Meditation, Stress Relief, and Well-Being

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As the pace of life increases, stress is becoming endemic, and in the radiologic sciences, stress is keenly felt by technologists and patients. Meditation, a potential remedy to stress, is the subject of an increasing number of medical studies that often rely upon radiologic imaging scans to determine the physiological effects of meditation on brain activity. A wide range of meditation techniques have beneficial effects on the mind, body, and emotions. Radiologic technologists might find that meditation improves their quality of life as well as their level of job satisfaction, allowing them to provide improved quality of care to their patients.

After completing this article, the reader should be able to:

- Define stress and burnout.
- Identify causes of stress in the medical imaging workplace.
- List strategies for reducing stress in patients.
- Explain the limbic system’s role in stress and meditation.
- Describe the role of medical imaging in meditation research.
- Discuss medical research about the effects of meditation.
- Describe mindfulness meditation practice and its effects on the body.

Radiologic technologists work in a fast-paced environment that demands their complete attention to perform tasks quickly, accurately, and with the utmost concern for patient safety. While multitasking is an important and valued skill, there is a point at which too many simultaneous tasks—or even the thought of too many simultaneous tasks—can cause a system overload. In this unrelenting atmosphere, stress and strain can escalate. Add to this the ordinary pressures of life, and the combination is ripe, ironically, for diminishing the health of those who work to maintain and improve the health of others. Ultimately, the cumulative effects of stress on health care providers can have significant impact on patients’ testing experiences and their personal well-being. Reducing the stress levels of health care providers might increase efficiency, reduce burnout, and improve the overall quality of life for health care workers.

Radiologic technologists might experience stress when asked to take on multiple roles because of staff reductions caused by financial cutbacks. This money-saving move can lead to a drop in patient satisfaction and bigger economic woes. Romano explains that if patients are satisfied with the service during a radiologic examination in a low-stress setting, they are more likely to recommend the facility to others. In contrast, those who have a stressful experience will not. Patients’ stress can result from feeling as if their needs are important to the staff or that they are a burden to the staff.

Beach et al suggest that a mindful approach allows health care providers to enhance patient-clinician communication. A study of 45 clinicians interacting with 437 patients infected with HIV at 4 clinic sites across the United States found a clear correlation between mindfulness in clinicians and patient satisfaction, as reported in patient satisfaction.

As the pace of life increases, stress is becoming endemic, and in the radiologic sciences, stress is keenly felt by technologists and patients. Meditation, a potential remedy to stress, is the subject of an increasing number of medical studies that often rely upon radiologic imaging scans to determine the physiological effects of meditation on brain activity. A wide range of meditation techniques have beneficial effects on the mind, body, and emotions. Radiologic technologists might find that meditation improves their quality of life as well as their level of job satisfaction, allowing them to provide improved quality of care to their patients.

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interviews. The ability to be available (mentally and emotionally) to patients at a time when the health care system is being challenged by increased demands to treat more patients in a day is of great value for radiologic technologists as well. For example, if technologists are experiencing stress or burnout in the workplace, they must change how they manage these common stressors or they could continue the cycle of stress buildup and burnout.1

Medicine and meditation have a common root, mederi; the deep Indo-European root of mederi means “to measure.” Medicine restores a body’s disturbed inward measure, and meditation is “the direct perception of right inward measure and the deep experiential knowing of its nature.”2 Medical studies provide increasing evidence of the ability of stress-reducing approaches, such as meditation, to improve physical and psychological health in patients and health care providers.

Stress

While stress is a familiar term, the many psychophysiological aspects of stress are still not fully understood. Stress is brought on by a complex mixture of factors and forces. Long hours, anxious patients, and a demanding work environment are some of these factors. Stress can be described as short-term (acute) or long-term (chronic) and can include positive stress as well as negative stress. Spanning a range of possibilities, stress can be caused by something as common as a life change such as a promotion or job change or as dramatic as an injury or loss of a loved one. In addition, stress can be classified as mental, emotional, physical, financial, or environmental. Depending on the nature of the stressor, specific physiological functions including digestion, excretion, reproduction, and immunity can be affected. When stress is left untreated, conditions such as depression, anxiety, and insomnia might develop.3

Butler defined stress as a response to pressure or a response to aversive stimuli and lists Seyle’s description of a general adaptation syndrome in response to stress that includes a 3-stage process:4

1. The body is alerted and alarmed.
2. The autonomic system is triggered.
3. The body becomes exhausted.

More recent definitions of stress in clinical practice describe stress as a dynamic process characterized by internal and external factors. In this model of stress as a dynamic process, there is a great deal of diversity in what is perceived as stressful by different people, as well as in the capability to respond effectively to these perceived stressors; however, everyone is exposed to multiple sources of stress.4

In addition to the automatic physiological responses to stress, people can experience cognitive effects such as distractibility, deterioration in short-term and long-term memory, increased error rate, and reduced ability to plan and organize. Chronic stress might lead to hyper-vigilance, which results in exhaustion and sometimes periods of denial regarding the effects of the stress. At extreme levels of stress, thought patterns can become irrational, leading to difficulty staying grounded in reality.4 In addition to cognitive effects, emotional reactions to stress include frustration, anger, anxiety, fear, and irritability. In chronic stress, these emotions can progress to depression, hypochondria, and demoralization; moreover, people might become controlling, indifferent, or have sudden outbursts of emotion.4

The cognitive and emotional effects often eventually manifest in behavioral changes, such as diminished enthusiasm at work resulting in increased absenteeism. Stress also can cause changes in eating patterns and use of substances such as caffeine, nicotine, alcohol, and drugs. Speech problems, such as difficulty finding words and muddled articulation, also can occur, and sleep patterns might be disrupted.5

Some people under stress will fight, some will flee, and some will feel paralyzed and do nothing at all. Those who fight the stress might do so by adding more responsibilities, further contributing to overload. Those who flee stress through denial often will miss the opportunity to address the causes of stress. However, coping strategies often can exacerbate stress because people choose options for immediate relief rather than long-term solutions.4

The cumulative effect of minor stressors can have an erosive result. People might feel they are failures if they admit to being stressed because of the accumulation of many smaller issues instead of a major calamity. Furthermore, events in the past can contribute to a
present state of stress. All these factors require a comprehensive approach to assessing an individual’s stress, including past and present welcome and unwelcome major life changes as well as repetition of minor stressors. Responding to stress before it reaches a state of distress is vital because chronic stress that gets locked into the second stage of Seyle’s model (triggering the autonomic nervous system) can lower a person’s threshold for stress, making recovery slower, so that more than a day or 2 off might be needed to recover. Therefore, it is possible that responding to stress sooner rather than later can prevent physiologically damaging effects from taking hold and avoid a person’s decline into fatigue and demoralization, which requires a more involved recovery.

**Stress and Health Care Providers**

Health care professionals work within challenging environments, and there are high expectations for their performance. Being rushed only adds to the stress level. For decades, the issue of time pressure has been cited as one of the top causes of physician dissatisfaction. In addition, scheduling more than 3 or 4 patient visits per hour can cause a reduction in patient satisfaction as well as in the quality of the visit. While communication techniques can be honed to heighten efficiency of these brief appointments, the general overload and accumulation of being bound by the clock can be an additional causative factor in stress for health care providers, including radiologic technologists.

**Stress and Radiologic Technologists**

Many radiologic technologists must cope with packed schedules, long shifts, and malfunctions of equipment along with the behaviors of stressed coworkers or managers. In addition, they must assist patients, whose stress might affect their ability to follow testing instructions and who might not understand why the technologist cannot share what is seen on diagnostic images. These factors can contribute to frustration, misunderstanding, or even error.

New technology also can be a stressor for radiologic technologists. Having to learn to use new devices and software programs can create resistance simply because the familiar processes are being changed, and as employees they do not have control over these changes. This can be compounded by low levels of computer literacy, lack of sufficient communication and training, and overdependence on the technology. The stress from these changes might be expressed in indirect, rather than direct, ways. For example, apathy or ambivalence can surface when employees outwardly accept the changes in machinery or protocol but were not fully on board with the changes that were imposed on them and their work.

Stress in the radiology department is not limited to any one particular role. Staff technologists experience stress because of busy schedules, new technology, and patient care, while managers encounter additional challenges. DiPaola explained, “In a setting of layoffs, cutbacks, increasing regulation, competition, and patient satisfaction scores, the radiology manager will find it difficult to be free from anxiety.” Reduced flexibility in scheduling and tightened budgets require radiologic technologists to struggle to find time in their off-duty hours to complete continuing education, and managers strive to free their employees’ schedules to allow for training on new or upgraded equipment. Support from managers in scheduling training on new equipment is key to ensuring that staff is highly qualified on an ongoing basis. When technologists’ training is up to date, they can feel confident, less stressed, and provide the highest level of care to their patients.

These financial and managerial issues challenge managers in all fields, but the awareness that patients’ health is directly affected by their decisions and actions magnifies stress for a manager in health care. Indicators of job stress often are physical, such as headache, sleep disturbance, upset stomach, and fatigue; however, they also can emerge as frustration, short temper, anxiety, depression, irritability, apathy, and loss of confidence.

As early as 1992, a survey of 198 radiologic technologists conducted by Sechrist and Frazer found that the top stressors in radiologic technology are:

1. Disrespectful physicians.
2. Inadequate pay.
3. Performing unnecessary examinations.
4. Inadequate numbers of staff.
5. Lack of respect.
6. Abusive patients.
Additional stressors include uncooperative radiologists, overwork, malfunctioning equipment, and work scheduling.9

Stress often can begin for radiologic technologists even before they enter the job market. A 2006 study of students in 2-year community college radiography programs found that students were stressed the most by the following10:

■ Fear of making a mistake.
■ Feeling unprepared.
■ Feeling intimidated by staff or instructors.
■ Having difficult or critically ill patients.
■ Experiencing hurtful criticism.
■ Having too much supervision.
■ Receiving negative responses to requests for help.

Four techniques mentioned most often to ease the stress were more frequent feedback, availability of personnel, assurance that mistakes happen, and the opportunity to make mistakes and learn from them. Although the authors note that a follow-up study is needed to further assess these results, their findings suggest that some of the same clinical stressors, such as work overload and lack of respect that radiologic technologists and other health workers encounter, also were experienced by the radiography students in this sample.10

Even when the health care professional is healthy, on-the-job stressors such as an adverse event or medical error can catapult stress levels to a dangerous level. Seys et al pointed out that the organization should provide access to mental health resources and support. They also refer to a study by Engel et al advocating reducing stigmas related to medical errors and the associated shame or loss of respect.11 Engel et al also encouraged development of "error conferences" to discuss errors—even those that did not result in negative consequences—and the impact of the error on patients and other health care professionals.11 Holding an error conference can create a valuable opportunity for learning and might prevent and reduce stress.

In a time when many solutions for day-to-day stress seem to come in the form of innovative technological inventions, it is interesting to consider that an ancient and technology-free method such as meditation could support health care workers in the 21st century.

Stress and Patients

Imaging examinations are not a stress-free experience for patients. Obvious stressors are the symptoms that prompted the procedure in the first place and concern about the results, but other factors can come into play depending on the procedure and the patient’s individual situation. The unfamiliar nature of the testing procedure can cause a significant level of anxiety, and the noise of the machines used in testing can put a strain on the nervous system. Enders et al reported that between 1% and 15% of all patients scheduled for magnetic resonance (MR) imaging cannot be imaged because of claustrophobia, and some require sedation to complete the imaging. Approximately 2 million MR procedures worldwide cannot be performed or are prematurely terminated as a result of claustrophobia.12

Lang reported that claustrophobia, panic, or other factors that interfere with a patient’s ability to remain still prevent an estimated 2.3% of patients from completing MR scans, resulting in losses of hundreds of thousands of dollars.13 In addition, anxiety caused by fear of the results often creates more stress for patients than the procedure. Lang’s study measured the distress level of 214 women in a radiology waiting room and found that those patients awaiting breast biopsy had a much higher degree of anxiety and perceived stress than those awaiting a chemoembolization for liver cancer.13

Practices for anxiety relief, such as breathing and relaxation techniques, visualization, and mental exercises, have been shown to reduce stress for patients undergoing an MR scan.13 These practices echo the earlier but often unknown use of relaxation and hypnotic techniques used primarily with MR in the 1980s.13

Pediatric Patients

Children might express stress through crying, fear, and lack of cooperation. Radiologic examinations can be a difficult experience for children because of the unfamiliar sounds of the equipment, uncomfortable positions, and sometimes painful procedures.14 The use of devices for immobilization, such as the Pigg-O-Stat, can be distressing to parents, and procedures such as the voiding cystourethrogram can be distressing for children. In addition, the needle sticks used in lumbar punctures, cardiac catheterization, and contrast-enhanced MR or computed...
tomography (CT) scans can be painful for children. Current methods used in pediatric radiology departments to reduce stress include:

- Parental involvement.
- Preprocedural preparation.
- Distraction.
- Sedation.
- Involvement of a child-life specialist.
- Hypnosis.
- Consideration of the child’s sense of modesty.
- Positive reinforcement.

Although current methods don’t involve meditation, perhaps some form of meditation will be used for these patients in years to come.

**Reducing Patient Stress**

Radiologic technologists often are the only health care professionals to interact with patients undergoing medical imaging. Media coverage of radiation concerns and the wealth of information available online might cause patients to have fear and anxiety. The radiologic technologist should be equipped to answer patients’ questions and demonstrate current knowledge related to their concerns so they can calm patients and acquire accurate diagnostic images. Romano suggests that technologists maintain eye contact, show a caring attitude, and provide detailed explanations of procedures to increase patients’ trust in the medical care they are receiving. Studies indicate that when health care providers are able to exude a caring attitude to patients, patient satisfaction increases, which decreases patient stress.

One method of expressing care is listening carefully, answering questions, and providing clear information. Offering educational resources and support services also can help in reducing long-term stress for patients. In the midst of a packed schedule, it might be easy to forget that each interaction with a patient has potential for healing, and it is not only the diagnostic quality of the images that matters. According to Adams and Rush, caring radiologic technologists could inspire patients to take better care of themselves, which can lead to patients’ increased compliance with diagnostic and treatment regimens because of an improved sense of self-worth.

Patients or the parents of pediatric patients also might harbor unexpressed anxiety because of the potential for exposure to radiation during imaging scans. Technologists can reduce radiation dose by shielding sensitive areas, such as the thyroid and gonads. Reducing exposure time and beam intensity, collimating properly, and avoiding repeat imaging scans also can reduce patient dose. Taking time to explain to patients the benefits of shielding to reduce patient exposure to ionizing radiation can help diminish their anxiety.

Although sedation can be used to calm some patients undergoing imaging tests, there are additional issues and complications that can result from this approach. For example, in the MR suite, extra time, effort, and additional staff are required to check for compatibility between sedation equipment and monitoring devices and the magnetic field and radiofrequency emissions. In addition, sedation can cause some patients to experience complications such as vomiting, apnea, hypoxia, and the need for assisted ventilation. Furthermore, if sedation is inadequate, the procedure might be cancelled and the patient might need to make additional hospital visits.

Hypnosis has shown success as a nonpharmacological approach to stress reduction for pediatric patients in radiology as well as emergency medicine. A study by Butler et al of pediatric patients who previously had a distressing experience with a voiding cystourethrogram procedure and then were provided hypnosis for a subsequent voiding cystourethrogram procedure “showed significant improvements in stress compared to the previous procedure. Parents reported that undergoing the procedure with hypnosis was significantly less traumatic for the child.” Using hypnosis to reduce distress has been helpful for pediatric patients undergoing radiologic tests, and meditation has potential to provide similar benefits as well.

In 2013, Zeidan et al suggested that mindfulness meditation can reduce anxiety and is demonstrated by activation of the anterior cingulate cortex, ventromedial prefrontal cortex, and the anterior insula. This study used MR imaging to compare the brain region activity of participants who received four 20-minute sessions of mindfulness training to those who had not been trained but were paying attention to their breath. Those who received training in mindfulness (observing the breath,
noticing thought patterns, returning to the breath) experienced diminished states of anxiety, as measured by cerebral blood flow.14

Thus, the fear of the unknown weighs heavily on people and can manifest in measurable anxiety in patients waiting for a radiologic examination. One study found that when radiologists shifted their language to neutral terms, such as “I will give you the local anesthetic,” vs terms that suggest discomfort, such as “Just a sting and a burn,” they significantly reduced patient anxiety. Similarly, radiologic technologists could potentially reduce patient anxiety by explaining to patients which procedure will come next and how long the patient will need to hold a position during an imaging examination. Increasingly, medical institutions are providing alternative approaches to respond to the public’s interest in these methods. Within the radiologic technology profession, one study found that “many MRI patients combatted anxiety on their own using breathing and relaxation techniques, visualizing pleasant scenes, and performing mental exercises.”17

Burnout

The medical profession draws highly intelligent, motivated, and caring individuals who often find themselves experiencing increased stress on the job. High expectations, a high level of competition, the emotional nature of the work, and the relentless pace contribute to burnout in health care workers. Burnout is a psychological state of physical and emotional exhaustion and is a result of prolonged occupational stress.

According to a 2002 study by Akroyd et al, radiographers experience higher-than-average levels of emotional exhaustion as measured by the Maslach Burnout Inventory (MBI). The study compared the results to data on other health professionals and national norms. Nurses who worked with certain patient populations had higher levels of burnout, but burnout in radiographers was at a similar level with nurses in general.18,19 The MBI is a survey tool originally designed for use by professionals working in human services such as health care; it has been adapted for use by educators and workers in other occupations. The survey measures emotional exhaustion, depersonalization (treating people as objects), and personal accomplishment at work.20 Technologists’ ongoing interaction with patients presents emotional challenges for technologists who want to offer patients support while simultaneously maintaining professional boundaries.

Another contributor to burnout in health care professionals is irregular scheduling, which can create or exacerbate stress. Eldevik et al cited the negative physical and emotional effects that can result from shift work, irregular hours, and quick returns (short breaks) in their study of nurses having fewer than 11 hours between shifts. Effects such as anxiety, insomnia, and fatigue can result, as well as shift work disorder.21 Shift work disorder is characterized by:

- Excessive sleepiness.
- Insomnia.
- Difficulty concentrating.
- Fatigue.
- Irritability or depression.
- Difficulty with personal relationships.

In Europe and the United States, shift work has been associated with increased incidences of cancer, gastrointestinal disorders, rheumatoid arthritis, and other health issues.21

Radiologist and former Stanford Medical School professor Peter Moskowitz, MD, is an advocate for health care professionals. After coping with the results of his own work-related stress and how it affected his family, he founded the Center for Professional and Personal Renewal. Moskowitz noticed how prolonged and untreated chronic irritability or personal conflicts at work can manifest physically as hypertension and gastrointestinal disorders, as well as symptoms of coronary distress.23 According to John-Henry Pfifferling, the founder of the Center for Professional Well-Being, although stress has always been a part of working in medicine, a disconnect between expectations and reality is growing, with a resulting shift in what is considered to be an acceptable level of stress, leading to “emotional exhaustion.” Ahnna Lake, MD, a senior associate at Pfifferling’s center, describes a “depletion syndrome” in which, starting in college, health care professionals push themselves, often staying up all night more than once a week, and this intensifies at the professional level where they often can feel like they are weak if they acknowledge the limits of their body.23 Larry Vickman,
MD, noted that interventions for burnout by colleagues or family are rare, and usually care is sought only when the issues have become so extreme that they jeopardize patient care. Prior to the point of crisis, physicians and other health care professionals might use coping mechanisms such as overeating, substance abuse, gambling, and extramarital affairs, while further along the continuum they might exhibit depression, reduced attention span, and an inability to concentrate and work effectively.23

Burnout also affects radiologic technologists. In 2002, Akroyd et al surveyed more than 2000 full-time staff radiographers and found that “radiographers had significantly higher levels of emotional exhaustion when compared with the MBI norms.”19 Emotional exhaustion can have “detrimental effects on patients and employee morale”; however, this study found that radiographers were still able to “view their patients with a positive and caring attitude.”19 The authors also compared radiographers to radiation therapists and found that radiation therapists experienced higher levels of emotional exhaustion and depersonalization. They noted this difference might be caused by the type of care that radiation therapists provide and the types of patients they treat.21 Chronic high levels of stress without intervention can lead to depression, frustration, and job dissatisfaction.24

Coping with Burnout

Health care professionals clearly need stress prevention as well as treatment for stress and burnout. To cope with stress and burnout in positive ways, radiologic technologists can:23:

- Rest, relax, and reconnect with family.
- Reassess purpose and values.
- Exercise, have fun, and eat a healthy diet.
- Get sufficient sleep.
- Praise coworkers for a job well done.
- Cultivate friendships outside of the medical field.

Managers can help by reassuring staff of their worth, such as honoring radiographers as valuable members of a work team through formal awards and ceremonies or informal ways through praise. Managers also can provide guidance as sources of knowledge, advice, expertise, and social support to mitigate burnout. Keeping watch over employees’ workload can help reduce burnout because, for radiographers, an increased workload is related to an increase in burnout.19 Oore et al found that workshops to enhance civility were shown to improve colleague relations, help patients, and improve patient care and safety.24

It also has been shown that short-term intervention programs for health care professionals can have long-term benefits. One 8-week intervention program that offered training in mindfulness (body scans, sitting meditation, walking meditation, and mindful movement) for primary care physicians resulted in short-term and long-term improvements in the physicians’ well-being and their attitudes associated with patient-centered care.22 Body scans are simply the act of “noticing bodily sensations and the cognitive and emotional reactions to the sensations without attempting to change the sensations.”25 In their study of internists, Krasner et al found that physicians “being present” with their patients “correlated more strongly with finding meaning in their work than diagnostic and therapeutic triumphs.”23 Being present meant understanding that their patients were unique individuals and fellow humans and that the physicians had “an awareness of the patients’ (and their own) emotions,” which are often experienced during difficult clinical situations.25

The mindfulness practice of scanning the body has clear parallels to the technological scans that radiology professionals use on a regular basis. It is possible that visualizing the internal anatomy while performing a mindfulness body scan can assist health care professionals with becoming more aware of sensations such as physical tension, aches, and strains that accumulate from work-related (or personal) stress. Krasner et al stated that “[s]elf-awareness can assist practitioners in becoming more attentive to the presence of stress, to their relationship with the sources of stress, and to their own personal capacity to attenuate the effects of stress.”25

As health care providers and health care organizations seek ways to address employee burnout, meditation might be an avenue to explore. While radiology has long been associated with diagnosis of pathology, newer and more subtle capabilities of technology allow the detection of healing potential in the brain via imaging. In fact, Sato et al reported that people who meditate can be identified by brain scans alone 94% of the time.26
Anatomy and Physiology of the Brain

To understand the findings of recent studies that examine meditation’s effects on the brain, it is necessary to understand the complex terrain of this organ, specifically the limbic system, which includes the amygdala, the diencephalon, the hypothalamus, and the hippocampus (see Figure 1).

The term limbic system derives from the word *limbus* meaning “ring” because its cerebral structures encircle the upper part of the brain stem. It is located on the medial aspect of each cerebral hemisphere and diencephalon and includes part of the rhinencephalon (septal nuclei, cingulate gyrus, parahippocampal gyrus, dentate gyrus, and C-shaped hippocampus), as well as part of the amygdala. The main limbic structures in the diencephalon are the hypothalamus and the anterior nucleus of the thalamus. Two parts of the limbic system that have a primary connection to our emotions are the amygdala and the anterior cingulate gyrus. The amygdala, an almond-shaped set of neurons deep in the medial temporal lobe, is part of the limbic system and is associated with the emotions; conditions such as anxiety, depression, and post-traumatic stress disorder have been linked to abnormal functioning of the amygdala. When an individual encounters a stressor such as physical danger, information travels via the eyes and ears to the amygdala for emotional processing of the sights and sounds. If a threat is perceived, the amygdala sends a distress signal to the hypothalamus.

At the core of the forebrain and between the cerebral hemispheres lies the diencephalon, which consists primarily of 3 paired structures: the thalamus, hypothalamus, and epithalamus. These are areas of gray matter that enclose the third ventricle of the brain. The hypothalamus lies beneath the thalamus and atop the brain stem, extending from the optic chiasma to the posterior margin of the mammillary bodies. The hypothalamus is imperative to the overall homeostasis of the body and influences nearly all tissues in the body. Its key functions of homeostasis include: autonomic control center, center for emotional response, body temperature regulation, regulation of hunger and satiety, regulation of water balance and thirst, regulation of sleep-wake cycles, and control of endocrine system functioning. The hypothalamus communicates with the autonomic nervous system and, during stress, activates the sympathetic nervous system. In turn, the sympathetic nervous system activates the adrenal glands, releasing epinephrine (commonly known as adrenaline) into the bloodstream, triggering physiological changes such as increased pulse rate, increased blood pressure, highly activated sensory perception, and release of glucose. Marieb explained that the hypothalamus is the “neural clearinghouse for both the autonomic (visceral) function and emotional response”; therefore, when people are exposed to acute or chronic emotional stress, they can develop “visceral illnesses, such as high blood pressure and heartburn.”

The hippocampus is a horseshoe-shaped paired structure in the limbic system associated with memory, emotion, and spatial orientation. Stress has significant effects on the hippocampus through adrenal steroids and excitatory amino acids. Stress also causes hippocampal neurons to retract.
**Default Mode Network**

The term *default mode* was first used in 2001 by Martin Raichle, MD, to describe resting brain function. Essentially, waves of electricity associated with an MR signal can be seen on a functional magnetic resonance imaging (fMRI) scan when the patient is in resting mode. When these waves are synchronized, functional connectivity can be determined; this means that parts of the brain that are far apart can be in synchrony as a result of receiving signals from a specific region of the brain. “The default mode network (DMN) involves low frequency oscillations of about one fluctuation per second. The network is most active when the brain is at rest, but when the brain is directed toward a task or goal the default network deactivates” (see Figure 2).\(^3\)

The DMN might actually include many smaller networks. In the past 10 years, increasing attention has been focused on understanding networks in the brain, such as the DMN, that are related to specific activities. The DMN comprises the medial temporal lobe, the medial prefrontal cortex, and the posterior cingulate cortex, as well as the ventral prefrontal and parts of the parietal cortex. Although the complexity of the DMN makes it difficult to study, abnormalities in the network, such as increased or reduced activity, have been linked to many diseases, including Alzheimer disease, schizophrenia, autism, bipolar disorder, and depression.\(^3\)

The DMN also has shown aberrations in the resting state of patients with post-traumatic stress disorder, suggesting that it can indicate particular forms of stress.\(^3\)

**Meditation Research**

**Radiology’s Role**

Radiology’s initial purpose was to aid in the diagnosis of pathology. Today, medical imaging continues to assist in diagnosis in increasingly sophisticated ways, and it also is being used to document brain changes that occur from meditation practice. The diversity of meditation techniques and traditions can support as well as impede neuroscience research on meditation. For example, the fact that so many different techniques have produced measurable changes in neurological images supports the correlation between meditation and physiological response, yet the diversity of meditation techniques also can make interpretation of results difficult. Even so, many medical researchers have documented a correlation between meditation and the functioning of specific regions of the brain using medical imaging.

Functional MR imaging measures brain activity by detecting changes in blood flow and oxygenation that occur during neural activity. When used to assess brain activity in experienced and novice meditators who practiced 3 different meditation techniques, fMRI showed that regardless of the type of meditation, decreased activity was seen in the brain’s DMN associated with attention lapses and disorders like anxiety, attention deficit hyperactivity disorder, and buildup of beta amyloid plaques linked with Alzheimer disease.\(^4\)
Proton magnetic resonance spectroscopy can detect and measure metabolite concentrations in the brain, and diffusion tensor imaging can be used for functional anatomy mapping of the brain.\textsuperscript{35,36} Using these modalities, Fayed et al found that meditation results in higher myoinositol, a sugar alcohol compound that might act as an osmoregulator, intracellular messenger, and detoxification agent in the posterior cingulated gyrus, as well as decreased glutamate, N-acetylaspartate, and N-acetylaspartate/creatinine in the left thalamus. N-acetylaspartate, one of the most abundant amino acids in the central nervous system, is found most commonly in neurons, axons, and dendrites. Glutamate is one of the most commonly evaluated metabolites in magnetic resonance spectroscopy, and creatine, the most stable cerebral metabolite, is used as an internal reference value.\textsuperscript{37}

The Fayed study compared results from MR imaging, proton magnetic resonance spectroscopy, diffusion-weighted imaging, and diffusion tensor imaging from 2 groups: hospital staff who had no meditation experience and Zen Buddhist monks. The authors concluded that MR spectroscopy and diffusion tensor imaging are “excellent tools for examining training-related plasticity and the neural mechanisms underlying meditation” and that long-term meditation modifies the white fiber microstructure and resting state regional neural activity.\textsuperscript{37}

The concept of neuroplasticity suggests that brain functions are malleable and can improve over time. Medical imaging is at the forefront of documenting these capabilities using scientific methods, and advances in CT and positron emission tomography (PET) “make it possible to physically observe how the brain works and how the neural pathways in the brain change.”\textsuperscript{38} Increasingly, neurological imaging, such as single-photon emission CT, PET, and fMRI, is being used to pinpoint the regions of the brain that are activated and deactivated through meditation.\textsuperscript{39} According to Fayed et al, these areas include the anterior cingulate cortex, posterior cingulate cortex, medial prefrontal cortex, insula, temporoparietal junction, hippocampus, and amygdala.\textsuperscript{37}

A recent meta-analysis of 123 brain morphology differences from 21 neuroimaging studies examining approximately 300 meditators, found 8 brain regions to be consistently altered as a result of meditation: areas of meta-awareness (frontopolar cortex), areas of exteroceptive and interoceptive body awareness (sensory cortices and insula), areas of memory consolidation and reconsolidation (hippocampus), areas of self and emotion regulation (anterior and midcingulate, orbitofrontal cortex), and areas of intra- and interhemispheric communication (superior longitudinal fasciculus, corpus callosum).\textsuperscript{40}

Furthermore, Cohen et al performed pre- and post-program baseline single-photon emission CT scans of the right and left dorsal medial frontal lobes, right prefrontal cortex, right sensorimotor cortex, and right frontal lobe in 4 subjects who underwent a 12-week Iyengar-style yoga program with meditation.\textsuperscript{41} Iyengar-style yoga is a form of hatha yoga that focuses on the alignment of the body as well as regulation of the breath. The authors found that all areas were activated more significantly after the meditation training than they were before the training (see Figure 3). The connection of amygdala and sensorimotor cortex to emotions and perception of sensory data and the baseline changes are consistent with other clinical studies that have shown meditation improving emotional responses and depression, as well as affecting perception of sensory stimuli. Although this was a limited study of 4 individuals with stage 1 hypertension, the results of increased cerebral blood flow can perhaps be expanded upon in a future study.\textsuperscript{42} Cohen et al noted that the diversity and complexity of meditation techniques can lead to possible confusion when comparing results of studies related to meditation; however, Schoormans and Nyklicek suggest that the frequency rather than the type of meditation may be what matters most.\textsuperscript{42}

One form of meditation studied by Kalyani et al is the practice of chanting. Functional MR scans have shown that chanting Om was shown to deactivate limbic regions—an effect similar to vagal nerve stimulation. Vagal nerve stimulation has been used to treat depression and epilepsy, suggesting a positive effect from chanting on behavior and mood. For example, PET imaging has shown decreased blood flow to limbic brain regions during direct vagal nerve stimulation as a result of meditation. In the study by Kalyani et al, subjects performed 10 cycles of resting for 15 seconds,
followed by chanting *Om* for 15 seconds, followed by resting for 15 seconds. Blood oxygenation level-dependent scans showed significant deactivation in the orbitofrontal, anterior cingulate cortex, parahippocampal gyri thalami, hippocampi, and right amygdala in comparison to the resting brain state.42

Newberg et al also conducted an 8-week study of the effects of chanting *Sa Ta Na Ma*, a *Kirtan Kriya* meditation (chanting), for 12 minutes daily. They found that this form of meditation has the potential to improve memory, which could have significant benefits for patients with Alzheimer disease and also could hold value in stress relief because reduction in short-term and long-term memory can result from chronic stress. This meditation technique resulted in improved cerebral blood flow in the prefrontal, superior frontal, and superior parietal cortices, as demonstrated by a single-photon emission CT scan, as well as improved verbal fluency and memory, as measured by neuropsychological tests.43

Meditation also can be practiced silently. Though often the term *mantra* is associated with specific cultural and spiritual phrases, it can refer to any word or phrase that is repeated. In this study, the neutral phrase “table and chairs” was used during silent repetition to prevent an emotional response from the words. Subjects meditated and silently repeated the given phrase as indicated while in the MR scanner. In this study of subjects with less than 2 years of meditation experience, Engstrom et al used fMRI and demonstrated that activation of the hippocampi, regions of the brain related to memory, occurs during silent mantra meditation practice (see Figure 4). This finding also has been shown in previous studies with experienced meditators. Engstrom et al noted that the role of hippocampal activity needs to be further clarified in future studies.44

The technological advances of medical imaging and the emerging patterns documented by researchers about the efficacy of meditative practices are aiding scientific understanding of the healing properties of meditation.

**Medical Research**

There is a growing body of medical research aimed at understanding the specific effects of meditation in areas such as cognition, pain control, management of disease symptoms, emotion, and behavior. A review of research on mindfulness by Jeffrey Greeson in 2009 indicated that mindfulness is associated with more positive states of mind and can benefit the brain, the autonomic nervous system, stress hormones, and the immune system, as well as improve behaviors related to health, including eating, sleeping, and substance abuse.45

Chung et al studied the effect of *Sahaja* yoga meditation on aspects of participants’ quality of life,
anxiety, and blood pressure. Participants were divided into 2 groups: 67 in the meditation group and 62 in the control group. The participants in the control group had not practiced meditation for at least 3 months prior to the study. The meditation group followed a daily schedule of individual and collective meditation throughout each day and showed significant improvements in all areas after one week of the regimen. Moreover, the control group had greater anxiety, a decline in quality of life, and no improvement in blood pressure after 2 weeks. The authors concluded that even a short-term treatment of 1 to 2 weeks can yield measurable improvement (see Figure 5).

Similarly, Geary et al reported that an 8-week MBSR course decreased stress in academic health care employees, citing psychoneuroimmunological benefits sustained for at least one year as charted by biomarkers such as pulse rate variability and a series of questionnaires assessing self-report measures of stress. MBSR teaches participants to pay attention through meditation practices such as yoga, walking and sitting meditation, and mindfulness in everyday activities; the essence of these activities is living in the moment and being open to change, which equips people to cope with the unexpected changes in their personal and professional lives.

The results of the 2012 National Health Interview Survey (the most current, comprehensive, and reliable source of information on the use of complementary health approaches by U.S. adults and children) suggest that:

- Approximately 21 million adults (nearly double the number from 2002) and 1.7 million children practiced yoga.
- Nearly 20 million adults and 1.9 million children had chiropractic or osteopathic manipulation.
- Nearly 18 million adults and 927,000 children practiced meditation.
- The increase in yoga has occurred across all age, racial, and ethnic groups.

The high rates of use might be partly due to a growing body of research showing that some mind and body practices can help manage pain and reduce stress. Another study of the effects of meditation using chanting focused on caregivers of family members.
with dementia. Chanting Sa Ta Na Ma for 12 minutes a day for 8 weeks lowered stress and improved cognitive function, as measured by the Hamilton Depression Rating Scale and the Mental Health Composite Summary score. The authors also measured telomeres, the “caps” at the end of DNA strands that protect chromosomes. Telomeres affect how human cells age and have been identified as psychobiological markers for psychological stress. Telomerase is an enzyme that prevents the shortening of telomeres. Shortened telomeres are associated with health risks and premature mortality. In this study, telomerase activity increased. This was the first study to show an effect on telomerase dynamics levels in distressed caregivers who practiced Kirtan Kriya meditation. 49

**Mindfulness Meditation for Stress Relief**

While some consider mindfulness training to be separate from meditation, the term and practice called mindfulness meditation merges the 2 approaches, suggesting that they are, at times, intrinsically related. Beach explained that mindfulness is “attentiveness, curiosity, presence, and the ability to adopt multiple perspectives simultaneously—all qualities that promote greater awareness of self and others.” Mindfulness training teaches skills to lower an individual’s reactivity and improve responses to stressful situations. Moreover, mindfulness might free clinicians’ attention so that they are better able to attend to others’ experience, less likely to distance themselves from distressing situations, and more likely to consider a variety of explanations in complex situations. 2

According to Newberg et al, “[m]editation, in general, is a complex neurocognitive task that is often associated with alterations in the brain physiology and neuropsychological measures.” Contributing to the complexity are the many forms, definitions, and techniques of meditation. Some of these techniques are the ancient Buddhist tradition of Vipassana (mental training),
chanting Om, repeating mantras silently, focusing on the breath, and even mindfulness-based stress reduction courses. Some forms of meditation include movement, usually walking.

The diversity of meditation techniques often makes it possible to match a meditation technique with an individual’s cultural and religious preferences and physical abilities. For example, the University of California, San Francisco offers a 4-step meditation technique to breast cancer patients (see Box 1). Mindfulness meditation helps the individual focus on being in the moment instead of dwelling on the past or thinking about the future. It slows down the body and the mind and temporarily removes the temptation to react to our surroundings.

The Mayo Clinic offers guidance on a range of meditation techniques including mindfulness meditation, guided meditation, yoga, Qi Gong, and Tai Chi, stating that the most common elements of meditation practices are focused attention, relaxed breathing, a quiet setting, and a comfortable position. Suggested approaches include breathing deeply, scanning the body for sensations of temperature and touch, repeating a prayer or mantra, walking, reflecting upon poems or sacred texts, and focusing on love and gratitude. The benefits range from reduced stress to increased self-awareness and improved management of symptoms of asthma, heart disease, and cancer. However, the National Center for Complementary and Alternative Medicine has stated that there have been “rare reports” that meditation might worsen symptoms in people who have certain psychiatric problems, but that these claims have not been fully researched. Hickey stated that although “meditation may not be sufficient or appropriate for some people (eg, those suffering from severe post-traumatic stress, major depression, or psychosis), mindfulness, in conjunction with medication, does seem to be helpful to those who have difficulty regulating their emotions.” Nevertheless, those who wish to start a meditation program should consult with a health care provider about their condition before beginning.

Because a medical imaging test can create anxiety in patients for days leading up to the examination, the Cancer Support Community of Philadelphia has found that cancer patients benefit from classes that teach deep breathing to cope with uncertain futures. They also teach patients that learning to control their thoughts and accept their emotions can reduce the stress associated with radiological tests and related diagnoses and prognoses. In addition, a controlled study of 90 patients who meditated for 7 weeks yielded a 65% reduction of mood disturbance episodes and 31% reduction in stress symptoms.

Patricia Ann Sealy, RN, suggested that autoethnography, a written narrative that focuses on the universal emotions of loss, grief, shame, fear, and anxiety, can be combined with meditation to provide deep healing when a health care professional encounters illness or trauma. Healing from these personal sources of stress can allow health care professionals to support their patients instead of being triggered into reactivity when a patient issue, or stress in general, brings an unresolved emotional experience to the surface. Meditation can promote emotional healing if people can find ways to integrate understanding and self-compassion with past wounds. Meditation, therefore, moves healing beyond what the brain can think itself through, offering a pathway for stress relief that does not depend solely upon intellect and logical thinking but instead offers a holistic integration of the body’s most subtle resources.

However, in addition to being used as treatment, meditation also can be used as a preventive approach to stress. Mohan et al studied a group of young men who had never meditated. They were provided 20 minutes of instruction and 20 minutes of practice prior to interacting with a stressor. Measurements of their stress included:

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**Box 1**

**The Process of Meditation**

1. Posture — Find a comfortable posture, sitting or lying down.
2. Begin to meditate — Observe the details of your body, such as the soles of your feet touching the floor and your spine against the back of the chair.
3. Focus on breathing — Notice your breath as it moves through your nostrils, as it rises and falls in your body.
4. Work with the mind — Watch the movement of your mind.

If your thoughts have moved away from the breath, notice that, and again return the focus to the breath.
Galvanic skin response – evidence of a person’s emotional state as measured by changes in perspiration and electrical resistance of the skin.
Heart rate – the release of adrenaline causes the heart rate to increase.
Electromyography – records muscle activity, which is elevated during stress.
Sympathetic reactivity – the responses of glands, smooth muscle, and cardiac tissue during stress.
Cortisol levels – the release of cortisol during stress increases glucose levels in the blood.
Acute psychologic stress scores – assesses mental and emotional stress.
Wechsler memory scale – a neuropsychological test to measure memory function, which can be affected by stress.
Visual-choice reaction time – measures the time required for an individual to make a choice based on visual input.

The authors found that meditation prior to a stressor more effectively reduced the stress levels of subjects than did meditation after the stressor. Although it seems that benefits might not be available in a short-term meditation program for those who have never meditated, Manzaneque et al found incidences of hormonal regulation and decreases in depression and anxiety from a 2-month study in individuals who had never meditated.

Some might resist implementing a meditation program because of the need for preparation and resources of time and money. However, Prasad et al, who designed a “dose-ranging feasibility study,” concluded that one dose (one introduction session) plus 4 weeks of 30-minute-per-day practice of meditation was sufficient to reduce anxiety and perceived stress and to improve perceived quality of life. Therefore, considering the low cost, the small amount of time required, and the documented potential for positive behavioral, mental, and emotional benefits, encouraging meditation practices might relieve patients’ stress and reduce staff burnout and employee turnover.

As health care professionals work to keep up with ever-increasing demands on their time and attention, meditation might provide an inexpensive treatment with a beneficial return in increased concentration and cognitive abilities. Zeidan et al conducted a study in which participants completed four 20-minute sessions of meditation training. Using the State Anxiety Inventory, they found that anxiety was reduced: “20 min of meditation reduced anxiety by as much as 22% in healthy subjects.” Zeidan et al postulated that “if the benefits of mindfulness meditation can be realized after a brief training format, then patients might feel more inclined to continue to practice and clinicians may not feel as reluctant to recommend mindfulness meditation to their patients.”

In addition to short-term benefits to cognition, the accumulation of meditation practice has the potential to increase brain activation in areas connected with response inhibition and attention while decreasing activity in regions associated with discursive thoughts and emotions, which suggests that meditation might increase a person’s ability to resist inappropriate actions and focus better. In a study by Brefczynski-Lewis et al, brain activity in experienced meditators was compared to that of novice meditators. The brains of experienced meditators showed greater activation in the areas related to response inhibition and attention, such as the frontoparietal regions, the cerebellar, temporal, and parahippocampal regions, and the posterior occipital cortex. Furthermore, the authors suggest that meditation might strengthen a person’s self-control, especially “cognitive and emotional mental processes such as rumination that can lead to or exacerbate stress, anxiety, or depression.”

Hasenkamp and Barsalou examined how meditation assists with problems such as mind wandering, awareness of mind wandering, shifting attention, and sustained attention. The ability to sustain attention and reduce mind wandering can benefit radiologic technologists and all health care professionals. In this study, fMRI was used to measure the neural activity in those participating in focused attention meditation. Specifically, researchers considered how meditation affects functional connectivity in the default mode network and other attention networks associated with mind wandering. Those with experience in meditation showed increased connectivity within attentional networks, as well as between attentional and medial frontal regions. The researchers pointed out that the study was
small and the results could have multiple causes, but they noted growing evidence for neuroplasticity, with benefits in connectivity associated with meditation that could yield cognitive, behavioral, and emotional gains.63

Of particular relevance to the field of radiology is a study of perceptual motor awareness by Naranjo and Schmidt who found that an 8-week mindfulness-based stress reduction program resulted in slower motions, as well as increased accuracy in motions. This hand movement study extends the studies of meditation beyond its cognitive and emotional benefits to examine visuomotor and sensorimotor performances.64 Radiologic technologists rely on the stability and accuracy of their hands in positioning patients and using equipment to procure accurate images; thus, meditation might help improve accuracy of motion while performing radiologic examinations.

Meditation can have other physical benefits for patients besides stress relief, including pain relief, immune system support, increased concentration, and perceptual motor awareness (see Box 2). Because pain relief is one of the leading reasons Americans turn to complementary health approaches such as yoga, massage, and meditation, the National Center for Complementary and Integrative Health has made it a priority to study these complementary approaches to managing pain and symptoms not consistently addressed well by drugs and other conventional treatments.44

Neuroscience Offers Hope

Scientific studies repeatedly show reduced activation in brain regions of interest as a result of meditation, suggesting that meditation has healing effects regardless of a person’s cultural, religious, or spiritual background. Given the complexity of biomarkers as well as the complex nature of stress itself, Halsband et al suggested that stress hormones and neurotransmitters could be used in conjunction with imaging tests to document and illustrate the effects of meditation on the brain. In addition, they suggest that a blend of PET and fMRI, along with electroencephalography/magnetoencephalography, might be useful in measuring regional activation effects in the brain.75

Additional research is needed to further corroborate initial findings on meditation research, to understand more fully how meditation affects the brain, and to point out gaps or inconsistencies in previous studies. Hickey notes a need for increased funding for research and expansion of definitions in the realm of imaging scans so that reference to a typical brain scan accounts for variables of race, gender, age, and left-handedness, which can produce differing results. Other factors to consider include the time of day scans are performed, recently ingested substances such as caffeine and nicotine, the variation in colored images of scans, and small sample sizes due to the expense of imaging technology.75

Although meditation might seem too intangible to have merit in the medical profession, research suggests otherwise. Furthermore, in 2014, the National Institutes of Health renamed the National Center for Complementary and Alternative Medicine to the National Center for Complementary and Integrative Health. The integrative approach to health has continued to grow in the United States in facilities such as hospitals, hospices, and military health settings, and the center’s research priorities include meditation and other therapies such as spinal manipulation and massage to manage pain and other symptoms not always sufficiently addressed by conventional treatments.76 The Center lists meditation as one of its research priorities, which indicates that medical research has substantiated the value of this modality as worthy of federal dollars, and the Center’s name change suggests that approaches such as meditation will be increasingly integrated into the health care system.

Conclusion

The cartography of the brain is a work in progress. While the brain’s structures have been mapped for decades, much is unknown about neural circuitry, communication between regions of the brain, and communication between the environment and the brain. The radiologic sciences are at the forefront of using neuroimaging to reveal evidence of a cause-and-effect relationship between meditation and brain health. With much of the research on meditation focused on its effect on patients, the effect of meditation on health care professionals is poised for further exploration. It would be interesting to examine, for example, MR scans of health care professionals who meditate regularly, as well as their perceived stress levels.
### Box 2

**Additional Benefits of Meditation**

<table>
<thead>
<tr>
<th>Condition</th>
<th>Research</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cardiac problems</td>
<td>A 2009 study examined the potential for a meditation-based stress management intervention to reduce depression, hostility, anxiety, and perceived stress, all of which can be precursors or risk factors for adverse cardiac events. The intervention program introduced participants to guided seated meditation, guided body scan meditation, and mindful Hatha yoga. In addition, participants were encouraged to remain aware of informal practices (e.g., remaining aware of cooking while cooking, walking while walking, showering while showering) and meditate daily for 20 minutes. Hostility and anxiety were not statistically affected during the 4-week study, but depression and perceived stress were reduced significantly. Thus, meditation-based stress reduction might have a positive impact on psychological health that could reduce the progression of coronary heart disease.</td>
</tr>
<tr>
<td>Chronic illness</td>
<td>In a study by Pritchard et al, 12 patients with multiple sclerosis and 10 cancer participated in 90-minute Yoga Nidra (meditation and deep relaxation) classes for 6 weeks. Participants’ stress levels were measured by the Perceived Stress Scale, an instrument that has been successfully used to assess stress in patients with multiple sclerosis and cancer, through noninvasive, low-cost means. The authors found a reduction in participants’ stress levels after the program and concluded that the Yoga Nidra exploration of sensations, emotions, and thought patterns can be especially helpful to those experiencing chronic pain and trauma.</td>
</tr>
<tr>
<td>Chronic pain</td>
<td>In one study, a heat device was used to induce pain response in 15 volunteers. With just 80 minutes of meditation (4 sessions of 20 minutes each), the volunteers experienced pain reductions of 11% to 93%. Meditation increased activity in the anterior cingulate cortex, anterior insula, and orbitofrontal cortex. These areas influence how the brain creates an experience of pain from nerve signals coming into the body. Pain sensation was reduced as meditation stimulated these areas, suggesting that meditation can relieve stress associated with pain.</td>
</tr>
<tr>
<td>Epilepsy</td>
<td>In 2006 Rajesh et al conducted a study on the topic of drug-resistant chronic epilepsy. Treatment of these complex cases with a yoga meditation protocol yielded promising results. For the 12-week program, patients began in a seated position (sukhasana) and practiced a specific form of breathing (pranayama) called nadishodana, in which “subjects had to inhale and exhale through alternate nostrils, maintaining a ratio of 1:1 without holding the breath.” They practiced this breathing for 5 to 7 minutes and followed the breathing with silent meditation concentrating over the region between the eyebrows. Patients continued these sessions once a week for 3 months and also were expected to perform daily meditation for 20 minutes each morning and evening. After 3 months, reduction in seizure frequency was noted in all but one patient, and 6 patients had 50% or greater seizure reduction. Of 16 patients who continued the practice for more than 3 months, 6 of them were seizure-free for 3 months. Three of the patients continuing the practice for more than 6 months were seizure-free for 6 months. The ability of this yoga meditation protocol to improve seizure control, if confirmed through randomized trials involving large numbers of patients, could make this intervention a valuable, low-cost treatment with no adverse effects for patients with difficult-to-control epilepsy.</td>
</tr>
<tr>
<td>Immune system</td>
<td>A 2012 study by Fernandes et al suggested that pranic meditation can bolster the immune system specifically by improving function and metabolism of phagocytes. Pranic meditation uses breathing and visualization techniques to quiet the mind. Twenty-nine individuals who had never meditated before participated in a 10-week program of 3-hour weekly sessions (along with 20-minute daily individual sessions) of meditation theory and practice. Venous blood and saliva samples were collected. The venous blood was used to measure phagocytes and saliva was tested for melatonin levels. Although in this study cortisol and melatonin levels were not altered by meditation, the authors found improvement in phagocytic health as well as a reduction in plasma levels of corticotropin—a hormone secreted by the pituitary gland that stimulates the adrenal gland, and a key component in the circuitry of stress.</td>
</tr>
</tbody>
</table>
and their patient-centeredness as reported in patient questionnaires in comparison to the MR scans of health care professionals who do not practice meditation. It also could be useful to compare MR scans of health care professionals who meditate vs those who use other forms of stress reduction.

Radiologic technologists might consider spending 10 to 20 minutes a day meditating given the depth and breadth of the benefits to well-being that medical science suggests it can bring. Furthermore, it could be valuable for health care providers to offer short training programs on meditation to patients and employees. As the speed of life increases exponentially, perhaps slowing to meditate, even briefly, can create a helpful counterbalance to the frenetic pace that increasingly characterizes modern society.

**Box 2 Continued**

### Additional Benefits of Meditation

<table>
<thead>
<tr>
<th>Disorder</th>
<th>Description and Details</th>
</tr>
</thead>
<tbody>
<tr>
<td>Menstrual disorders</td>
<td>A 2012 study focused on reducing physical and emotional symptoms associated with menstrual disorders using Yoga Nidra. Over a period of 6 months (35-minute sessions, 5 days a week), patients with mild to moderate anxiety and depressive symptoms improved significantly, although those with severe symptoms did not show similar benefit.</td>
</tr>
<tr>
<td>Mild cognitive decline</td>
<td>High stress levels can lead to increased risk for developing mild cognitive decline and Alzheimer disease. In a small 2013 study of adults with mild cognitive decline, participants underwent Mindfulness Based Stress Reduction (MBSR) therapy for 8 weeks (a weekly 2-hour meeting, 30 minutes a day practice, and 1 mindfulness retreat day). Mild cognitive decline is often a precursor to Alzheimer disease, and this study indicated that meditation might affect the regions of the brain that are most likely to develop dementia. Researchers used fMRI to measure connectivity changes in the default mode network and to measure volume changes in the hippocampi. After MBSR therapy, participants showed an increase in functional connectivity in the posterior cingulate cortex, the bilateral medial prefrontal cortex, and the left hippocampus. Although this was a small study and the changes seen were minor, the finding of less volume atrophy in those who practiced MBSR is of interest. Even a slowing of the decline in mental faculties can improve quality of life for patients with Alzheimer disease. In addition, atrophy of the hippocampus can adversely affect stress hormone levels, which can then contribute to the development of illnesses. Moreover, because more than half of people with mild cognitive decline develop dementia within 5 years, the preventative cognitive benefits of meditation are of value to those healthy individuals exposed to high levels of stress.</td>
</tr>
<tr>
<td>Obsessive compulsive disorder</td>
<td>In a 2012 study, 12 patients with the disorder underwent mindfulness-based cognitive therapy for 8 weeks in a group setting. Researchers found that two-thirds of the group experienced perceived decline of obsessive compulsive symptoms; furthermore, they were able to live more actively in the present moment, had a calmer attitude, as well as improved mood and sleep. Although the sample was small, these preliminary findings are encouraging for many who have obsessive compulsive disorder.</td>
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References


1. Stress can be classified as:
   1. mental.
   2. physical.
   3. emotional.
   a. 1 and 2
   b. 1 and 3
   c. 2 and 3
   d. 1, 2, and 3

2. Physiological functions that can be affected by stress include:
   1. reproduction.
   2. excretion.
   3. immunity.
   a. 1 and 2
   b. 1 and 3
   c. 2 and 3
   d. 1, 2, and 3

3. In the 3-stage process that Seyle describes, the third stage is:
   a. short-term memory loss.
   b. physical exhaustion.
   c. hypervigilance.
   d. an alert and alarmed body.

4. People can experience cognitive effects of stress, such as:
   1. distractibility.
   2. demoralization.
   3. increased error rate.
   a. 1 and 2
   b. 1 and 3
   c. 2 and 3
   d. 1, 2, and 3
5. Cognitive and emotional effects often manifest in behavioral changes, such as:
   1. anxiety.
   2. diminished enthusiasm at work.
   3. increased absenteeism.
   a. 1 and 2
   b. 1 and 3
   c. 2 and 3
   d. 1, 2, and 3

6. For radiologic technologists, the stressors from introducing new technology into the workplace can be compounded by which of the following?
   1. low levels of computer literacy
   2. lack of sufficient communication and training
   3. lack of dependence on the technology
   a. 1 and 2
   b. 1 and 3
   c. 2 and 3
   d. 1, 2, and 3

7. Indicators of job stress include which of the following?
   1. frustration
   2. fatigue
   3. loss of confidence
   a. 1 and 2
   b. 1 and 3
   c. 2 and 3
   d. 1, 2, and 3

8. In a 2006 study, which of the following techniques were mentioned most often to ease stress in the students studied?
   1. frequent feedback
   2. fewer personnel in the area
   3. assurance that mistakes happen
   a. 1 and 2
   b. 1 and 3
   c. 2 and 3
   d. 1, 2, and 3

9. After an adverse event or medical error, some suggest holding an ______ to discuss the event’s impact on patients and health care professionals.
   a. error conference
   b. team huddle
   c. formal inquiry
   d. organizational investigation

10. According to Enders et al, what percent of patients scheduled for magnetic resonance (MR) imaging cannot be imaged because of claustrophobia?
    a. 1 to 15
    b. 15 to 30
    c. 20 to 40
    d. 30 to 50

11. Practices for anxiety relief, such as breathing and relaxation techniques, visualization, and mental exercises, have been shown to reduce stress for patients undergoing an MR scan.
    a. true
    b. false

12. Pediatric radiology departments employ all of the following methods to help reduce patient stress except:
   a. sedation.
   b. hypnosis.
   c. parental involvement.
   d. deconditioning.
13. According to Romano, which of the following can help technologists increase patients’ trust in the medical care they are receiving?
   1. maintain eye contact
   2. show a caring attitude
   3. provide detailed explanations of procedures

   a. 1 and 2
   b. 1 and 3
   c. 2 and 3
   d. 1, 2, and 3

14. ______ is one of the possible adverse effects of sedation.
   a. Hyposmia
   b. Hypoxia
   c. Hypotoxia
   d. Hypovola

15. Shift work disorder is characterized by all of the following except:
   a. insomnia.
   b. fatigue.
   c. diabetes insipidus.
   d. difficulty with personal relationships.

16. To cope with stress and burnout in positive ways, radiologic technologists can do which of the following?
   1. get sufficient sleep
   2. praise coworkers for a job well done
   3. cultivate more friendships within the medical field

   a. 1 and 2
   b. 1 and 3
   c. 2 and 3
   d. 1, 2, and 3

17. One 8-week intervention program that offered training in mindfulness included:
   1. being intellectual by using critical thinking and analysis skills.
   2. walking meditation and mindful movement.
   3. doing body scans and sitting meditation.

   a. 1 and 2
   b. 1 and 3
   c. 2 and 3
   d. 1, 2, and 3

18. The mindfulness practice of scanning the body involves:
   a. changing one’s bodily sensations.
   b. shortening telomeres.
   c. noticing bodily sensations.
   d. being in synchrony with the mind.

19. The ______ is an almond-shaped set of neurons deep in the medial temporal lobe, is part of the limbic system, and is associated with the emotions.
   a. hippocampus
   b. hypothalamus
   c. prefrontal cortex
   d. amygdala

20. The default mode network is most active when the brain is:
   a. involved in a task.
   b. at rest.
   c. synchronized.
   d. creating neural pathways.

21. Which of the following modalities can help determine the parts of the brain that are activated and deactivated during meditation?
   1. single-photon emission computed tomography (SPECT)
   2. positron emission tomography (PET)
   3. functional magnetic resonance imaging (fMRI)

   a. 1 and 2
   b. 1 and 3
   c. 2 and 3
   d. 1, 2, and 3

continued on next page
22. According to Fayed et al, the parts of the brain that are affected by meditation include all of the following except the:
   a. cerebral cortex.
   b. amygdala.
   c. anterior cingulate cortex.
   d. hippocampus.

23. In a study by Kalyani et al that involved chanting meditation, PET imaging showed increased blood flow to limbic brain regions during direct vagal nerve stimulation as a result of meditation.
   a. true
   b. false

24. In Newberg et al’s study on the effects of chanting Sa Ta Na Ma, which of the following modalities demonstrated improved cerebral blood flow in the prefrontal, superior frontal, and superior parietal cortices?
   a. computed tomography (CT)
   b. PET
   c. fMRI
   d. SPECT

25. Engstrom et al used ______ to demonstrate that activation in the hippocampi occurs during silent mantra meditation practice.
   a. SPECT
   b. CT
   c. fMRI
   d. PET

26. Chung et al demonstrated that physiological effects of meditation include:
   1. decreased blood pressure.
   2. decreased anxiety.
   3. increased quality of life.
   a. 1 and 2
   b. 1 and 3
   c. 2 and 3
   d. 1, 2, and 3

27. ______ affect how human cells age and are psychobiological markers for psychological stress.
   a. Hormones
   b. Telomeres
   c. Enzymes
   d. Centromeres

28. Which of the following is not part of mindfulness meditation practice?
   a. making mental lists
   b. observing the details of your body
   c. focusing on your breath
   d. watching the movement of your mind

29. The National Center for Complementary and Alternative Medicine has stated that there have been “rare reports” that meditation might worsen symptoms in people who have certain psychiatric problems.
   a. true
   b. false

30. People who wish to start a meditation program, especially those with mental health disorders, such as post-traumatic stress disorder or major depression, should:
   a. begin immediately.
   b. start with 20 to 30 minutes of meditation per day.
   c. consult a health care provider.
   d. avoid meditation altogether.