

We Are What We Think: Downregulating the Chronic Stress Response with Technology-Assisted Mindfulness Meditation

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“We are what we think. All that we are arises with our thoughts...
Be the witness of your thoughts.”
Gautama Buddha

ABSTRACT

For hundreds of thousands of years of human evolution, high alertness was the key to survival in a predatory and dangerous world. Those whose stress responses remained active survived to pass along their genes, thus setting up modern humans with a mechanism primed to respond to threats to survival. This mechanism in the modern world can become maladaptive when prolonged exposure to chronic stressors keeps it on high alert, even in the absence of any threats. This article explores the potential of technology-assisted mindfulness meditation to support a healthy stress response within the demanding context of modern lifestyles.

Keywords: Stress, Mindfulness; Meditation; Hypothalamic–pituitary–adrenal axis; Downregulate

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INTRODUCTION

A retrospective survey from the population-based National Health Interview Survey 1998–2006 was linked to mortality data from the National Death Index. A total of 186 million adults polled were asked two questions:

1. During the past 12 months, have you had a lot of stress, a moderate amount, or little or no stress?
2. How much has that stress affected your health?

Both higher levels of reported stress and the perception that stress affects health were independently associated with an increased likelihood of poorer health and mental health outcomes. Additionally, researchers found that individuals who reported high levels of stress and held the belief that stress affects health had a 43% increased risk of premature death.¹

Robert Sapolsky, professor of neurobiology and primatology at Stanford University, has spent his professional career researching stress and neuronal degeneration in baboons and other mammals in Kenya, then applying much of that learning to humans. He describes the “anticipatory stress response,” which turns on the acute stress response even in the absence of an actual threat and is unique to humans.² This primitive stress response, which has enabled 200,000-plus years of human evolution, has not received a “software update” and may be one of the greatest contributors to modern-day disease. The anticipation and perception of a potential stressor can be more damaging than the threat itself.

Danish researcher Jos Brosschot and his colleagues have spent over 20 years studying stress and the stress response in both acute and chronic presentations. In his literature review article, “Ever at the Ready for Events That Never Happen,” he points out the distinction between acute and chronic stress responses. The acute response, designed for survival, increases blood pressure and turns on a cascade of the hormones adrenaline (epinephrine), noradrenaline (norepinephrine), adrenocorticotropic hormone, and cortisol in order to flee or confront danger. This short-term acute stress response is considered “healthy” when it turns off shortly after the

perceived threat passes. However, prolonged stress can morph into a chronic, long-term response that has a damaging effect on health.³

Brosschot and his colleagues have identified three mechanisms that cause an unhealthy, prolonged stress response:

1. *Perseverative cognition*: Constant thought about negative events in the past or in the future. Like Sapolsky, Brosschot argues that only humans possess the brain capacity to re-create representations from the past and to create potential representations of the future, both giving rise to anxious worrying. This perseverative cognition leads to increased physiological activity of the cardiovascular and endocrine systems.
2. *Unconscious stress*: Humans are not consciously aware of most of the brain’s activity, which enables the body to physiologically react to stress without conscious awareness of a stress response taking place.
3. *Stress as a default response when safety is not perceived*: This stress response needs no stressor at all; it is simply always “on” and stays on in the absence of obvious safety. It turns off when situations and surroundings are perceived as “safe” and turns back on again if the perception of safety disappears.⁴

On the basis of his research, Brosschot suggested that the stress response is not “turned on” by stressors; rather, the stress response is the default – it is always on, or “disinhibited,” in the absence of perceived safety. For hundreds of thousands of years of human evolution, high alertness was the key to survival in a predatory and dangerous world. Those whose stress responses remained active were those who survived and passed along their genes, thus setting up modern humans with a perpetual mechanism to respond to threats to survival, even in the absence of any threats. Brosschot argues that too much time is spent identifying stressors and subsequently trying to diffuse them, which puts the emphasis on stress and responding to it. He suggests that the role of the healthcare provider is to motivate patients to engage in activities that generally promote feelings of safety that will inhibit the default stress response.

WHAT IS STRESS AND HOW DO HUMANS RESPOND TO IT?

The hypothalamic–pituitary–adrenal (HPA) axis is an important component in the regulation of the stress response by controlling the release of cortisol. The HPA axis plays two roles:

1. Cortisol is released in a diurnal rhythm throughout the day, with levels being highest 30 min after awakening (cortisol awakening response).
2. The stress response is activated as an adaptive response to any threat or stressor in order to regain homeostasis and improve chances of survival.

As the potency and/or frequency of the stressor increases, the specificity of the adaptive response decreases, leading to a nonspecific, chronic stress state.⁵

Stress can be defined as “any circumstances that threaten or are perceived to threaten one’s well-being and that thereby tax one’s coping abilities.”⁶ In chronic stress, after extended periods of hyperactivity of the HPA axis, the cortisol awakening response has been shown to be lower than in healthy control subjects, and the diurnal curve is flatter.⁷ A flattened slope is considered to reflect a failure to activate the HPA axis after awakening and a failure to deactivate it in the evening, indicating a hypoactive HPA axis. Additionally, elevated cortisol levels in the evening can reflect poor recovery from stress, which has been shown to be a major risk factor for developing a more severe (clinical) burnout.⁸ High cortisol in the evening has been shown to reflect poor recovery from stress, which may be a risk factor for developing more severe burnout.⁹

In his field research, Sapolsky has studied the social strata of baboons and how an individual’s position in the troop impacts health. Males with a higher rank have greater control and predictability and hence less stress in their lives and better health outcomes. In contrast, social subordination is marked with a disproportionate share of stressors, which has negative pathophysiological correlates, including high basal levels of cortisol and elevated resting blood pressure, sluggish endocrine and cardiovascular stress responses, and delayed recovery of cortisol levels and blood pressure following

the end of a stressor.¹⁰ Sapolsky’s perspective that chronic stress is perpetuated by lack of predictive information, lack of control, and lack of support closely resembles Brosschot’s notion that lack of perceived safety perpetuates the uninhibited default state of chronic stress. Sapolsky argues that the circumstances under which subordinate animals experience health disadvantages have a counterpart in human societies, such that a stressed primate will endure a physiological toll similar to that of a stressed human.

Assuming that the models of stress as proposed by Sapolsky and Brosschot are valid, what evidence-based tools are available to increase perspective or reinforce the perception of safety? How can the chronic stress response for survival inherited from our ancestors be inhibited? There is a growing body of scientific literature pointing to mindfulness meditation and its focus on breathing and quieting the mind as essential to thwarting the cortisol response and providing an opportunity for reframing experiences.

WHAT IS MINDFULNESS AND CAN IT HELP IN MANAGING STRESS?

Mindfulness meditation has been shown to produce positive effects on psychological well-being that extend beyond the time the individual is formally meditating, leading to decreased physiological markers of stress in a range of populations. A 2017 meta-analysis of 45 studies concluded that when all meditation subtypes were analyzed together, meditation reduced cortisol, C-reactive protein, blood pressure, heart rate, triglycerides, and tumor necrosis factor- α .¹¹ In other studies on the effects of mindfulness, concentration, attention, serenity, and ability to tolerate negative emotions have been shown to increase.¹² With mindfulness training, the individual does not stop responding to negative events altogether; however, the stress reaction fades more quickly, and one is less likely to perseverate on inappropriate action strategies.¹³

Mindfulness aims to cultivate increased moment-to-moment awareness of one’s thoughts, feelings, and bodily sensations while maintaining an open mind free from distraction and judgment. A central tenet

of mindfulness is that mindfulness does not aim to suppress or change one's direct experience; the focus is rather on how the present moment is being interpreted. This cultivation of moment-to-moment awareness of thoughts and feelings as neutral mental events, rather than as reality or truths about the self, has been shown to change negative thought patterns and reduce reactivity in both healthy and clinical populations.^{14,15} It has been suggested that this process can initiate a perceptual shift whereby thoughts and feelings are recognized as events occurring in a broader field of awareness.¹⁶

Although mindfulness meditation is at the heart of ancient Buddhism and has been practiced for centuries, it is only within the past two decades that it has received attention in the scientific and medical literature. There is mounting evidence of the role mindfulness can play in reducing stress and improving anxiety, depression, anger, cancer, substance abuse, fibromyalgia, and psoriasis.¹⁷ In fact, meditation has become so mainstream in the scientific literature that it has caught the attention of the National Institutes of Health (NIH), which states on its National Center for Complementary and Integrative Health website, "Research suggests that meditation can be a powerful tool for learning control of attention, regulating emotion, and increasing self-awareness."¹⁸ It was reported in the *Washington Free Beacon* that, as of December 2014, the NIH had spent \$100.2 million on mindfulness meditation-based research.¹⁹

Meta-analyses have reported that mindfulness-based psychological interventions decrease stress in healthy nonclinical populations, as well as improve psychosocial outcomes for people with clinical disorders such as anxiety and depression.²⁰⁻²³ The potential effects of teaching mindfulness for stress reduction and psychological well-being in the workplace are receiving increasing attention and have been shown to decrease global perceptions of psychological stress in healthy working adults.^{24,25}

Although mindfulness training delivered via in-person training programs has been shown to improve aspects of psychosocial well-being, the requirement that test subjects attend live sessions led by a trained meditation teacher has limited research.²⁶ Less is known about the efficacy of digital training via smartphone apps as a convenient alternative

to group sessions. Recent, smaller studies using smartphone apps and electronic devices have enabled more accessible ways to test and measure the benefits of mindfulness.²⁷

CAN TECHNOLOGY BE A TOOL FOR MINDFULNESS?

A very small study of 27 participants was designed to evaluate whether mindfulness training would reduce the perception of stress in officer cadets preparing for parachute training in a Norwegian military academy. In the days leading up to the jump, the experimental group took an in-person 4-h mindfulness training course, followed by 12 days of mindfulness training consisting of 30 min/day of guided meditation listened to on an MP3 player, and the control group received no interventions. Anxiety was lower and self-confidence higher in the experimental group than in control subjects when measured at both 4.5 h and 30 min before the first jump, suggesting that mindfulness played a role in reducing the perception of stress leading up to an acute stress situation.¹³ Although the results showed a consistent difference between the experimental and control groups, it is difficult to rule out other factors that may have influenced the results. Only subjective measures were used (questionnaires), as opposed to clinical measures such as heart rate monitors or cortisol levels.

Another small study of 69 participants examined the impact of mindfulness on psychosocial well-being via two different educational delivery methods: daily 10-min sessions of guided mindfulness for 10 days via smartphone app or listening to an audiobook about mindfulness. Affect, irritability, and stress were measured via online questionnaires before and after each session. Both interventions were effective at reducing stress associated with personal vulnerability, but only the mindfulness intervention had a significant impact on affect, irritability, and stress from unexpected external pressure. Study limitations included modest sample size, lack of follow-up data, homogeneity of cohort (white/Caucasian, university degree), and positive expectations about the benefits of meditation prior to beginning the intervention, limiting the generalizability of the results.²⁷

A larger study of 238 participants used a smart-phone app to investigate whether a mindfulness meditation program could improve psychological well-being, reduce job strain, and reduce ambulatory blood pressure during the workday in middle-aged adults. Participants were asked to complete one 10- to 20-min guided audio meditation per day for 8 weeks. Psychosocial measures and blood pressure throughout one working day were measured twice: at baseline and 8 weeks later. A follow-up survey was completed 16 weeks after the start of the intervention. Usage data revealed that participants randomized to the intervention completed an average of 17 meditation sessions (out of a potential total of 45). Compared with control subjects, the intervention group reported significant improvement in global well-being, daily positive affect, anxiety and depressive symptoms, job strain, and workplace social support. The improvements in global well-being, depressive symptoms, and job strain were sustained for 8 weeks after the primary intervention endpoint. In addition, a marginally significant decrease in self-measured systolic blood pressure from before to after intervention was noted. At the 16-week follow-up, sustained positive effects were found for well-being and job strain. The researchers concluded that short, guided mindfulness meditations delivered via smartphone and practiced multiple times per week can improve outcomes related to work stress and well-being, with potentially lasting effects.²⁶

Finally, a meta-analysis of randomized controlled trials examined the neurobiological effects of many different forms of meditation on markers of stress. Studied outcomes included markers of sympathetic nervous system activation: cortisol, blood pressure, heart rate, lipids, and peripheral cytokine expression. Forty-five studies were included. When analyzed together, meditation reduced cortisol, C-reactive protein, blood pressure, heart rate, triglycerides, and tumor necrosis factor- α . The study's authors concluded that meditation practices can lead to decreased physiological markers of stress in a wide range of populations. In addition, researchers stressed the importance of these findings and the potential for meditation to thwart debilitating clinical illnesses associated with HPA axis hyperactivity, such as anxiety and depression.¹¹

CONCLUSION

Civilization has “evolved” to a point that one is more likely to die of a chronic, inflammatory disease based on lifestyle choices than to die of an accident or infection.²⁸ The inflammatory mechanisms associated with perseverative cognition that lead to chronic stress contribute to these diseases.²⁹ Research shows that meditation can improve markers associated with chronic stress and chronic illness, namely cortisol, inflammatory markers, blood pressure, heart rate, and triglycerides.¹¹ Mounting reports confirming the role that occupational stress plays in mental health, as well as the associated substantial costs for society, are gaining more attention.³⁰ It is ironic that the very mechanism that keeps us alive when confronted with danger can also be the mechanism that contributes to chronic ill health.

There is much emphasis in popular culture on stress and how to “manage” it. What if, instead of focusing on stress – how to avoid it, remove it, treat it, and name it – the focus instead became preparing the nervous system for the unpredictability of life and thus the omnipresence of stress? Based on our primate-based wiring for survival, the human nervous system is “ever at the ready for events that never happen,” to quote Brosschot. Brosschot and Sapolsky assert that stress is here to stay. They emphasize the importance of perception and its ability to up- or downregulate the stress response. If one perceives danger, the stress response is turned on, even in the absence of actual danger; if one perceives safety, the stress response is downregulated. The human mind is the biggest culprit in this picture.

Perhaps it is time for a paradigm shift away from managing stress and toward “the care and feeding of a healthy nervous system.” Brosschot and Sapolsky assert that managing perceptions and feelings of safety contribute to downregulating the stress response. In short, one can change one's brain by changing how one thinks. Both suggest mindfulness and meditation as tools to turn off the chronic stress response as well as better handle stress as it arises.^{4,31}

Because of the deleterious effects that stress can have on health, mindfulness is not an option – it is a

requirement. Think of mindfulness as the lifejacket that enables one to ride the waves of stress without sinking into them. Integrative medicine doctors are in a unique position to teach their patients about the power of perspective, as well as the perception of safety that results from a mindfulness practice, as necessary to manage the stress response. Ironically, some of our most practical and accessible tools for teaching mindfulness – meditation apps – are accessible via one of the most stress-inducing tools, a smartphone.³² The nascent yet growing body of research on mindfulness and meditation supports the effectiveness of these apps and suggests that, in

the long run, they may be as effective as traditional approaches to meditation, such as transcendental meditation and attending classes at meditation centers. Mindfulness training, regardless of delivery system and time spent practicing, may have the power to reset the human brain because research shows that even minimal amounts can downregulate the default chronic stress response inherited from our primitive ancestors.

COMPETING INTERESTS

The author declares she has no competing interests.

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