ORIGINAL RESEARCH

Immediate and Long-term Effects of Meditation on Acute Stress Reactivity, Cognitive Functions, and Intelligence

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ABSTRACT

Context • With the current globalization of the world's economy and demands for enhanced performance, stress is present universally. Life's stressful events and daily stresses cause both deleterious and cumulative effects on the human body. The practice of meditation might offer a way to relieve that stress.

Objective • The research team intended to study the effects of meditation on stress-induced changes in physiological parameters, cognitive functions, intelligence, and emotional quotients.

Methods • The research team conducted the study in two phases, with a month between them. Each participant served as his own control, and the first phase served as the control for the second phase. In phase 1, the research team studied the effects of a stressor (10 minutes playing a computer game) on participants' stress levels. In phase 2, the research team examined the effects of meditation on stress levels.

Setting • The research team conducted the study in a lab setting at the All India Institute of Medical Sciences (AIIMS), New Delhi, India.

Participants • The participants were 34 healthy, male volunteers who were students.

Intervention • To study the effects of long-term meditation on stress levels, intelligence, emotional quotients, and cognitive functions participants meditated daily for 1 month, between phases 1 and 2. To study the immediate effects of meditation on stress levels, participants meditated for 15 minutes after playing a computer game to induce stress.

Outcome Measures • The research team measured galvanic skin response (GSR), heart rate (HR), and salivary cortisol and administered tests for the intelligence and emotional quotients (IQ and EQ), acute and perceived stress (AS and PS), and cognitive functions (ie, the Sternberg memory test [short-term memory] and the Stroop test [cognitive flexibility]). Using a pre–post study design, the team performed this testing (1) prior to the start of the study (baseline); (2) in phase 1, after induced stress; (3) in part 1 of phase 2, after 1 month of daily meditation, and (4) in part 2 of phase 2, after induced stress, both before and after 15 minutes of meditation.

Results • Induced stress from the computer game resulted in a significant increase in physiological markers of stress such as GSR and HR. In the short term, meditation was associated with a physiological relaxation response (significant decrease in GSR) and an improvement in scores on the Stroop test of reaction times. In the long term, meditation brought significant improvements in IQ and scores for cognitive functions, whereas participants' stress levels (GSR and AS) decreased. EQ, salivary cortisol, and HR showed no significant changes.

Conclusions • The practice of meditation reduced psychological stress responses and improved cognitive functions, and the effects were pronounced with practice of meditation for a longer duration (1 month). (*Altern Ther Health Med*. 2012;18(2):46-53.)

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Author Disclosure Statement: The author(s) declare that they have no competing interests.

Meditation involves a family of complex practices that regulate emotions and attention and that affect mental and related somatic events by engaging a specific attentional set.[1] Specific neural systems associated with selective attention (eg, the temporal-parietal junction), ventro-lateral prefrontal cortex, frontal eye fields and intraparietal sulcus,[i] and sustaining attention (eg right frontal and parietal areas and the thalamus)[ii,iii] are involved in inducing and maintaining the state of meditation. These neurophysiological changes induced by meditation training are also correlated with improvements in behavioral measures of sustained attention, such as functioning in continuous performance tasks or binocular rivalry tasks, and of selective attention, such as performance in the Posner cueing task.[iv]

Many recent behavioral, electroencephalographic, and neuroimaging studies have revealed the importance of investigating meditation's states and traits to achieve an increased understanding of cognitive and affective neural plasticity, attention, and self-awareness as well as to evaluate their possible clinical implications.[2]

Meditation is a conscious mental process that induces a set of integrated physiological changes termed the *relaxation response*. The regulation of attention is a central feature of different methods of meditation.[3] Meditation itself may involve efferent attenuation, sensory attenuation, and nonanalytic attention. *Efferent attenuation* means adapting a relaxed, motionless posture. *Sensory attenuation* means minimum sensory input to central nervous system (ie, sitting comfortably with eyes closed in a quiet surrounding with minimum joint and proprioceptive input). *Nonanalytic attention* means pure observation of thoughts or emotion without any analysis, attachment, or flowing away with them.[4]

A type of meditation, progressive self-focused meditation, has shown significant reductions in scores for depression, an increase in attention, and improvements in memory.[5] In a qualitative study on individuals' experiences of transcendental meditation, Rosean and Benn[6] reported an increasing state of restful alertness; improvement in skills indicative of emotional intelligence (ie, self-control, self-reflection/awareness, and flexibility in emotional responses); and improvements in academic performance. Kaul et al[7] reported the acute beneficial effects of meditation on novice subjects in reaction time measured by using the psychomotor vigilance task. The psychomotor vigilance task is a sustained-attention, reaction-timed task that measures the speed with which subjects respond to a visual stimulus. PVT-192 (Ambulatory Monitoring Inc, New York) was used to test for vigilance and reaction time in the quoted reference.

Researchers have reported that mental stress can impair cognitive function.[8] This impairment is of relevance to the performance of students, office workers, and many others for whom optimal alertness, concentration, and memory are essential. The sympatho-adrenal system and the hypothalamic-hypophysial-adrenal (HPA) axis may mediate the adverse effects of stress on cognitive performance.[9,10,11,12]

In recent years, medical professionals have emphasized the importance of stress-management techniques. Practice of yoga and meditation has emerged as a powerful way of relieving stress. Meditation provides a profound physical, emotional, and cognitive experience; each of these three types of experience is capable of influencing the brain. Meditation uses neural plasticity to bring about sustained changes in the structure and function of the brain, and in an overall sense, it harmonizes the brain's processes, leading to a well-balanced and adjusted experience of life. Therefore, the research team hypothesizes that meditation neutralizes the harmful physiological and psychological changes that stress induces and brings about positive changes in cognitive functions and intelligence. Recently, the research team reported the benefits of meditation in young adult subjects who had never practiced meditation previously.[13] In the aforesaid study, the practice of meditation reduced physiological stress responses, while it retained the beneficial effects of stress, namely improved memory scores.

Researchers can classify the studies on the neuroscience of meditation broadly as (1) those focusing on the nature of changes in the brain's activity during the practice of meditation (meditation-state or short-term effects) and (2) those that focus on the cognitive and neural changes due to the long-term practice of meditation (meditation trait).[2]

In the present study, participants took part in a meditation session immediately after a stress phase to explore the short-term (immediate) effects of meditation on acute-stress reactivity. The research team also explored the sustained effects of the long-term practice of meditation (trait) on stress reactivity, intelligence, and cognitive functions.

METHODS

The research team conducted the study in two phases, with a month between them. Each participant served as his own control, and the first phase served as the control for the second phase.

Participants

Participants were 34 male volunteers (aged 18-30 years; mean $\pm$ SD, 24.4 $\pm$ 3.2). The research team excluded individuals (1) who had a history of practicing meditation or any other relaxation technique; (2) who indulged in substance abuse or were smokers or alcoholics; and (3) who had any disease or who were undergoing treatment for any medical condition. The research team included only male volunteers because females have different levels of stress and stress reactivity during different phases of the menstrual cycle.

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Moreover, the research team performed all experiments in the forenoon to minimize the diurnal variation.

The research team received ethical clearance for the study from the ethics committee for human subjects of the All India Institute of Medical Sciences (AIIMS), New Delhi, India. On the first visit, the team briefed all participants about the study with the help of an information sheet and obtained their informed written consent for participating in the study.

Meditation

To enable an evaluation of the effects of meditation on stress, a trained instructor taught guided meditation to participants. Participants took part in a practice session of meditation, in which the instructor explained the importance of relaxing completely.

The research team instructed participants to meditate daily for a period of 1 month (between phase 1 and phase 2 of the study) with the help of an audio tape and to complete a daily diary, which the team collected every week to monitor participants' compliance. The tape acted as a guide, with instructions given through a headphone connected to a Walkman. The instructor told participants to listen to the tape during each meditation if they felt they could meditate better with it, but they were free to meditate without it. The instructor gave participants the option of replaying the tape if they felt they could not follow the instructions and hence relax completely without doing so.

The duration of each session of meditation during the study was approximately 15 minutes, with participants' eyes closed throughout the practice. For the first few minutes of each session, the participant concentrated on breathing, followed by a stage in which the recording suggested feelings of peace, stillness, and freedom from thought that the participant was to experience with each breath. As soon as the participant's mind reached that peaceful stage, he was to observe and maintain that status quo.

Stressor

The research team used computer games as lab stressors. Computer games usually give immense pleasure after a win. In the initial stages of the game when an individual suffers repeated defeats or constraints, however, the game becomes very stressful.[14] The study's games required working with very few keys so that participants could become familiar with them quickly and rapidly reach a stage where they could prevent repeated defeats or losses. The team asked each participant to play a few computer games and recorded his heart rate (HR), using an electrocardiogram (ECG), and his galvanic skin response (GSR) during the games. For the actual intervention, the team chose the game that a given subject could not master during that play period. The chosen game was the computer game that resulted in an increase in GSR and HR and induced the maximum stress for that particular participant.[14]

Design

See Table 1 for a summary of the study's design. Before starting the study's interventions, the research team measured participants' baseline levels for GSR, HR, and salivary cortisol and administered tests for his intelligence and emotional quotients (IQ and EQ), acute stress (AS), perceived stress (PS) and cognitive functions. At intervals during the interventions, the research team again measured GSR, HR, salivary cortisol, and cognitive functions to determine the effects of stress in phase 1 and the effects of meditation on stress in phase 2. The team kept the duration of the stressor at 10 minutes in both phases of the study.

In phase 1, participants played the chosen computer game (the stressor), and the research team took measurements to determine the effects of stress. After this testing, the research team introduced the practice of meditation to participants, and participants practiced it daily for 1 month.

Phase 2 consisted of two parts. First, after participants had practiced meditation for 1 month, the team again took all measurements to evaluate the effects of long-term meditation. Second, the team then induced stress for participants using the relevant computer game, and immediately after the stressor, participants meditated for 15 minutes. The team then took all measurements again to measure short-term effects on stress.

To analyze the effects of the stressor on HR and GSR, the team made two comparisons: (1) In determining the effects of stress on the participants, phase-1 basal values were compared to phase-1 poststress values obtained during early (first 5 minutes) and late (second 5 minutes) intervals of the stress intervention; (2) The acute effects of meditation on HR and GSR were determined in part 2 of phase 2 by comparing during-stress intervention values with values recorded during the early, mid, and late intervals of the meditation intervention, each of 5 minutes duration.

To analyze the effects of meditation on cognitive functions and levels of salivary cortisol, the team made two comparisons: (1) To assess the long-term effects of meditation, the team compared the mean value of parts 1 and 2 of phase 1 with the mean value of parts 1 and 2 of phase 2; (2) The team assessed the acute effects of meditation on stress in part 2 of phase 2 by comparing prestress with poststress values.

Outcome Measures

The research team recorded measurements using a computerized recording system, a personal computer running Windows 98 (Microsoft Corporation, WA, USA) coupled with an RMS POLYWRITE-D (Recorders and Medicare Systems, Chandigarh, India). The team recorded the following parameters.

ECG (0.5-35 Hz). The research team continuously recorded ECG using Lead-2, at a sample rate of 200/sec and gain × 2000. The team calculated the participant's heart rate from the R-waves, using a mean value of beats per minute from an artifact-free graph for each stage of recording.

Table 1. Overview of the Study's Design: Phase 2 Followed Phase 1 After a Period of 1 Month

Phase 1	**Phase 2** (One month after introduction and practice of meditation)
Assessment of IQ, EQ, and acute and perceived stress levels	Assessment of IQ, EQ, and acute and perceived stress levels
Measurement of baseline cortisol using a salivary sample	Measurement of baseline cortisol using a salivary sample
Start of ECG and GSR recordings	Start of ECG and GSR recordings
Assessment of cognitive functions	Assessment of cognitive functions
Measurement of prestress cortisol using salivary sample	Measurement of prestress cortisol using salivary sample
Stressor (computer game, 10 minutes)	Stressor (computer game, 10 minutes)
Measurement of poststress cortisol using salivary sample	Measurement of poststress cortisol using salivary sample
	Meditation (15 minutes)
	Measurement of postmeditation cortisol using salivary sample
Assessment of cognitive functions	Assessment of cognitive functions
End of recordings	End of recordings

GSR (0-35Hz). The research team tied two Ag/AgCl electrodes around the index and middle finger of the participant's left hand to record the GSR, which is a relatively reliable index of sweat-gland activity and changes in the activation level of the sympathetic nervous system.

Salivary Cortisol. The research team assessed salivary cortisol as a hormonal response to stress. Hormones can enter saliva by a variety of mechanisms, but for the neutral steroids, the most common route is rapid diffusion through the acinar cells. As such, their concentration is independent of the rate of saliva flow.[15] The prime advantage of saliva is that it offers noninvasive, stress-free, and real-time repeated sampling where blood collection is either undesirable or difficult. Salivary steroid levels reflect the circulating level of free steroids rather than total circulating levels, which the presence of circulating, high-affinity binding proteins confounds.[16] Salivary cortisol is a reasonable reflection of the functioning of the hypothalamic-pituitary-adrenal (HPA) axis. In a diagnostic setting, salivary cortisol levels parallel those in plasma following adrino corticotrophic hormone (ACTH) and corticotropin releasing hormone (CRH) stimulation and exercise induced-stress.[15] The research team estimated levels of cortisol using commercial ELISA kits (DRG International Inc, New Jersey, USA). The interassay and the intra-assay coefficients of variation were below 5.4% and 2.8%.

Acute Stress Level (AS). The research team administered the Stanford Acute Stress Reaction Questionnaire (SASRQ) to assess each participant's mental and emotional stress.[17]

Perceived Stress Level (PS). The research team assessed chronic stress levels using the Cohen Perceived Stress Scale.[18]

Cognitive Functions. The research team assessed cognitive functions using two assessment tools: (1) Sternberg memory test (MEMSCAN) designed to test the immediate short-term memory load for accuracy and fastness. The program MEMSCAN runs a version of the Sternberg memory-scanning paradigm. On each trial, a set of to-be-remembered digits is first presented. The size of the set varies on different trials from 1 to 6. The memory set is then replaced by a plus sign and, after a short delay, a probe digit. The subject's task is to respond as quickly as possible by pushing the *forward-slash* key if the probe was a member of the set, or the *Z* key if the probe was not a member of the memory set. If the response was incorrect, or if an invalid key was pressed, a short tone is presented. (2) A cognitive flexibility test (Stroop color interference test). The Stroop test measures the ease with which a subject can shift one's perceptual set to conform to changing demands and inhibit attention to competing stimuli. The subject's task is to respond to the color in which the word is printed by pressing the correct key as quickly as possible. Three conditions are presented in separate blocks. In *neutral task* (Stroop N) the letter string is composed of *X*s. In *interference task* (Stroop I) the letter string is one of the words *red*, *green*, *blue*, or *yellow* printed in a color different from the named color. In *facilitation task* (Stroop F) the letter string is the name of the color that the letters are printed in. The Stroop test was administered using computerized Psych/Lab software (Richard A. Abrams Psychology Department, Washington University, Missouri, USA).

General Intelligence Quotient (IQ). The research team assessed participants' general intelligence using an Indian adaptation of the Wechsler Adult Intelligence Scale-Performance Scale.[19]

Emotional Intelligence Quotient (EQ). The research team assessed emotional intelligence using the N.S. Schutte Emotional Intelligence Scale. It contains 33 items, of which

30 items are forward types and three are backward types. There are two types of questions in this scale, positively and negatively stated. The subject responds in a subjective scale, ranging from 1 to 5, where 1 = strongly disagree and 5 = strongly agree. EQ score is calculated by summing the scores of all positive questions and reversing the scores of negatively stated questions. Positively stated questions are also known as *forward type* and negative stated questions as *backward type*. This scale contains questions related to emotional management and interpersonal and intrapersonal relationships.[20]

Statistical Analysis

The research team performed the statistical analysis using STATA Software (StataCorp. 2005. Stata Statistical Software: Release 9, Texas). The team found the distribution of the data to be both Gaussian and non-Gaussian. Therefore, the team applied both parametric and nonparametric tests to the data. The research team compared mean data prestress and poststress using a paired *t* test. The team used a nonparametric test, the Wilcoxon sign rank test, and the Kruskal–Wallis test for evaluation of non-Gaussian data (EQ, AS, and PS scores). The team considered a *P* value of less than .05 to be significant.

RESULTS

Immediate Effects of Meditation

When participants played a computer game that induced acute stress in phase 2 of the study, the research team observed a significant rise in HR and GSR (Table 2). Meditation induced the opposite physiological effects. HR showed a decline as the meditation progressed, from a mean of 92/min to 88/min, but the decrease was not statistically significant. GSR did not change during the early interval (first 5 minutes) of meditation, but as the meditation progressed, GSR decreased significantly during the mid and late intervals. Cortisol levels and memory reaction times showed no changes. The Stroop reaction times improved significantly for all test conditions after the meditation (Table 3).

Effects of Long-term Meditation

The research team compared baseline data from phase 1 with baseline data of phase 2 to study the effects of 1 month of meditation on the study's measurements. Practice of meditation brought significant improvements in general intelligence (IQ), performance on the Sternberg memory test, and results for the interference and facilitation conditions of the Stroop test (Table 4). The study also saw a significant decrease in AS and GSR; however, the research team observed no changes in emotional

Table 2. Immediate Effects of Meditation on HR and GSR (N = 34)

	Phase 2		
Parameter	Prestress/ basal Mean ± SD	During-stress, Prior to Meditation Mean ± SD	During Meditation Mean ± SD
HR (Early phase)	82 ± 14	92 ± 14	92 ± 15
HR (Mid phase)			88 ± 14
HR (Late phase)			88 ± 16
GSR (Early phase)	5.3 ± 3.9	6.3 ± 3.3	7.3 ± 9.8
GSR (Mid phase)			5.1 ± 2.3[a]
GSR (Late phase)			4.9 ± 2.2[a]

Abbreviations: SD, standard deviation; HR, heart rate; GSR, galvanic skin response.

[a]$P < .001$

Table 3. Immediate Effects of Meditation on Cortisol and Cognitive Functions (N = 34)

Parameter	Baseline, Prior to Interventions Mean ± SD	After One Month of Meditation Mean ± SD
Cortisol (N = 31) (nanograms/ml)	2.5 ± 1.1	2.5 ± 1.3
MEM RT (ms)	780 ± 169	754 ± 157
Stroop N RT (ms)	796 ± 94	729 ± 86[a]
Stroop I RT (ms)	864 ± 119	784 ± 107[a]
Stroop F RT (ms)	689 ± 80	669 ± 83[b]

Abbreviations: SD, standard deviation; MEM RT, Sternberg memory reaction time; Stroop N RT, Stroop reaction time during neutral condition; Stroop I RT, Stroop reaction time during interference condition; Stroop F RT, Stroop reaction time during facilitation condition; NS, not significant.

[a]$P < .001$, represents significance between pre- and postvalues.

[b]$P < .05$, represents significance between pre- and postvalues.

Table 4. Effects of Long-term Meditation (N = 31)

Parameter	Phase 1 Mean ± SD	Phase 2 Mean ± SD
IQ	106.8 ± 9.7	116 ± 11.3[c]
EQ	131.9 ± 12.6	135.5 ± 17.5
AS	36.1 ± 12.4	31.5 ± 13.8[a]
Chronic Stress Level	16.5 ± 5.6	15 ± 7.6
Cortisol	2.6 ± 1.5	3.4 ± 2.8
HR	81 ± 10	82 ± 14
GSR (micromho)	8.5 ± 8.8	5.4 ± 3.9[b]
Mem Rt (ms)	887 ± 179	780 ± 169[a]
Stroop N RT (ms)	782 ± 111	796 ± 94
Stroop F RT (ms)	904 ± 138	864 ± 119[a]
Stroop I RT (ms)	719 ± 106	689 ± 80[a]

Abbreviations: SD, standard deviation; IQ, intelligence quotient; EQ, emotional intelligence quotient; AS, acute stress; HR, heart rate; GSR, galvanic skin response; MEM RT, Sternberg memory reaction time; Stroop N RT, Stroop reaction time during neutral condition; Stroop I RT, Stroop reaction time during interference condition; Stroop F RT, Stroop reaction time during facilitation condition; NS, not significant.
[a]$P < .05$, represents significance between pre vs postvalues.
[b]$P < .01$, represents significance between pre vs postvalues.
[c]$P < .00$, represents significance between pre vs postvalues.

Table 5. Effect of Acute Stress Reactivity

	Phase 1 (N = 34)		Phase 2 (N = 31)	
Parameter	Basal Mean ± SD	During Stress Mean ± SD	Basal Mean ± SD	During Stress Mean ± SD
HR early phase	81 ± 10	85 ± 10[b]	82 ± 14	87 ± 12[b]
HR late phase		85 ± 11[b]		92 ± 14[b]
GSR early phase	8.4 ± 8.7	10.3 ± 9	5.3 ± 3.9	6.1 ± 3.8
GSR late phase		11 ± 10[a]		6.3 ± 3.2
Parameter	**Prestress**	**Poststress**	**Prestress**	**Poststress**
Cortisol	2.5 ± 1.4	2.4 ± 1.4	2.6 ± 1.2	2.6 ± 1.1

Abbreviations: SD, standard deviation; HR, heart rate; GSR, galvanic skin response
[a]$P < .05$, represents significance between pre vs postvalues.
[b]$P < .00$, represents significance between pre vs postvalues.

intelligence, chronic stress levels, basal cortisol, or heart rate. The research team assessed the compliance of participants regarding meditation practice using their daily diaries and found more than 90% compliance in all participants.

Acute Stress Reactivity

Use of a computer game as a lab stressor was associated with a significant rise in HR through the early and late intervals of both phase 1 and phase 2, whereas GSR increased significantly in the late-stress interval only for measurements during phase 1. In phase 2, the research team observed no rise in GSR, which may be due to a long-term (trait) meditation effect (Table 5). Cortisol levels did not increase in either phase.

DISCUSSION

In examining the immediate effects of the practice of meditation, an earlier study from the research team's lab reported that meditation reduced physiological stress responses, while it retained the beneficial effect of stress, namely improved memory scores.[13] The team undertook the present study to explore the sustained effects of 1 month of practice of meditation on cognitive functions and stress reactivity.

Sharma et al have documented that computer games can act as stressors, increasing GSR and HR, physiological changes that are associated with stress. In the current study, salivary concentrations of cortisol, commonly considered a biochemical marker of stress, showed no significant changes between poststress levels in phase 1 and phase 2 and between premeditation and postmeditation levels in phase 2. Although the research team performed all the experiments in the forenoon, the effect of pulsatile changes in cortisol level could have confounded the results. In our study, stressor was of relatively short duration and mild in intensity, so resulting cortisol changes would also be small in magnitude, which could have been masked by intrinsic fluctuation in cortisol level. Also, hormonal response to stress is slower in onset, unlike changes in other physiological stress markers (HR and GSR), which are quicker in onset.

Practice of meditation for a period of one month improved IQ and performance in the Sternberg memory and Stroop test scores. Lower baseline GSR and AS scores for phase 2 are related to an individual's relaxed state and are indicative of sustained changes after participants' practice of meditation for one month. Less reactivity to stress after long-term meditation, as assessed by GSR, further suggests that the practice of meditation may benefit young adults in reversing the effects of stress.

Researchers already have documented the use of meditation in psychological and medical practice for stress management as well as for a variety of physical and mental disorders.[21] Parshad showed that meditation's physiological benefits help yoga practitioners show greater resilience in stressful conditions.[22]

Meditation leads to an alert and open mode of perceiving and monitoring all mental content from moment to moment, including perceptions, sensations, cognitions, and affects.[23] It promotes a capacity for heightened, present-moment awareness that all humans possess to a greater or lesser extent. Research has shown that enhancing this capacity through training can alleviate stress and promote physical and mental well-being. Studies that perform neuroimaging using fMRI (functional magnetic resonance imaging) to examine the effects of meditation have shown significant signal decreases in midline cortical structures associated with interoception (sensitivity to stimuli originating inside of the body), including to the bilateral anterior insula, left ventral anterior cingulate cortex, right medial prefrontal cortex, and bilateral precuneus.[24]

Many studies have reported an improvement in IQ through the practice of meditation.[6,25,26] How does meditation, a conscious mental process, induce improvement in IQ? Intelligence as a psychological concept indicates the global functional efficiency of neuronal networks, and many key brain structures—such as the temporal lobe, hippocampus, and overall grey-matter mass—are associated with it.[27] Also attention, concentration, and memory have a role in the betterment of IQ. Possibly, improvement may be due to increased cerebral blood flow in neural networks that are associated with attention and memory.

Using magnetic resonance imaging (MRI), in 2000, Lazar et al[28] showed that the practice of meditation activates neural structures involved in attention and control of the autonomic nervous system, which may lead to improved cognitive function. Studies of the practice of long-term meditation have shown differences in regional cerebral blood flow that is indicative of a different basal brain functioning as compared to nonmeditators. Using SPECT (single-photon emission computed tomography) imaging, Newberg et al found that long-term meditators' cerebral blood flow in the prefrontal cortex, parietal cortex, thalamus, putamen, caudate, and midbrain was significantly higher compared to nonmeditators.[29] Also, a significant difference existed in the thalamic laterality, with long-term meditators having greater asymmetry. The observed changes associated with long-term meditation appear in structures that underlie the attention network and also in those that relate to emotion and autonomic function.

Studies by Tang et al[30] showed that 11 hours of meditation resulted in an increase in fractional anisotropy (FA), an index indicating the integrity and efficiency of white matter in the corona radiata. This radiata is an important white-matter tract connecting the anterior cingulated gyrus to other structures, indicating that meditation changed white matter in the anterior cingulate cortex, a key structure involved in emotional control and self-regulation. In the current study, emotional intelligence did not improve significantly after the practice of meditation. No studies are available that study this effect, and future research should increase the duration of meditation to determine if it has a more lasting effect on the emotional circuitry of the brain.

Xiong and Doraiswamy have summarized various health benefits of meditation, suggesting preserved cognition and prevention of dementia.[31] While the mechanisms remain investigational, studies show that meditation may reduce cortisol secretion. This reduction potentially could have neuroprotective effects via elevation of levels of brain-derived neurotrophic factor, which could play a role in brain aging and mental fitness. An overall effect could be improved intelligence scores and cognitive functions. Future studies, however, require an increase in the duration of meditation and the study of several other domains of cognitive function. These studies could result in a better understanding of the effects of meditation on and its usefulness to young subjects.

CONCLUSION

The practice of meditation for a period of 1 month improved IQ and cognitive functions over and above the immediate effects of meditation. Furthermore, meditation reduced baseline stress and reactivity to a stressor, suggesting that the practice of meditation may benefit young adult males in reversing the effects of stress.

ACKNOWLEDGEMENTS

A financial grant from the Central Council for Research in Yoga and Naturopathy, Ministry of Health, New Delhi, India supported this work.

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