

Sleep, Cognition, and Yoga

Abstract

Stress is one of the major problems globally, associated with poor sleep quality and cognitive dysfunction. Modern society is plagued by sleep disturbances, either due to professional demands or lifestyle or both the aspects, often leading to reduced alertness and compromised mental function, besides the well documented ill effects of disturbed sleep on physiological functions. This pertinent issue needs to be addressed. Yoga is an ancient Indian science, philosophy and way of life. Recently, yoga practice has become increasingly popular worldwide. Yoga practice is an adjunct effective for stress, sleep and associated disorders. There are limited well controlled published studies conducted in this area. We reviewed the available literature including the effect of modern lifestyle in children, adolescents, adults and geriatric population. The role of yoga and meditation in optimizing sleep architecture and cognitive functions leading to optimal brain functioning in normal and diseased state is discussed. We included articles published in English with no fixed time duration for literature search. Literature was searched mainly by using PubMed and Science Direct search engines and critically examined. Studies have revealed positive effects of yoga on sleep and cognitive skills among healthy adults as well as patients of some neurological diseases. Further, on evaluating the published studies, it is concluded that sleep and cognitive functions are optimized by yoga practice, which brings about changes in autonomic function, structural changes, changes in metabolism, neurochemistry and improved functional brain network connectivity in key regions of the brain.

Keywords: Meditation, Brain function, Sleep, Cognition

Human Sleep

Sleep is an important process of human physiology which represents the relaxation phase of the biological clock. There are two main broad types of sleep, each with its own distinct physiological, neurological, and psychological features: rapid eye movement (REM) sleep and non REM (NREM) sleep. NREM sleep can, in turn, be divided into three or four separate stages. NREM sleep is sometimes referred to as “quiet sleep” and REM as “active sleep” during which a person dreams.^[1] Physiologically, sleep is an active process. Basically, there are two sleep regulators: the homeostatic mechanism and the circadian rhythm which regulates physiological patterns over the course of the 24 h day.^[2] The sleep-wake pattern is regulated by the activity of the suprachiasmatic nucleus of the hypothalamus in the brain.^[3]

The present review paper is a compilation of literature and study reports based on sleep, cognition, and yoga. Articles (review,

research, clinical trial, case report) were collected on PubMed, Google Scholar, and Science Direct search engines. “Sleep and cognition,” “Sleep and yoga,” “Yoga and cognition” and Sleep, cognition and yoga’ were the key words used for literature search. No particular period was fixed for the literature search. The selection criteria for articles were unbiased. Only those studies were included whose findings were relevant to the objective of this paper. On the collection of sufficient literature, studies were critically examined and filtered. The papers were read in full text for critical examination for the quality and validity of the data. Nonscientific studies and duplicated findings were excluded. To evaluate the quality of studies for inclusion, we primarily focused on their study design, research objective, number of participants, and suitable statistical method applied if any and level of significance of the findings.

Lifestyle and sleep

Our lifestyle includes day to day behaviors and functions of in profession, leisure,

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activities, and diet. The modern lifestyle patterns often have negative effects on health physically, psychologically, and socially. A significant basis of healthy life is sleep. Sleep disorders have several social, psychological, economical, and health consequences. Lifestyle may have an adverse effect on sleep which in turn has a clear influence on mental and physical health. The modern lifestyle adversely affects sleep, i.e., advances in modern technology, causing later bedtimes and longer hours of nighttime arousal due to the use of electronic media devices. These challenges are common World Wide both in the Western world and in our country, due to the rampant use of all electronic media, including mobile phones, television, games, and computers.^[4] The effects are commonly observed in all age groups, including toddlers, school-going children, teenagers, and adults. The usage of electronic media has been associated with shorter sleep duration and excessive body weight. Several behavioral and environmental factors, which interfere with normal sleep patterns are summarized. Describes the effect of environmental factors on individual behavior which further leads to sleep disturbance.^[5] The effect of night light exposure, which suppresses the secretion of the key sleep regulatory hormone melatonin and leads to sleep disturbances including fragmented sleep and delayed sleep onset. Moreover, the stimulatory and unpleasant media content like violent content and games needing undivided attention can lead to disrupted sleep. Interruptions due to the ringing of phones and texting late at night disturbs sleep and awakens people and makes it difficult to go back to sleep. All these issues as well as poor parental monitoring and control leads to an additive effect in children.^[6]

Stimulants and drugs such as caffeine, nicotine, and alcohol used for alertness or mood elevation interfere with normal sleep. Altered patterns of diet and exercise and obesity are also associated with changes in sleep architecture.^[7] Coffee which contains caffeine, widely used psychoactive compound stimulates dopaminergic circuits associated with “reward,” producing behavioral effects similar to other dopamine-mediated compounds, such as cocaine and amphetamine. The accumulation of neuro-chemical adenosine in the basal forebrain promotes sleep by decreasing the sensitivity to dopamine receptors and helps initiate sleep. Caffeine is a nonspecific blocker of the adenosine receptor, which enhances the effect of dopamine on the D2 receptor and increases the availability of dopamine, leading to a stimulatory effect. Caffeine, due to its adenosine antagonistic effect, brings about electroencephalographic (EEG) changes associated with decreased homeostatic sleep pressure, responsible for promoting wakefulness.^[8] In certain cases, daily caffeine consumption has been linked to impaired sleep architecture, sleep fragmentation, and impaired daytime functioning. The effect is possibly due to a long half-life of caffeine, ranging from 3 to 7 h. Caffeine consumed

during the afternoon or late evening would be present in the system till past sleep time and influence the physiological arousal system, hindering sleep initiation. Energy drinks too lead to sleep disturbances. Moreover, these fall in the category of “wake-inducing drug supplement” are not subject to regulations valid for soft drinks. Psycho-stimulant Caffeine and Modafinil fall in this category and are used to maintain alertness for in patients and for professional requirements during sleep deprivation.^[9]

The circadian sleep-wake cycle is influenced by nutritional and hormonal signals and mealtimes can alter the sleep onset. In some situations, metabolic cues can affect the master circadian clock as well as the circadian responses to light. Recent studies have shown that time of feeding is important to set the circadian rhythmicity and delayed dinner time is linked to increased sleep latency, reduced sleep duration, and short total sleep time.^[10] Sleeping may be thought of as counter-productive due to a lack of proper information and awareness about the deleterious effects of sleep loss.^[11] The sociocultural milieu including erratic work schedule, late-night entertainment, use of psycho-stimulants, use of electronic media compromises healthy sleep-wake schedules, giving a low priority to sleep. The busy schedules of parents add to the issue. The dinner and family activities are postponed to later hours.^[12] Teenagers and children are often involved in several extracurricular activities which are eating into the evening time as well as demanding school events taking a toll into personal time with family. Sleep loss is not currently considered a public health issue. The busy parents and children often push back sleeping in order to accomplish other activities considered a priority. With long hours at school, children are unable to obtain adequate sleep. On the other hand, the idea of greater achievement through prolonged wakefulness for accomplishing more at studies and extracurricular activities is counter-productive as exhausted children under-perform during the day and would accrue less from creative and extracurricular tasks.^[13]

Sleep is integral to academic excellence. However, its value and relevance is often ignored in the academic realm and in designing programs aimed at excelling academic performance. Moreover, sleep is rarely integrated into interventions designed to improve overall health and well-being. A weight regulation program targeting childhood obesity for instance, would target only nutrition and exercise. The essentiality of optimum sleep as an essential factor is not a part of government policy in or pediatric practice.^[14] Thus, there is a general lack of awareness when it comes to the serious consequences of chronic sleep insufficiency on the health and success of children and adults. Modern lifestyle affects body’s regulatory processes associated with sleep regulation and are a reflection of our personal and professional demands

leading to rampant sleep deprivation in children and adolescents.

Sleep and cognitive functions

There is ample literature available that establishes the role of sleep in brain maturation as well as the development and maintenance of cognitive functions such as learning and memory consolidation.^[15] New learning and its consolidation, i.e., the formation of long-term memories is attributed to REM sleep and a relationship between cholinergic function, duration, and depth of REM sleep and cognitive functioning was observed.^[16] The hippocampus-dependent declarative memory also is facilitated sleep stages. Sleep spindles occurring in Stage 2 sleep are associated with verbal memory retention which is correlated with an increase in the number of sleep spindles. It is proposed that there is a hippocampal and neocortical network for consolidation of memory wherein NREM sleep facilitates the conversion of episodic memories from hippocampus dependent to relatively hippocampus-independent. In a situation of sleep deprivation occurring after learning this process is hampered so that there is a greater chance of memory retrieval from the hippocampus.^[17,18]

Sleep deprivation is categorized as acute, i.e., an extended single wake episode or chronic, with inadequate sleep over several days. There is literature on the effect of chronic sleep deprivation. A study showed that shorter sleep duration and fatigue were associated with subjective rather than objective measures of cognitive function.^[19] It has been shown that chronic changes in sleep architecture are associated with compromised cognitive function scores in several measures. Circadian phase alterations which routinely occur for instance after returning to work after a weekend influence cognitive function.^[20] Another research also pointed out that tests of memory and verbal fluency showed reduced scores on Monday morning following longer hours of weekend sleep.^[21] Sleep quality may likewise assume a vital role in cognitive functions. Sleep quality alludes to how well an individual sleep during the night. It is normally assessed by means of self-revealed recurrence of night-time awakenings; sleep latency, sleep duration, awakening, and feeling of freshness or tiredness and utilizing standard tests like Pittsburgh Sleep Quality Index.^[22] One examination, however, found that while disturbed sleep was related to an impairment in cognitive functions but it was not linked to increased cognitive decline.^[23]

It is well documented that sleep as well as cognitive functions decline with age. Cognitive decline is linked with impairment in working and episodic memory with lesser impact on semantic and recognition memory.^[24] The rate of cognitive decline for individuals emerges to vary significantly, furthermore neuronal changes that are associated with cognitive decline emerge to begin during middle age. In addition, poor sleep (quantity, quality, and efficiency) are also associated with cognitive decline.

Yoga to improve sleep and cognition

Yoga is rooted in Indian culture and it is a way of life, which promotes physical, spiritual, and mental well-being. There are different composites of yoga including postural activities (asanas), breath control (pranayama), and meditation.^[25] The following text reviews the effect of yoga and meditation on sleep, cognitive functions, and mental well-being in normal adults, the elderly, and in some neurologically patients (epileptics and migrainers). The reviewed literature is summarized in Table 1.

Meditation for sleep quality and mental well-being in young and middle-aged adults

Medication practice helps in maintaining homeostasis in the body via producing Global changes in the brain including sleep and its regulation.^[45] The practice of Yoga improves sleep architecture and mental well-being in young and middle-aged adults. Sudershan Kriya and Vipassana practice prevented the decline in NREM and Vipassana increased REM sleep in healthy adults 31-55 years.^[26] In another study, Vipassana practitioners had increased NREM and REM across age groups, young, middle, and older ages.^[27] Yoga improves mental functions in professionals working in demanding environments. A 5-day capsule program was reported to improve the anxiety, insomnia, and mental well-being of managers.^[28] The same group also showed improved Emotional intelligence following a Yoga course among a sample of university students.^[29] In a previous study by Patra and Telles, cyclic medication (twice a day) practice had shown positive effects on sleep quality.^[46] Cyclic medication practice had been found to be beneficial for respiratory, muscular, and cardiac variables due to yoga posture and guided relaxation, specifically during sleep.^[47] In another recent study, a Yoga training program for 15 days improved mental well-being and reduced anxiety among primary school teachers.^[30] In a recent meta-analysis on the effect of mindful meditation on sleep,^[48] observed that sleep architecture was improved and that it may be helpful in treating some aspects of sleep disturbance but pointed out that further research into the area was warranted.

Studies have been conducted on experienced practitioners of meditation showing morphological changes in brain regions as well as functional networks pointing to changes associated with brain plasticity in meditators. EEG studies in experienced meditators have shown that alpha-band functional network topology is better integrated but not beta and theta bands.^[31] In a recent study, Sevinc *et al.*^[32] reported that hippocampal circuits have a role in reducing anxiety following meditation training by modulating fear memory.

Meditation to improve cognitive functions in stress (sleep deprivation) and neurological disease (migraine and epilepsy)

All meditation practices involve two attention guided

Table 1: Literature on the effect of Yoga in improvement of Brain functions, in order of citation in text in the present review

Reference	Participants (no., age, gender and category)	Type and duration of yoga	Outcome measures/ variables	Salient findings
Panjwani <i>et al.</i> ^[25] 1996	32 patients of idiopathic epilepsy	Sahaja yoga for 6 months	Decrease in seizure frequency (62% at 3 months and 86% at 6 months), EEG frequency bands changes	Meditation is an adjunct for epilepsy management
Sulekha <i>et al.</i> ^[26] 2006	78 healthy males 20-30 years 31-55 years	Sudarshan Kriya and Vipassana practitioners	No age-related decline in NREM and increased REM in 31-55 years aged practitioners	Meditation and related practices prevent the age related changes in sleep architecture in middle aged persons
Pattanashetty <i>et al.</i> 2010 ^[27]	Vipassana meditators Young 30-39 years Middle 40-49 years Older 50-60 years	Vipassana practitioners	Increased NREM and REM across age groups	Vipassana practitioners had better sleep architecture
Ganpat <i>et al.</i> 2011 ^[28]	Managers, <i>n</i> =72 Mean age 48.7 years	SMET 5 days	Somatic symptoms, anxiety and insomnia questionnaires	SMET improved mental health
Ganpat <i>et al.</i> 2014 ^[29]	University students <i>n</i> =184 Mean age 25.8 years	Yoga instructor course, 21 days	Emotional intelligence	Emotional intelligence improved
Telles <i>et al.</i> 2018 ^[30]	Primary school teachers, <i>n</i> =236 Mean age 42 years	Residential yoga programme, 15 days	Mental well-being, anxiety	Mental health improved
Van Lutterveld <i>et al.</i> , 2017 ^[31]	16 novice meditators and 16 experienced meditators	Basic and self-selected meditation practice. <20 h in lifetime (novice) and ≥30 minutes per day for at least 5 days/week over the past 5 years (experienced)	EEG	Alpha band functional network topology is better integrated in experienced meditators than in novice meditators
Sevinc <i>et al.</i> , 2020 ^[32]	Age: 18-50 94 participants Males and females Age 31±7 years	MBSR 8 weeks, 2 h per week	Magnetic resonance imaging	Hippocampal circuits connectivity contributed to reduced anxiety following meditation training
Oken <i>et al.</i> , 2006 ^[33]	135, 65-85 years, men and women	Hatha yoga class and walking exercise at home for 6 months	Physical functions, quality of life, cognitive functions	Yoga practice is beneficial for healthy seniors but no cognitive function benefit
Chatterjee <i>et al.</i> , 2012 ^[34]	10 young, 21-30 years old, Healthy male from Indian Army	Om meditation practice, 2 months	P300, CNV, RAPM scores	Medication effectively improved SD induced cognitive deterioration
Kisan <i>et al.</i> , 2014 ^[35]	60 migraine patients	Yoga, 5 days/week for 6 weeks	Headache frequency and intensity	Yoga reduced frequency and intensity of migraine
Panjwani <i>et al.</i> , 2000 ^[36]	32, 15-35 years old, male and female, Idiopathic epileptic patients	Sahaja yoga meditation twice daily for 6 months	Visual contrast sensitivity, auditory mid latency responses, brainstem auditory evoked potentials	Meditation practice improved electrophysiological functions
Panjwani <i>et al.</i> , 1995 ^[37]	32 epileptic patients	Sahaja yoga meditation for 6 months	Galvanic skin resistance, blood lactate and urinary vinyl mandelic acid	Sahaja yoga practice may benefit epileptics via reduction in stress levels

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Reference	Participants (no., age, gender and category)	Type and duration of yoga	Outcome measures/ variables	Salient findings
Bankar <i>et al.</i> , 2013 ^[38]	65 (35 nonyoga and 30 yoga) 60 and above years, men and women	Daily different yoga exercises (1 h) for 2 years or more	Less sleeping disturbances, s better sleep quality and sleep efficiency scores and decreased use of sleep medications in yoga group Physical functioning, cognitive functioning and self-care scale was better; depression and anxiety were lower in yoga group	Long-term yoga practices improved sleep quality in elder age population
Ebnezar <i>et al.</i> , 2011 ^[39]	Participants (118 yoga, 117 control), 35-80 years, osteoarthritis patients	Yoga exercise (shithilikaranavyayama, asanas, relaxation techniques, pranayama, meditation and didactic lectures on yama, niyama, jnana yoga, bhakti yoga, and karma yoga) for 2 weeks (6 days per week, 40 min per day)	Improvement in life quality, physical activities, health (emotional, social and physical), energy level, and pain	Yoga therapy may be an approach for osteoarthritis management
Pal <i>et al.</i> , 2014 ^[40]	60, 17-20 years, male, undergraduate medical students	Breathing exercise practice for 3 months	Autonomic changes (increased parasympathetic; decreased sympathetic activity) following slow breathing practice	Slow breathing exercise improves autonomic system activity
Veerabhadrapa <i>et al.</i> , 2011 ^[41]	50, 18-25 years, male, healthy	Mukh Bhastrika training for 12 weeks	Decreased basal heart rate; reduced falling of systolic blood pressure	Mukh Bhastrika is beneficial for cardiac activity
Chételat <i>et al.</i> , 2018 ^[42]	6 older adult expert Buddhist meditators and 67 age matched adult naïve meditators (Controls)	>10,000 h of meditation practice	PET gray matter volume and glucose metabolism	Gray matter volume and/or glucose metabolism was higher in six older adult expert meditators compared to 67 age-matched controls
Afonso <i>et al.</i> , 2017 ^[43]	21 elderly women each in group of yoga practitioners and control group Age: 67±2	14.9 years of hatha yoga practice	IADL BDI MMSE Anthropometric measurements—Weight and heights were measured. Whole-brain CT analysis was then performed on each vertex using the GLM embedded in the SurfStat toolbox ² for Matlab (R2010b; MathWorks)	Greater CT in the left prefrontal cortex of healthy elderly women who trained yoga for a minimum of 8 years compared with women in the control group

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Reference	Participants (no., age, gender and category)	Type and duration of yoga	Outcome measures/ variables	Salient findings
Santaella <i>et al.</i> , 2019 ^[44]	Age: ≥60 years 20 women each two groups: yoga practitioners and control women participants	Hatha yoga; practicing a minimum of twice a week with a duration of at least 8 years	MMSE, BDI, IADL and resting-state fMRI	Elderly women with at least 8 years of yoga practice presented greater intra-network anteroposterior brain functional connectivity of the default mode network

EEG: Electroencephalographic, NREM: Nonrapid-eye-movement, REM: Rapid-eye-movement, MBSR: Mindfulness based stress reduction, PET: Positron emission tomography, IADL: Instrumental activities of daily living, BDI: Beck depression inventory, MMSE: Mini mental state examination, GLM: General linear model, fMRI: Functional magnetic resonance imaging, CT: Computed tomography, SMET: Self-Management of Excessive Tension

practices. First is focused attention centered on a given object. The second one encourages the practitioner to be silent while not to responding and passively observing the thoughts. The growing scientific and clinical interest in mindfulness meditation has produced various intervention studies authenticating its benefits for managing pain; boosting immune response; regulating brain activity to enhance positive emotion, and simultaneously preventing depression, anxiety and negative affect and decreasing perceived stress, and promoting self-compassion. Literature has shown that meditation practice helps an individual in coping up with the various type of physical and mental health issues.^[33,49,50] “Om” meditation practice for 2 months significantly reduced various aspects of cognitive decline including different components of memory, attention, and vigilance. During total night sleep deprivation, standard neurophysiological tests including Raven’s Advanced Progressive Matrices, Auditory Evoked potential component Middle Latency Response, Event-related potential P300-ERP, and Contingent Negative Variation were recorded. All the measures of cognition were impaired during sleep deprivation. “Om” meditation practice ameliorated the standard deviation induced impairment in cognitive decline.^[34,51]

Meditation in addition to promoting health and well-being in normal people also has a curative function in diseased states. The frequency and intensity of headaches improved in patients of migraine who practiced Yoga in addition to conventional therapy. Yoga practice has been used by clinicians for the management of epilepsy.^[35,52] Sahaj yoga meditation was found to be a beneficial intervention against epilepsy as shown in some of the electrophysiological responses of patients. There was a significant reduction found in seizure frequency, improvement in EEG, with an increase in percent Alpha frequency, reduction in Delta frequency, increase in ratios of Alpha/Delta, Alpha + Beta/Delta + Theta, increased Galvanic Skin Response response, improved Visual Contrast Sensitivity (VCS), reduced urinary catecholaminergic metabolites following meditation practice. On these grounds, it was suggested

that meditation practice by modulation of the limbic system modulates the hypothalamo-hypophyseal axis and the autonomic nervous system activity and regulates endocrine functions. A reduced stress level contributed to seizure reduction since stress was a trigger for seizure episodes in most of the patients. The reduced level of stress following meditation practice also led to a better response to auditory and visual stimuli in terms of Auditory Evoked Potentials and VCS. The changes observed after meditation practice may also be attributed to behavior alterations. The ability to focus attention, improve concentration, and motivation are relevant. An altered lifestyle with a reduction in stress is important for the clinical and electrophysiological changes. Meditation practice as an adjunct to anti-epileptic medication helped in seizure reduction and brings about changes in electrophysiological and biochemical measures.^[25,36,37]

Geriatric population and yoga

Due to the physiological process of aging, sleep architecture alters in the elderly. Furthermore, sleep disturbances also increase with age. Alterations in sleep architecture in elderly people include increased sleep latency (time to fall asleep), frequent awakenings, and sleepiness during the daytime. It has been observed that there is a direct correlation between poor sleep quality and morbidity, compromised cognitive function, and quality of life. Most basic elements referred to sleep disturbances influences are inadequate physical activity, poor sleep preparation, and unreasonable daytime napping. Even though sleep-related issues in old individuals put additional weight on medicinal services as well as economic burden doctors overlook this issue and consider it as a part of normal aging Different medications like benzodiazepines and nonbenzodiazepines are accessible for pharmacological treatment of sleep-related issues in the elderly. The drugs, however, have detrimental side effects, hitting the sensitive geriatric age group. The use of these compounds leads to physical just as mental dependence, compromised psychomotor function, REM sleep disturbance, and reoccurrence of insomnia.^[53-55]

Hence, the adverse effects of sleep medications further compromise the quality of life of the elderly. Due to the aforementioned considerations, the relevance of yoga in improving the health and well-being of the elderly cannot be over-emphasized.

The health beneficial effects of Yoga like improved sleep quality, reduction of blood pressure, and better serum lipid profile have been observed. Also, after regular Yoga exercises for 6 months, shorter sleep latency, reduced night sleep disturbance, better quality of sleep, and reduced use of sleep medications were observed in geriatric people.^[33] In another study, improvement in different aspects of sleep and decrease in symptoms of depression was observed after Yoga practice. Aged people who practiced Yoga on regular basis had a better quality of sleep with enhanced NREN and REM sleep, less lethargy during daytime, reduced intake of sleep medications, and subjective feeling of freshness in morning.^[27] Yoga practice help in the amelioration of age-related degeneration by changing cardiometabolic risk factors, autonomic function, and BDNF in healthy males.^[54] In another study, a relationship between poor sleep quality and reduced oxygen saturation of <90% which compromised physical performance in the form of decreased grip strength and walking speed was observed.^[55] Pranayama improves the strength of the respiratory muscles which leads to better tissue perfusion and improved oxygen saturation. Since sleep apnea is associated with decreased oxygen saturation, improved oxygen saturation due to Yoga may explain reduced sleep disturbances in Yoga group.^[38] Obstructive sleep apnea (snoring) increases the chances of sleep disturbances which may be attributed to the weakened upper airway muscles and narrowing of the respiratory passage. Yoga strengthens upper airway muscles resulting in less sleep disturbances.^[56]

Yoga encompasses asanas, pranayam and meditation. A reduced muscular strength and muscle mass leading to a decreased exercise capacity is associated with aging. Day to day activities become difficult leading to dependency on family and other support systems. Yoga improves body flexibility, prevents decline in physical function and improves the quality of life of elderly persons.^[39] Comparative outcomes have been obtained in another study on Yoga professionals in the age group 60 years or more. Better body flexibility and critical decreases in movement execution timings were noted in the Latin-American Development Age Group. Yoga practices over long durations like stretching of the joints lead to the slackening of the muscles and connective tissues encompassing the bones and joints. Regular exercise involving joints in Yoga practices prevents the dystrophy of the ligament and improves the functionality of joints. Yoga practices are related to less sleep debt and better physiological function and old individuals can live independently. A putative explanation for better sleep quality in individuals who

perform Yoga on a daily basis is that all Yoga postures involve stretching and relaxing of muscles which lead to enhanced physical and mental activity leading to better sleep quality.^[57] It also appears that the benefits of Yoga are retained even after long-term Yoga practice.

Some mechanisms of action of Yoga to improve sleep quality have been proposed. Studies on health volunteers have shown that there is an increase in the vagal tone, decrease in sympathetic discharge with reduced postural heart rate response and decreased catecholamine levels in plasma after Yoga practice.^[40] Relaxation with reduced responsiveness to extraneous signals may be a factor for reduced sleep disturbances with Yoga practice. Some reviewers have pointed out that caution needs to be exercised in the interpretation of findings. In a review on the effect of meditation on age-related cognitive decline, it was observed that although most studies have a high risk of bias and small sample size, yet it could be interpreted that meditation could ameliorate the cognitive decline in elderly.^[58]

Aging is associated with changes in the central nervous system structurally and functionally, especially in regions associated with cognitive functions such as executive functions, attention, and working memory including a reduction in the volume of cortical areas.^[59,60] Yoga improves cognitive function; several studies have shown better scores of cognition after yoga. Yoga improves mood and relieves stress. Sleep disturbance impairs psychomotor alertness, which further reduces cognitive function linked with brain regions like the prefrontal cortex. As age advances, blood flow to the brain decreases in a time-dependent manner. Habitual practice of Yoga enhances parasympathetic activity with a simultaneous decrement in autonomic over-activity.^[41] This reduces the decline in oxygen consumption and metabolic rate of prefrontal cortex cells, thereby ameliorating neuronal loss and cognitive function]. Meditation practice increases gray matter volume and glucose metabolism in prefrontal and cingulate cortices and insula and temporoparietal junction suggesting long-term meditation practice reduces age-related cognitive decline.^[42] Elderly women long-term yoga practitioners had a greater prefrontal cortical thickness than age-matched controls.^[43] The default mode network has been an area of interest in meditation. In elderly practitioners, a better anterior-posterior brain functional connectivity on Decision Model and Notation may also be present in long-term meditators.^[44] Overall, regular yoga practice by the elderly improves the age-associated cognitive decline by structural and functional changes in key brain regions.

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Conflicts of interest

There are no conflicts of interest.

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