010 guidelines and reactive oxygen species (ROS), DNA fragmentation index, 8-oxoG, and telomere length were estimated at day 0 and after 3 and 6 months of intervention. The intervention lasted for 2 hours each day for six months, comprising theory and practice of yoga. Mean relative sperm telomere length (T/S) of fathers of children with retinoblastoma was shorter as compared to controls (0.35±0.021 vs. 0.38±0.027; $p>0.01$) though the difference was not significant. Similarly, the seminal mean ROS levels ($p<0.05$), sperm DNA fragmentation Index ($p<0.001$), and 8-oxoG ($p<0.01$) levels were significantly higher in fathers of children with retinoblastoma as compared to controls. Nevertheless, after yoga intervention, favorable changes were observed within three months. At six months after the intervention, their levels of ROS, DNA fragmentation levels, and 8-oxoG were significantly reduced ($p<0.05$)[51].

DISCUSSION AND CONCLUSION

Comparative remarks and future perspectives:

Owing to the ability of yoga and meditation to address both mind and body, it works through a well-defined psycho neuro-endocrine pathway which then affects a wide range of processes from primary metabolism, epigenetics, DNA repair, oxidative bioprocesses to aging, blood pressure, organ system maintenance, subjective well-being, and reproductive health.It also aids in the maintenance of genomic stability through maintenance of telomere length and increased expression of genes involved in DNA repair, downregulation of pro-inflammatory genes, and upregulation in telomerase activity. Regular yoga and meditation practice could also be the key to healthy senescence (significantly delaying testicular aging). It might have a buffering effect on the smoking and drinking-induced oxidative stress, oxidative DNA damage, and DNA fragmentation index. Oxidative stress, DNA damage, and shorter telomeres are three cardinal aging marks. Thus, yoga and meditation reverse all these three parameters, and though we cannot alter our biological age, we can slow the rate at which we age.

The studies involving yoga-based interventions have certain limitations which include: 1) there is lack of randomization in several studies; 2) significant variability in the samples selected and their number across studies; 3) self-selection of samples that probably result from the compliance that is needed for people to participate in intensive yoga protocols over prolonged periods; 4) lack of good physical activity/attention between groups; 5) Time or duration of Yoga variability across studies in the length of classes (20-90 min), frequency (daily/weekly/monthly) and duration (weeks/months/years); 6) physical effects, e.g. weight and body mass index, physiological effects, e.g. heart rate and blood pressure, are rarely measured, biochemical changes are even more rarely assessed, e.g. cortisol and other hormones, even though physiological and biochemical effects are primary, and immune effects have almost never been studied even though they are critical for immune comprised samples such as women with breast cancer.

Most studies of yoga or meditative-based interventions rarely evaluated long-term (months or more) effects. Despite this, few studies show immediate impacts of these practices on molecular makeup or gene expression; our recent findings have found that a comprehensive yoga program induces significant gene expression changes, compared with an exercise/relaxation regimen, within a few days of the intervention. Further studies with more samples for extended periods are required. Such findings would be interesting to compare the short- and long-term effects of yogic/ meditative practices on gene expression and how they may relate to each other.

CONCLUSION

This review adds to the ever-growing literature on the effects of Yoga/MBIs on health and disease, specifically the changes in the regulation of gene expression levels. More research and extensive trials on yogic techniques and diseased populations could give us valuable information and a deeper understanding of the functioning of various diseases. Future trials should focus on rigorous methods and reporting, adequate sample size, adequate randomization, and allocation concealment. By adopting a yoga and meditation-based lifestyle, we surely can slow down the pace of our biology or chronological age. This review also demonstrates the improvement in cardinal and metabotropic biomarkers of cellular aging and longevity in apparently healthy populations after Yoga and Meditation based lifestyle intervention. Gene expression or molecular phenotype profiling can have utility in comparative analysis of different types of yoga/MBIs and help differentiate effects they may induce at the molecular and systemic levels.

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ORCID

Mrithunjay Rathore, https://orcid.org/0000-0001-5196-4596

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