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Review

Breath Practices for Survivor and Caregiver Stress, Depression, and Post-traumatic Stress Disorder: Connection, Co-regulation, Compassion

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Special Issue: How Compassion Benefits in the Healing Process

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Abstract

Does compassion itself benefit the healing process or does the activation of neurophysiological processes, from which the experience of compassion arises, trigger a cascade of physical and psychological changes that support health and well-being? Exploration of the neurological substrates of compassion reveals multiple healing pathways that can be activated by mind-body practices. Furthermore, these pathways affect physical health, emotion regulation, and how we perceive and relate to others.

Physiological states affect the capacity for empathy, compassion and understanding. A state of calm alertness based on sympatho-vagal balance may support such high-level prosocial functions. Evidence suggests that polyvagal-informed mind-body practices, particularly Voluntarily Regulated Breathing Practices (VRBPs), efficiently induce such physiological states and that these same states can reduce inflammation and oxidative stress, while improving cardiovascular function, respiratory efficiency, and physical health.

Mind-body practices, such as Coherent or Resonant Breathing can balance, strengthen, and increase the adaptive flexibility of stress response systems, potentially counteracting the detrimental effects of excess stress, neglect, and trauma on emotion regulation, physical health, and the ability to experience love and compassion. Research is needed to support integration of mind-body practices into healthcare systems. The methods being used to study mind-body techniques may be further refined by considering the target symptoms, population being studied, specific parameters of each practice, and methods of teaching subjects.

The current state of global health calls for treatments that can be delivered to large populations by small numbers of healthcare providers under conditions where resources are limited. Slow gentle Coherent or Resonant Breathing and related mind-body practices are low cost, low risk, easily taught, rapidly effective, scalable, non-stigmatizing, and sustainable. At the convergence of neurophysiological research with contemplative and other mind-body practices, we marvel at the possibilities for relieving emotional and physical suffering as well as improving how we relate to one another.

Keywords

Paced breathing; polyvagal; heart rate variability; compassion; caregiver stress; trauma; mind-body; public health; global health; mass disasters

1. Introduction

The neurophysiological processes that underlie our capacities for connection, self-regulation, compassion and cooperation are subject to positive and negative influences. Adverse childhood events, stress and trauma can impair these capacities and are associated with increased risk for many diseases of aging. Mind-body practices can activate and strengthen neurophysiological processes that counteract the detrimental effects of excess stress, neglect, abuse, war, disasters, and political upheaval.

Physiological states affect the capacity to respond to people and situations with empathy, compassion and understanding. A state of calm alertness based on autonomic sympatho-vagal balance may be ideal for supporting these high-level prosocial functions. Specific Voluntarily Regulated Breathing Practices (VRBPs) and related mind-body practices efficiently induce such physiological states.

Voluntarily Regulated Breathing Practices (VRBPs) have rapid, widespread effects on critical neural pathways that orchestrate the stress response and social engagement networks, and that upregulate innate healing processes (reducing effects of stress, free radical damage, and inflammation) [1, 2]. Evidence suggests that polyvagal-informed mind-body techniques focused on VRBPs have the potential to enhance our capacities for connection, self-regulation, compassion, and healing [3, 4].

Furthermore, these states of flexible, adaptive sympatho-vagal balance significantly improve mental and physical health by a multiplicity of synergistic mechanisms, including: reduced oxidative damage and inflammation; improved cardiovascular function; and increased respiratory efficiency and oxygenation [1, 3, 5, 6]. Such processes are relevant to the prevention and treatment of common diseases of aging [7].

As researchers explore the neurophysiology of VRBPs and their myriad of clinical applications, it is important that more care be given to the parameters and the specifics of how the practices are taught, how the subjects learn each breath practice, how the researchers monitor and adjust the breathing methods to optimize their physiological effects and benefits. Optimal paced breathing is not necessarily achieved by simply turning on a breath pacing device.

The current state of global health compels us to develop treatments that can be delivered to large populations by small numbers of healthcare providers under conditions where resources are limited. Priority should be given to interventions that are inexpensive, low risk, low in technology requirements, easily taught in a relatively short period of time, rapidly effective, scalable, non-stigmatizing, and sustainable. Slow, gentle breathing and related mind-body practices serve as evidence-based approaches that could fulfill these criteria and could integrate with any other treatment modality [8].

We also need to be cognizant of the adverse effects of working with traumatized populations on healthcare providers, first responders, relief workers, non-governmental organization (NGO) staff, schoolteachers, and other caregivers. Increasing rates of burnout, mental illness, substance abuse, and suicide among those who bear the burdens of care are manifestations of the need for simple, effective tools for managing caregiver stress and vicarious trauma. Data is presented from a study of a Breath-Body-Mind train-the-trainer program for healthcare providers serving populations affected by the Gulf Horizon oil spill. Healthcare providers showed significant reductions in measures of stress after participating in the program. Training caregivers in slow breath and related practices multiplies the benefits by sustaining a better functioning, more resilient work force who can then teach these same healing techniques to those who need their help.

This article begins with a discussion of the scientific basis for understanding the effects of slow-paced breathing and related mind-body practices on neurophysiological states, emotion regulation, and prosocial functions. Challenges and recommendations for improving research

efforts are discussed. Examples of adaptations of breath practices for individuals with psychiatric disorders, medical conditions (e.g. asthma or inflammatory bowel disease), and children are provided. A systematic review of research on breathing practices is beyond the scope of this paper. For reviews of clinical research on mind-body practices focused on breathing techniques, see Brown and Gerbarg [1, 9, 10], Telles, Singh, and Balkrishna [11], and Zaccaro et al [12].

2. Physiological States, Co-regulation, and Heart Rate Variability: Substrates of Empathy and Compassion

Co-regulation of physiological states by infants and their caregivers is essential for the development of healthy sympatho-vagal balance and emotion self-regulation. Infants are born with the ability to share emotional and mental states. In utero, the fetus is affected by the mother's moment-to-moment physical and emotional states. This continues post-partum as the infant responds to the mother's, father's, or other caregivers' physical presence, touch, taste, warmth, tone of voice, smell, eye contact, and facial expressions. Close physical contact with feelings of safety facilitate the co-regulation of physiological states that is the foundation for healthy self-regulation. Awareness of another person as distinct from oneself develops in later childhood.

Empathy and compassion require perception and neurophysiological simulation of the state of the other person, and understanding of another's physical, emotional and mental condition, while maintaining distinctions between the observed state, the simulated state and one's own state [13]. Lapses in the maintenance of these distinctions may be a factor in vicarious trauma and burn-out among caregivers.

3. The Polyvagal Theory

The autonomic nervous system regulates mental/emotional activity and the function of the internal glands and organs through a delicate balance between its sympathetic and parasympathetic branches. The vagus nerves (10^{th} cranial nerves) are the main pathways of the parasympathetic nervous system (PNS). Stephen Porges [14, 15] articulated The Polyvagal Theory based on his identification of three evolutionary stages of the autonomic nervous system: the unmyelinated vagus, the sympathetic nervous system, and the myelinated vagus.

All three are present in humans and most mammals. Depending on how we perceive the environment, as safe or as dangerous, different parts of the autonomic system become activated.

The most recent evolutionary development, the myelinated vagal system comprises approximately three percent of the fibers in the vagus nerves, yet it orchestrates the social engagement system and social interactions [4, 14, 16]. Vagal afferents bring *interoceptive* information, meaning sensory information about internal physiological states (e.g. visceral sensations, pain, vibration, temperature, pulsations of the heart and blood vessels) upward from the body to the brain.

Porges defines three states based upon perception of the environment as safe, dangerous, or life threatening. In the zone of feeling safe, the myelinated vagus is active, heart rate variability is high, defensiveness is low, social engagement is facilitated, and the individual is better able to experience prosocial emotions such as love, connectedness, bonding, caring, and cooperativeness.

This state is most conducive to empathy, compassion, and altruism.

When the environment is experienced as unsafe or dangerous, the sympathetic system becomes activated with lower heart rate variability, higher levels of defensiveness, lower capacity for social engagement, emotion dysregulation, hypervigilance, and a greater tendency to experience feelings of fear, anger, or aggression. Adrenaline is released and the body prepares to fight or flee with increased heart rate and blood pressure and a shift in blood flow from the viscera to the arms and legs in preparation for action. This state is necessary for survival, but it requires a higher metabolic rate and consumes more energy. Once the danger is past, if elevated sympathetic activity persists, the body suffers energy loss and physical damage.

3.1 Two Vagal Systems

The vagus nerves of humans and other mammals contain two vagal systems [14, 16]. The unmyelinated vagal circuit is phylogenetically older (also found in reptiles) and originates in the brain stem dorsal motor nucleus of the vagus. The newer, uniquely mammalian vagal circuit is myelinated and originates in the brain stem nucleus ambiguus. The older vagal motor pathways, which regulate subdiaphragmatic organs (e.g. gastrointestinal tract), can also function as a defense system. The myelinated vagal motor pathways, which regulate supradiaphragmatic organs (heart and lungs), enervates the sinoatrial node (pacemaker of the heart), slows heart rate and supports states of calmness. Mind-body treatments have positive, calming effects when the myelinated vagus pathway is activated to support a physiological state of safety and bonding rather than defense [3].

The myelinated vagus functions as a brake on the heart's pacemaker, slowing the heart rate: rapid inhibition of the pacemaker quickly induces calmness; rapid disinhibition allows mobilization. Concurrently, the myelinated vagus inhibits the sympathetic nervous system from accelerating the heart rate and reduces hypothalamic-pituitary-adrenal axis activity.

3.2 Heart Rate Variability, Polyvagal Theory and Relationships

The relative activity of the components of the autonomic system can be assessed using Heart Rate Variability (HRV). Respiratory sinus arrhythmia (RSA) and HRV are derived mathematically from normal variations in the cardiac beat-to-beat interval: during inspiration heart rate increases; during expiration heart rate decreases [17]. These changes reflect the flexibility of the cardiovascular and stress response systems. High Frequency Heart Rate Variability (HF-HRV) or vagally mediated Heart Rate Variability (vmHRV) is widely used as a marker of parasympathetic activity. Increases in HF-HRV are associated with activation of the social engagement network and prosocial behavior.

A study by Bornemann and colleagues [18] noted that self-induction of parasympathetic states may support altruistic action. Lischke and colleagues [13] showed that individuals with high vmHRV are more likely to experience mutual understanding in social relationships than those with low vmHRV, possibly a reflection of their greater capacity to share and understand mental and emotional states. While a state of calm, flexible, balanced self- regulation is conducive to prosocial competencies, some degree of arousal is necessary to engage in altruistic actions. Physiological flexibility in response to others' needs may support emotional and behavioral flexibility, which is important for prosociality [19]. Geisler and colleagues [20] found

that young adults with higher RSA had better response control, social-support seeking, and social wellbeing. The same group also discovered that higher RSA was associated with less disengagement (e.g. avoidance), greater use of socially-adaptive emotion regulation in coping with negative emotions, and fewer episodes of anger.

According to Polyvagal Theory, thoughts, activities, or interactions that evoke feelings of safety, bonding, caring, and love activate myelinated vagal pathways, upregulate the social engagement system, and increase HRV. "Top-down" cognitive therapies and meditation focused on loving kindness or compassion may engender psycho-physiological states characterized by activation of myelinated vagal pathways (increased HF-HRV) and social engagement-affiliative-caregiving networks. "Bottom-up" Mind- body practices, such as slow, gentle breathing rapidly induce a parasympathetic state (increased HF-HRV) that also engenders psycho-physiological states wherein safe, loving, caring, bonding, compassionate feelings arise. Coherent (Resonant) Breathing is the slow VRBP that specifically optimizes HRV [17, 21], calms the mind and body, and upregulates restorative and healing processes. The skillful integration of top-down with bottom-up methods would likely optimize treatments outcomes.

Social relationships have emotional and self-regulating properties. The experience of safety within a relationship is fundamental to activation of neurophysiological states that underlie prosocial emotions, such as compassion. In addition, activation of parasympathetic pathways supports the inhibitory action of the prefrontal cortex [22] whose functions include modulating and inhibiting emotional over reactions within the amygdala that could undermine or destroy important relationships.

4. Voluntarily Regulated Breathing Practices

Autonomic functions predominantly operate outside conscious awareness or control. Breathing is the exception. Volitional changes in respiratory pattern and rate can easily usurp involuntary control, providing a portal of entry into the mind-body communication systems, wherein we can alter physiological and mental processes. Breathing represents an efficient, easily accessible voluntary behavior that regulates the vagal brake by reducing or increasing the influence of the vagus on the heart [23]. The term *respiratory gate* refers to this function of the cardioinhibitory vagal pathway: during exhalation vagal influence on the heart increases, slowing heart rate; during inhalation vagal influence on the heart decreases, accelerating heart rate. Breathing practices, including Coherent (Resonant) breathing, pranayama, and other techniques, entail variations in respiratory rate, depth, the relative duration of four phases of the respiratory cycle (inhalation, pause, exhalation, pause), sounds (e.g. "om"), chants, and songs. Other mind-body practices also affect breath patterns. Meditation tends to slow the respiratory rate. Zazen, for example is associated with a respiratory rate of six breaths per minute. The cardioinhibitory vagal pathway, as a reflex, operates quite rapidly. Thus, the response to changes in breath pattern tend to be rapid, providing an efficient intervention for calming an individual who may be upset or anxious. This effect is enhanced by training and practice.

4.1 Coherent Breathing, Resonant Breathing

Coherent Breathing, also called Resonant Breathing, is gentle breathing in and out, preferably through the nose with equal duration of inspiration and expiration at a rate that optimizes

sympatho-vagal balance (as indicated by optimal HRV) between 3.0 and 6.0 breath cycles per minute (cpm) for most adults. In general, for individuals above six feet in height the ideal respiratory rate is between 3.0 and 4.5 cpm; for those less than six feet tall, 4.5 to 6.0 cpm is most effective [17, 24].

Coherent or Resonant Breathing should be performed without strain, without over- inflation of the lungs and without using force during the exhale. This method of gentle paced breathing rapidly (usually within minutes) induces a state of emotional calmness with mental alertness and enhanced cognitive processing [21, 23]. Coherent breathing, paced by a recorded chime tone or other sound (e.g., ocean wave), is easily taught to individuals or groups in 20 to 30 minutes. It can be done with coordinated movements while standing, sitting, walking, or supine.

For thousands of years, regulated breathing through rhythmic praying and chanting have been used throughout the world as Meditation and other contemplative practices are enhanced by slow breathing techniques, such as Coherent or Resonant Breathing [1, 21].

Immediate effects of Coherent Breathing include reduction of anxiety, tension, and insomnia. Longer term, daily practice improves autonomic system resiliency, emotion regulation, depression, and social relationships [25]. After 1 or 2 months of daily practice for 20 minutes, patients can also use coherent breathing with eyes open while engaged in everyday activities. It can be done anywhere without anyone knowing that the individual is engaged in a calming, self-regulatory practice. People appreciate having access to an efficient, inconspicuous, nonstigmatizing method for self-regulation, particularly under stress.

Adjusting respiratory rate to shift the system to approximate the optimal HRV for the individual (which can now be measured) supports sympathovagal-vagal balance, activation of the myelinated vagus, upregulation of the social engagement system, flexible and adaptive behavior, and high-level prosocial processes that engender feelings of safety, trust, compassion, understanding, empathy, bonding, and cooperation.

4.2 Effects of Voluntarily Regulated Breathing Practices on Emotion Regulation

Emotion regulation requires the higher centers, such as the prefrontal cortex, to modulate or inhibit emotional reactivity in the lower (subcortical) areas, particularly the amygdala through release of the central inhibitory neurotransmitter, gamma-aminobutyric acid (GABA) [26, 27]. Disorders of emotion regulation, for example, as seen in anxiety disorders and in stress- and trauma-related disorders, such as post-traumatic stress disorder (PTSD) are characterized by excess or erratic activity in the amygdala (where species-specific defensive reactions and anger arise) and by underactivity in the prefrontal cortex. Numerous concurrent mechanisms have been identified whereby slow breathing practices can improve emotion regulation, reduce overactivity in the amygdala, and increase underactivity in prefrontal emotion regulatory centers.

The respiratory system is richly endowed with receptors: chemoreceptors, baroreceptors, and mechanoreceptors. For example, mechanoreceptors (stretch receptors) within each alveolus send signals about the rate and magnitude of expansion and contraction that occurs with every breath. Millisecond to millisecond signals are transmitted, summed, and sent through vagal afferent pathways that ascend through brainstem nuclei (nucleus tractus solitarius and parabrachial

nucleus) to the limbic system, thalamus, prefrontal cortex, insular cortex, cingulate cortex, and other processing and regulatory areas [9, 10, 28, 29].

Thus, the brain is constantly informed about the state of the respiratory system.

This information has powerful effects on how we perceive the environment, ourselves, and other people (safe or unsafe) and on how we think, feel and behave. Additional mechanisms include vagal afferents to the hypothalamus that modulate hypothalamic-pituitary-adrenal function (cortisol release). Evidence also suggests that vagal afferent activation can increase levels of the inhibitory neurotransmitter gamma-aminobutyric acid, stimulate oxytocin release, upregulate social engagement, and improve cognitive function [9, 10, 21, 26, 27].

4.3 Voluntarily Regulated Breathing Practices with Awareness

Voluntarily regulated breathing with awareness (mindfulness or attentional focus) differs from the automatic breathing that is involuntarily paced from the brainstem. VRBPs have widespread, rapid effects on brain electrical activity, emotion regulation, and cognitive function.

Innovative research is opening doors to understanding the effects of specific aspects of breathing practices on different brain areas and functions. For example, direct recordings of brain electric activity in humans by intracranial electroencephalogram (iEEG) demonstrated that during volitional paced breathing, iEEG-breath coherence increases in frontotemporal-insular network; during attention focused on breathing the iEEG-breath coherence increased in the anterior cingulate premotor, insular, and hippocampal cortices [30]. These findings suggest breathing could serve as an organizing principle for neuronal oscillations throughout the brain and that cognitive functions, such as focusing attention can also be used to influence neural processes that are otherwise considered automatic. Oscillations in many brain regulatory centers are ‘locked’ or ‘entrained’ by respiratory patterns. Particularly strong respiration locking was found in the insula, amygdala, premotor, olfactory, caudal-medial frontal (executive function) and temporal cortices [30].

5. Clinical Trials of Voluntarily Regulated Breathing Practices

5.1 Major Depressive Disorder

The Vagal-GABA Theory, articulated by Streeter, Brown and Gerbarg [26] hypothesized that activation of vagal nerve afferent pathways was associated with increased activity in GABA-ergic pathways, thereby increasing inhibition of the overactivity that occurs in the amygdala in patients with disorders of mood, anxiety, and PTSD. GABA-ergic pathways from the thalamus and interoceptive (insular) cortex have been identified. The following study was approved by the Boston University Medical Center Institutional Review Boards. In a 12-week intervention for patients with major depressive disorder (MDD), comprised of yoga postures and Coherent Breathing, GABA levels, as measured by magnetic resonance spectroscopy (MRS), significantly increased in the thalamus while symptoms of depression significantly decreased [27]. In Phase I, a dose-finding study, 30 patients with MDD were randomized to a high dose group (HDG) of three 90-minute group sessions per week plus home practice or a low dose group (LDG) of two 90-minute groups sessions per week plus home practice. BDI-II scores declined significantly from

screening (24.6 + 1.7) to week 12 (6.0 + 3.8) for the HDG (–18.6 + 6.6; $p < 0.001$), and from screening (27.7 + 2.1) to week 12 (10.1 + 7.9) in the LDG (–17.7 + 9.3; $p < 0.001$). There were no significant differences between groups, based on response (i.e., > 50% decrease in BDI-II scores; $p < 0.65$) for the HDG (13/15 subjects) and LDG (11/15 subjects) or remission (BDI-II scores < 14; $p < 1.00$) for the HDG (14/15 subjects) and LDG (13/15 subjects), although a greater number of subjects in the HDG had 12-week BDI-II scores ($p < 0.04$). The correlation between the cumulative number of minutes each subject practiced the intervention and reduction in depression scores on the BDI-II was significant [31]. A comparative analysis of these results with Dr. Streeter's previous studies demonstrated a significant association between the improvements in depression and increases in thalamic GABA levels [27].

5.2 Generalized Anxiety Disorder with Co-morbidities

At the Stress Trauma Anxiety Rehabilitation (START) Clinic for Mood and Anxiety Disorders, a tertiary care mood and anxiety disorder clinic in Toronto, two open studies of breath-focused mind-body programs as adjuncts to standard treatment, found significant benefits in patients with a primary diagnosis of Generalized Anxiety Disorders (GAD) (DSM-IV), a minimum 8-week history of treatment with an appropriate dose of a standard anxiolytic, and baseline, Clinical Global Impressions-Severity of Illness (CGI-S) score of 5-7; HAM-A total score ≥ 20, HAM-A anxious mood and tension items including a score of >2. In the first study 41 subjects participated in a 5-day (total 22 hours) Sudarshan kriya yoga (SKY) program [32] of multiple yoga breath practices (pranayama), including slow, medium and rapid breathing, yoga postures, and meditation [33]. Subjects were offered weekly 2-hour group yoga sessions and encouraged to practice for 20 minutes per day at home. Among the 31 subjects who completed the study, significant reductions occurred between pre- and post-intervention mean HAM-A total score ($t = 4.59$; $p < 0.01$) and psychic subscale ($t = 5.00$; $p \leq 0.01$). Based on the HAM-A scores, the response rate was 73% and the remission rate 41%.

The second START study of similar group of patients with treatment-resistant GAD participated in a shorter 2-dayBreath-Body-Mind training (rather than the 5-day SKY program) showed retention of 20 out of 20 subjects, indicating that subject time availability can be a barrier to these types of interventions. To reduce the risk of previously observed adverse reactions to rapid, forceful breathing, all high-frequency breath practices were eliminated from the protocol. The Anxiety Sensitivity Index, ASI; Beck Anxiety Inventory, BAI; Beck Depression Inventory-II, BDI-II; Penn State Worry Questionnaire, PSWQ), obtained pre-intervention, immediately post-intervention and at 6 months post-intervention, revealed significant improvements across the three time points, consistent with improved symptoms [34].

Larger, controlled trials are needed to validate and extend the promising indicators that interventions combining VRBPs with movement practices, may be incorporated into the treatment protocols for patients and nonclinical populations to support better emotion regulation, social engagement, and cognitive functions.

5.3 Schizophrenia

The prosocial neurohormone, oxytocin, is known to enhance bonding and feelings of love. Electronic Vagal Nerve Stimulation (VNS) was found to increase levels of oxytocin [35]. Researchers in India have a long tradition of studying yoga, including VRBPs for treatment of psychiatric disorders. Studies at the National Institute of Mental Health and Neuroscience of India (NIMHNS) demonstrated that a yoga program, structured to include substantial components of slow VRBPs (pranayama), in schizophrenic patients significantly increased circulating levels of oxytocin. Concomitantly, the patients' ability to accurately recognize human facial expressions (a function of the social engagement system) improved [36].

In an open pilot trial 33 heavily medicated chronic schizophrenic and schizoaffective patients (DSM-IV) living in residences at the Nathan Klein Institute in New York were given one hour three times a week of paced Coherent (Resonant) Breathing plus movement (either yoga or Qigong). After 12 weeks, measures of cognitive function improved significantly in all domains of the Repeatable Battery for the Assessment of Neuropsychological Status (RBANS) [37].

6. Post-Traumatic Stress Disorder - Clinical Cases

In clinical practice and in BBM workshops open to the public, the authors (Dr. Gerbarg and Dr. Brown) see numerous cases in which VRBPs, by enhancing conventional psychotherapy and other modalities, reduce long-standing (treatment resistant) symptoms of anxiety, agitation, hypervigilance, emotional numbing, disconnectedness, dissociative symptoms, intrusive trauma memories, insomnia, night terrors, and trauma-related somatic symptoms [2, 3]. The following cases illustrates resolution of a specific trauma-related symptom.

Case 1: A 24-year-old woman with a history of childhood sexual abuse, specifically oral abuse, sought treatment for temporo-mandibular joint (TMJ) pain. All medical treatments short of surgery had failed to provide any symptom relief. The pain was so severe that her jaw hurt when she walked or engaged in any physical activity. During a course of psychodynamic psychotherapy, she was able to talk about her abuse experiences within a family of multi-generational abusers. Two of her aunts had validated the abuse by their grandfather, uncles and male cousins. During the second year of psychotherapy, Dr. Gerbarg referred the patient to take an intensive course of breath-focused yoga. She reported that on the days when she did 20 minutes of breath practices the TMJ pain was completely absent. On the days when she skipped her breath practices, the pain returned, but was much less severe.

Dr. Brown taught Breath-Body-Mind to the staff at the Department of Psychiatry in the Juba Medical Center in South Sudan. All of the staff had experienced multiple traumatic events and lived under constant threat of violence during most of their lives due to invasions from North Sudan and their own recurring civil wars. After practicing the BBM techniques for two months, anecdotally, they reported that the Coherent Breath practices helped them to feel calmer, less stressed, less angry, and better able to relate to their family members.

Case 2. A 28-year-old South Sudanese mental health clinician was traumatized when, at the age of 16, he was forced to watch the burning of his village and the murder of his family during one of the many invasions by the North Sudanese. Since then, for ten years, he had been experiencing constant intrusive visual images of his sister burning to death in the flames. He explained, "that

picture is before my eyes all day and all night when I sleep." Over the years, medication trials, including anxiolytics, sedative-hypnotics, and antidepressants had no effect on these symptoms. Finally, he participated for three hours in a Breath-Body-Mind (BBM) training program (rounds of VRBPs with attentional focus and movement) given by Dr. Richard P. Brown for the staff at the Juba Medical Center Department of Psychiatry in South Sudan. During the subsequent 7 days, he practiced Coherent Breathing for 20 minutes twice a day, as instructed. On the eighth day, he travelled 1000 miles to tell Dr. Brown that the images had ceased completely. He repeated over and over again, "I am free."

Case 3. A 66-year-old married administrator with a previous history of surviving traumatic events was working in an office on the 80th floor of the World Trade Center (WTC) on September 2001. As the plane struck the tower, she sensed mortal danger, despite the reassuring announcements on the intercom. Fleeing for her life down the stairwell, she became exhausted around the 40th floor. With the help of two men, she made it down to the basement and escaped just moments before the tower collapsed. For the next nine years she suffered severe PTSD including frequent flashbacks of the WTC attack, emotional numbing, avoidance of situations that triggered flashbacks, and depression.

This traumatized survivor went through numerous treatments, including psychodynamic psychotherapy, cognitive behavioral therapy (CBT), mindfulness, and medication trials, all without symptom relief. In 2010, nine years after the disaster, she participated in a 2-day 12-hour Breath-Body-Mind workshop and began practicing Coherent Breathing and related mind-body techniques every day. Her symptoms became less severe over a period of months and she reported "feeling alive again." Six months after the first BBM program, she took another 2-day BBM workshop with even better results. Her flashbacks, numbness, and depression resolved completely. She noted that, "I got my smile back." The amount of time, daily practice, and the number of intense sessions required for remission varies, depending on individual characteristics, previous trauma, and other factors which have not yet been quantified. This case again illustrates that the time elapsed between the traumatic event and the mind-body therapy does not preclude a highly positive outcome.

7. Breathing and Movement Practices for Children

Families and schools are becoming more accepting of mind-body practices. A systematic review of 47 studies by Khalsa and Butzer [38] concluded that, despite variability in methodology, these publications suggest that yoga in the school setting is a viable and potentially efficacious strategy for improving child and adolescent health and therefore worthy of continued research.

Breathing techniques are easily adapted for children of different ages. Children learn and respond quickly to breathing practices. Even children with serious psychiatric disorders may benefit [39]. A Breath-Body-Mind teacher recently described the response to Coherent Breathing of an adolescent with autism (personal communication March 20, 2019).

7.1 Case #4 Adolescent with Autism

"I teach special yoga for children with autism. I have been working with a profoundly autistic adolescent, named Adam. When I started to teach him yoga several years ago, he was very

aggressive and extremely sensitive to sound (he wore headphones to block out noise). His anxiety levels differ from week to week.
I tried teaching Adam the coherent breathing yesterday with the most amazing results! His anxiety decreased very rapidly. All the chatter in his mind stopped and he made great eye contact with me for the first time. I had been concerned that his sensitivity to sound would make it difficult to use the 2-Bells breath pacing track [2-Bells, Coherence, Stephen Elliot, 2006]. Despite his being so sound defensive, the 2 bells track really focused him! He liked it and was able to follow my instructions. It was amazing."

Children in classrooms, afterschool programs, and refugee camps are using Coherent Breathing and related practices to improve sleep, mood, anxiety, PTSD, somatic symptoms, self-regulation, mental focus, behavior, and their ability to relate to others. [10, 21, 39, 40] (www.nolimitgen.org). Traumatized children often have difficulty sleeping and may feel unsafe and anxious at bedtime. Once they are taught Coherent (Resonate) breathing using a small stuffed animal called a Breath Buddy, they are better able to calm themselves and to fall asleep. To observe this technique, see free access teaching modules by Dr. Gerbarg and Dr. Brown at www.nolimitgen.org.

The following is an example of specific benefits of simple paced breathing and movement practices for at-risk children in a low-income inner-city school. Dr. Richard Brown introduced Breath-Body-Mind techniques for children at an elementary school ranked in the lower 20% of schools in New York City. Most of the children came from stressful home environments. For example, many were being raised by a single grandparent, many had witnessed violence or had themselves experienced abuse. When asked to describe the challenges facing their school, the administration and teachers identified "runners" as their biggest problem. "Runners" are children who are so incapable of regulating their emotions that whenever they feel upset, they scream uncontrollably and run out of the school onto the streets. The school then calls the police department. It usually takes hours for the police to find and return the lost child.

Dr. Brown gave the school counselors and one teacher a Breath-Body-Mind lesson each month for three months on how to teach simple breath and movement practices in their classrooms. The teachers led the children for a total of about 5 minutes each morning using the following practices: shaking, 'Ha' breath (shouting the sound 'Ha' on the exhale while thrusting arms forward or using other arm movements) [21], and three minutes of Coherent Breathing. They also encouraged the students to use these techniques for a few minutes during the day to calm down, focus attention or cope with difficult emotions. When Dr. Brown returned to the school three months later, the staff reported that the "runners" had stopped running and there had been no further incidents. Apparently, the simple breath techniques improved the children's abilities to tolerate and regulate their emotional reactions enough to stay in the school.

8. Health and Longevity

High respiratory sinus arrhythmia and heart rate variability are associated with better health and longevity [41]. Low respiratory sinus arrhythmia and heart rate variability are associated with poorer health, chronic stress, anxiety, panic disorder, PTSD, depression, and aging [42]. The effects of paced breathing on respiratory sinus arrhythmia and heart rate variability have been well

documented. For most adults, gentle breathing at 3 to 6 cpm increases heart rate variability high-frequency spectra activity [17], leading to a calm state. Slow VRBPs are clinically useful because they can rapidly reduce the sympathetic overdrive associated with states of stress and anxiety while increasing parasympathetic activity. Studies show that slow VRBPs are associated with reduction in perceived stress, anxiety, and insomnia [9, 23].

Inflammation has been linked to an increasing number of illnesses including cardiovascular, gastrointestinal, musculoskeletal, depression, and brain aging (neurodegenerative). Studies have identified anti-inflammatory vagal pathways. Vagal afferents modulate the hypothalamic-pituitary-adrenal (HPA) axis release of glucocorticoids [43]. Other pathways may have cholinergic anti-inflammatory and anti- tumor necrosis factor-alpha (TNF-α) effects [44]. Thus, mind-body and breathing practices have multiple potential therapeutic applications.

8.1 Stress-Related Medical Condition – Inflammatory Bowel Disease

Too often conventional treatments for stress-related conditions such as inflammatory bowel disease (IBD), fall short of remission, even with intense drug treatments and bowel resections. IBD (Crohn's disease and ulcerative colitis) is a chronic disorder of immune response exacerbated by stress that can be disabling or life-threatening.

Gerbarg and colleagues [3] conducted a double-blind, randomized controlled trial of 29 patients with IBD at the Cornell-Weill Medical Center IBD Center. Patients were randomly assigned to either a BBM workshop (VRBPs alone and synchronized with movement, visualization, and Open Focus Attention Training [45] or an educational seminar (active control) of equal duration. Both groups continued their usual IBD treatments. Both the BBM workshop and the educational seminar provided 9 hours during 2 consecutive days followed by a 1-hour follow-up per week for 6 weeks, then once a month for 18 additional weeks. After 6 months, compared to the educational seminar group, the BBM group had significantly greater improvements on the Brief Symptom Inventory ($P = 0.04$), Beck Anxiety Inventory ($P = 0.03$), Beck Depression Inventory ($P = 0.01$), IBD Questionnaire ($P = 0.01$), Perceived Disability Scale ($P = 0.001$), and Perceived Stress Questionnaire ($P = 0.01$) compared with no significant change on any measure in the control group. In the BBM group only, significant decreases were documented on measures of physical and emotional symptoms and the inflammatory marker C-reactive protein ($P= 0.01$). No significant improvements were found in the educational seminar control group.

Although additional studies with larger groups of patients are needed, this study validates our hypothesis that Slow VRBPs (e.g. Coherent Breathing), through vagal activation of anti-inflammatory pathways, may trigger anti-inflammatory cascades within the gastrointestinal tract that promote healing. Furthermore, even severely ill medical patients, by learning and practicing polyvagal-informed breath and related practices, can reduce the stress reactivity driving the progression of their illness for many years. This model of mind-body healing centered on slow breathing could be used in numerous conditions through healing effects on both psychological and physical levels.

9. Stress in Caregivers, Healthcare Professionals, and First Responders

VRBPs can be used to prevent or treat illness in an individual or group, to reduce caregiver stress and to promote empathic responding by therapists and other professionals. Working with traumatized individuals and others with psychiatric disorders is stressful. While extending compassion to patients, healthcare providers and other caregivers may be affected vicariously, neglect their own needs, and become stressed and physiologically dysregulated themselves.

9.1 The Polyvagal Theory and the Therapist-Patient Relationship

Psychophysiological states supported by the myelinated vagus facilitate trusting relationships, including between therapist and patient. According to the Polyvagal Theory, when the therapist is in a calm state of sympatho-vagal balance, the motor pathways of the social engagement system that control the muscles of the neck, face and larynx soften the expression to communicate positive emotions and soften the voice to become more melodic (prosodic), simulating the sound of a loving mother talking gently to her child [4].

When physiological changes within the therapist resonate with the patient, conditions favor co-regulation towards psycho-physiological calming and engagement of the patient.

Coherent (Resonant) Breathing can be employed in treatment by the therapist discretely (quiet breathing with eyes open) to counteract the effects of stress [46] and to self-induce more psychophysiological activity. The therapist may sustain his or her own parasympathetic state, while allowing vocal tones and facial expressions to help calm the patient. In addition, the therapist may teach the patient to breath gently at a coherent rate such that the patient learns to self-induce a calm parasympathetic state that facilitates trust, engagement, and connectedness. This is further advanced when both patient and therapist engage in Coherent (Resonant) Breathing together, such that defensive reactions are minimized while calm, understanding, compassionate responses are optimized. Patients and therapists also report increased mental clarity which facilitates insight, growth, and symptom resolution [3, 21, 47].

9.1.1 The 2001 New York World Trade Center Attacks

During and after the 2001 World Trade Center attacks, hundreds of thousands of people, including the victims and their families, witnesses, area residents, first responders, caregivers, Ground Zero workers, and volunteers suffered acute and chronic physical and psychological symptoms related to the disaster. Despite receiving conventional treatments, tens of thousands remained symptomatic and eventually sought complementary and alternative therapies. Since 2008, thousands of people with persistent physical and psychological illnesses related to those attacks participated in Breath-Body-Mind workshops in New York Metropolitan area.

Two open naturalistic program evaluations assessed the effects of 2-day (total 10-hour) BBM workshops that included paced breathing, breathing with movement, open focus meditation, and group processes [8]. All participants were given the Mini International Neuropsychiatric Schedule (prior to the intervention [48]. For the first evaluation in 17 participants (2009), comparisons of baseline measures (immediately before the workshop) with tests taken immediately after the workshops found significant improvements on the following: Anxiety Sensitivity Index, ASI ($t = 5.33$, $df = 16$, $p < .001$), Beck Anxiety inventory, BAI ($t = 4.02$, $df = 13$, $p < .001$), and Beck Depression

Inventory-II, BDI-II (t = 7.38, df = 16, $p < .001$).

Among the 27 participants in the second evaluation (2010), the experiences related to the attacks included: First Responders (n = 6); firemen (n = 4); worked with and/or directly affected (n = 4), emergency healthcare provider (n = 2); Ground Zero worker post attack (n = 6), lived near the WTC (n = 10), witnessed the attacks (n = 8), family member of a first responder (n = 2), and escaped from the WTC towers (n = 2). Compared to pre-intervention, testing immediately following BBM showed significant improvements in long-standing symptoms based on change in scores. Out of 27 participants, 12 met DSM-IV criteria for MDD, 14 for GAD, 23 for PTSD, 16 for panic disorder, and 9 for agoraphobia. Following the 2-day workshop, significant improvements were documented: scores decreased on ASI (t = 3.93, df = 21, $p < .001$); BDI (t = 4.01, df = 20, $p < .001$); BAI (t = 3.09, df = 21, $p = .001$) [40].

9.2 The 2010 Deepwater Horizon Oil Spill in the Gulf of Mexico

Certain situations, particularly during and after mass disasters are more likely to impact providers. The large numbers of victims and survivors can rapidly overload the healthcare resources leading to longer work hours and feelings of being overwhelmed. In addition to vicarious caregiver trauma, first responders and healthcare workers themselves may be directly affected by the disaster (e.g. floods or fires). The effects of VRBPs and related mind-body practices on healthcare providers in such circumstances were demonstrated in a study funded by the Mississippi State Department of Mental Health. This study was approved by the Boston University Medical Center and the Mississippi State Hospital Institutional Review Boards. The healthcare system was overloaded. Healthcare providers and their families were also affected by the hurricanes, floods, fires, and the British Petroleum (BP) oil spill [46].

Following informed consent, 79 providers of mental healthcare to populations affected by the 2010 Gulf oil spill enrolled and completed a 3-day (18-hour) Breath-Body-Mind train-the-trainer program. Psychological tests were obtained immediately prior to and after the training. Thirty participants returned the 6-week follow up questionnaires. Baseline scores on the Perceived Stress Scale (PSS) were significantly elevated compared to normative values. Among the 30 respondents, six weeks after the intervention, PSS scores dropped to normal levels. Comparison of scores on the Exercise Induced Inventory (EIFI) between baseline and immediately after the BBM training showed significant improvements in: Positive Engagement (mean increase of 2.19 ± 3.26 ($t = 4.04$, $df = 35$, $p < 0.001$); Revitalization (mean increase of 3.94 ± 3.41 ($t = 6.95$, $df = 35$, $p < 0.001$); Tranquility (mean increase of 3.42 ± 2.99 ($t = 6.86$, $df = 35$, $p < 0.001$); and Physical Exhaustion (mean decrease of 2.67 ± 4.28 ($t = -3.74$, $df = 35$, $p < 0.001$). After 6 weeks, EIFI scores (n = 29) showed sustained increases in Revitalization increased 2.55 ± 3.61 ($t = 3.81$, $df = 28$, $p < 0.001$); Tranquility increased 2.48 ± 3.32 ($t = 4.02$, $df = 28$, $p < 0.001$); and sustained decreases in Physical Exhaustion decreased 1.66 ± 4.06 ($t = -2.20$, $df = 28$, $p < 0.001$). Positive Engagement scores showed increases of 1.07 ± 3.55 but did not reach statistical significance ($t = 1.62$, $df = 28$, $p = 0.12$) [40, 46]. Participants used the mind-body practices to better manage their own stress and to alleviate stress-related symptoms in their clients.

9.3 Contributing to Individual Health, Public Health, and Global Health

Short programs of breathing, movement, mental focus, and relaxation practices are being used

for immediate and long-term relief of trauma from mass disasters worldwide. A small number of trainers can provide rapid emotional relief to vast numbers of survivors and can train indigenous people to continue teaching others [8, 21, 46, 49](see Breath-Body-Mind.com). Such interventions may not require equipment or electricity and they can be relatively low in cost.

To address the current global epidemic of stress, depression, PTSD, alienation, violence, and suicide, priority should be given to low-tech, accessible, safe, inexpensive evidence-based interventions. Interventions that require electrical, magnetic, or computer-based equipment will be limited to the few who can afford them. Even wealthy countries are finding that the cost of prescription medications, in terms of money, addiction, adverse side effects, and mortality, is unsustainable. The model of one therapist to one patient is not only costly, but impractical in many areas where health care professionals are sparse. Group interventions are less costly and provide the added benefits of group psycho-social support, activation of the social engagement systems, and group reinforcement for continuation of the practices.

10. Research Issues – Methods and Consequences

The following issues recur in research studies of mind-body practices. This discussion focuses on studies of Coherent (Resonant) Breathing as an illustrative example.

10.1 Monotherapy or Multi-component

A question often arises regarding whether to study a VRBP alone or in combination with other mind-body techniques or therapies. Both types of studies are needed. On the one hand, greater understanding of single practices is needed. On the other hand, most practices are traditionally done as part of a sequence of techniques. Furthermore, within a sequence of practices—for example, movement, breathing and meditation—the earlier practices are believed to prepare the system to respond better to the subsequent practices.

10.2 Technique Parameters

Based upon the target symptoms or changes of interest, parameters of the specific breath practice should be identified and clearly described, for example, choosing the breathing rate(s). If the goal is to study physical performance at high altitudes or cardiovascular function in patients with heart disease, a Coherent Breath rate of 6 cpm may be preferable because this rate is more activating. Also, it optimizes changes in distribution of blood flow, arterial function, baroreflex sensitivity, tolerance of hypoxia, and oxygen saturation [50, 51]. However, if one intends to reduce symptoms of anxiety, insomnia, or trauma, then a lower Coherent Rate of 5 cpm on average is preferable. This slower rate may have more of an effect on the parasympathetic system such that it is more calming (physically and emotionally) and improves emotion regulation. Also, it may upregulate the social engagement system, which helps improve prosocial abilities such as relating to others, trust, connectedness, love, empathy, compassion, and cooperation.

10.3 Intervention Subject Training Considerations

VRBPs are different from natural automatic breathing. Therefore, it requires not only training,

but also a period of practice, usually from a few hours to a few days, for most people to become comfortable, able to perform the VRBP without any stress. Unfortunately, many studies do not provide for a period of acclimation. Consequently, the added stress or effort of performing the VRBP activates the sympathetic system, undermining the goal of parasympathetic activation. Although this may be a minor issue in studies of Coherent Breathing, it can become more of a confounder in studies of more difficult VRBPs such as *ujjayi* or Ocean Breath [52]. Ocean Breath entails creating a slight contraction of the laryngeal muscles and partial closure of the glottis to create a sound like white noise or ocean waves. Many people initially have difficulty creating this sound and requires repeated practice to obtain sufficient control over the laryngeal muscle. Some people, particularly older individuals cannot produce the sound correctly due to insufficient control over the muscles involved. Beginners often strain and exhale forcefully in their attempts to perform ocean Breath. In contrast, Coherent Breathing is simpler as it only requires slowing the respiratory rate and breathing gently.

Other breathing practices, such as unilateral nostril breathing or alternate nostril breathing can use a simple breath count of inhale 4, hold 4, exhale 4. However, they can become increasingly complicated with innumerable variations, for example, inhale 8, hold 4, exhale 12, hold 4. More complicated counting requires greater mental effort with corresponding increased sympathetic activation. Unilateral or alternate nostril breathing has shown calming effects and can reduce stress and anxiety [53]. However, because the hand must be held over the nose to manipulate the nares, it cannot be done inconspicuously.

10.4 Selecting VRBPs To Be Studied - Modifications for Target Symptoms and Patient Characteristics

The target symptoms, processes, and functions to be addressed should be considered when selecting specific VRBPs to study. Also, the characteristics of the population to be studied is important. For example, it would be necessary to adapt a protocol for geriatric or medically ill patients, especially those with respiratory problems (e.g. asthma, inhalation injuries, chronic obstructive pulmonary disease, COPD). Similarly, modifications would be advisable for military service personnel [47, 54], sexual trauma survivors [2], children, individuals with psychiatric disorders (e.g. autism, depression, post-traumatic stress disorder, bipolar disorder, schizophrenia), disaster survivors, refugees, and people of different cultures or religions [8, 49].

The following are a few examples of modifications of VRBPs from our clinical practices and research studies that have been necessary to enable patients to perform Coherent Breathing comfortably, without physical or emotional stress, and with optimal benefit.

10.4.1 Asthma

Most patients with asthma can learn Coherent Breathing without difficulty and find that it improves their respiratory function over time. However, some patients with poorly controlled asthma may experience increased respiratory distress. The initial parasympathetic activation that occurs at the start of slower (e.g. Coherent) breathing may cause a slight narrowing of airways, which makes breathing more difficult. This adverse reaction can be prevented using a breathing technique in which the individual uses imagination or visualization to move the breath up and

down inside the torso in time with their breathing. In so doing, the airways are kept open such that the patient can engage in Coherent Breathing without discomfort or distress.

10.4.2 Arthritis

Arthritic changes in older individuals can restrict movement of the ribs, limiting expansion of the thoracic cavity. Consequently, it may be difficult and stressful to try breathing at 5 cpm. An effective modification is to simply perform Coherent Breathing at 6 cpm.

10.4.3 Highly anxious patients

Highly anxious patients with elevated resting respiratory rates, e.g. 20 to 40 breaths per minute or more, may be unable to reduce their rate to 5 bpm initially. In such cases, by interweaving instructions for relaxation or 'softening' of muscles of the face, neck, shoulders, back, arms, and legs, the clinician gradually guides the patient to reduce the respiratory rate. If the respiratory rate becomes slower, but still elevated, then the patient is instructed to begin practicing paced breath with equal duration of inhalation and exhalation. Using a progressively slowing breath-pacing audio recording, the patient reduces the rate by one breath per minute each day until their coherent rate.

Other methods can be employed to enable highly anxious patients to reduce their respiratory rate. For example, patients who tend to hyperventilate during panic attacks or limited symptoms attacks, may find it easier to slow their breath rate if arm movements are coordinate with the breath pacing. Rather than focusing their attention on breathing, which occasionally heightens anxiety, shifting the focus to performing arm movements can be less anxiety provoking.

10.4.4 Insomnia

For most people who have difficulty going to sleep, Coherent Breathing at 5 bpm is a simple, effective solution. However, for those who continue to struggle with wakefulness at night, doubling the length of the exhalation makes the breath practice even more sedating. Adding resistance breathing, such as Ocean Breath (ujjayi) enhances the sedative effect.

10.4.5 Schizophrenia

Sedating side effects from medications used to treat patients with schizophrenia may cause them to fall asleep if they lie supine while doing Coherent Breathing. It may be necessary for them to sit up or even walk to stay awake during Coherent Breathing.

10.4.6 Military Service Personnel and Veterans

In general, active duty military personnel tend to be physically fit and action oriented. Trained to exert intense physical effort, they are likely to hold tension in thoracic and abdominal muscles and to exert excess force when learning breathing techniques. The net effect interferes with the shift towards sympathovagal balance and optimal relaxation. Brown and Gerbarg find that they respond well to more intense movement and breath practices before doing slow, calming breath,

such as Coherent Breathing. Extra coaching may be needed to relax the muscles and breathe more gently. The presence of post-traumatic stress symptoms, over-reactivity and traumatic brain injuries must be considered as well.

10.4.7 Children

Due to size differences, the optimal Coherent Breath rate varies in children. Most healthy children aged nine or above can perform Coherent Breathing at 5 or 6 bpm. Smaller children between ages 4 and 9 may require respiratory rates between 6 and 10 bpm. Studies of the effects of different breath rates on HRV in children of various sizes and ages are needed for more precise breath pacing.

10.4.8 Tall adults

Adults who are six feet tall or more, have lower Coherent Breath rates, between 3 and 4.5 bpm. Most can start at 5 cpm and within a few weeks, using adjustable breath pacing apps, reduce their rate to as low as 3 cpm if needed.

10.5 Study Context and Environment

Studies of the effects of VRBPs on parasympathetic system, neurotransmitters, brain electrical activity, brain imaging, emotion regulation, and prosocial functioning (e.g. trust, bonding, compassion) are affected by the environment and context of the study. For example, group interventions enhance feelings of safety, trust, bonding and compassion as the participants get to know and trust one another over time. Sitting in a familiar room while completing self- assessment questionnaires may feel safer than being tested in a laboratory or brain imaging suite. The perception of the safety of the environment impacts the psycho-physiological state.

10.6 Qualities of Research Staff and Intervention Trainers

The atmosphere, attitude, sensitivity, facial expressions, and voice quality of the staff and instructors who interact with the study subjects can affect the responses being studied. For example, intimidating staff can trigger defensive fear reactions.

10.7 Ability of Staff to Teach, Monitor, and Optimize the Practices

How well do the research staff and the breathing teachers understand the nuances of teaching breath practices, including how to recognize subtle indicators of stress or discomfort (which people may not mention unless specifically asked)? Do they know how to recognize and correct suboptimal performance of each breathing technique? Just as with any other treatment, if the technique is off, the outcome will be affected or even invalidated.

10.8 Assessment of HRV and Polyvagal-informed Breath Practices

Assessment of HRV [55] and incorporation of polyvagal-informed breath practices, such as Coherent (Resonant) breathing into research studies could provide more consistent methods,

enable comparisons between studies, illuminate mechanisms of action, yield better outcomes, and facilitate development of more effective, efficient mind- body programs. It is imperative that those who do research on breathing practices take the time to understand the more subtle aspects of VRBPs to improve the quality, validity, and impact of their findings.

11. Summary Discussion

Adverse childhood events, stress and trauma can impair our capacities for connection, self-regulation, and compassion. The long-lasting effects on stress response systems, inflammation, and oxidative stress are associated with increased risks for many diseases. Voluntarily Regulated Breathing Practices (VRBPs) have rapid, widespread effects on neural pathways that orchestrate stress response, activate social engagement networks, and upregulate innate healing processes. By rapidly balancing the autonomic system and shifting neurophysiological states from defensive to prosocial, slow VRBPs provide an efficient method for improving the physical and mental health of individuals and large populations. Consistent with Polyvagal Theory, Coherent (Resonant) breathing at 3.0 to 6.0 breaths per minute for most adults balances the autonomic system and activates parasympathetic pathways that support self- regulation and prosocial emotions, such as love and compassion.

Research continues to uncover effects of VRBPs, such as entrainment of brain electrical activity, improved attention and cognitive function, decreased inflammation, and reduced symptoms of stress, anxiety, insomnia, depression, and post-traumatic stress. The quality of clinical studies can be further improved by adapting the techniques to target symptoms and subject characteristics, attention to the parameters of each technique, providing learning time for subjects to perform breath practices without stress, and using measures of changes in autonomic function, such as heart rate variability.

Global health could benefit from safe, effective, evidence-based breathing techniques and related mind-body practices. These practices could be integrated into healthcare systems and other community services by training healthcare providers, yoga therapists, school personnel, first responders, and those who work in non-profits and non-governmental organizations.

Author Contributions

Patricia L. Gerbarg and Richard P. Brown formulated the ideas and compiled the evidence for this paper on the relationships between breath practices and connection, co-regulation and compassion, as well as how this understanding can benefit caregivers and inform treatments for PTSD and other symptoms in survivors of trauma and disasters. Dr. Gerbarg was the primary writer for this article, assisted by Dr. Brown.

Dr. Chris Streeter is co-creator of the Vagal-GABA Theory and was the Primary Investigator for the MRS study of yoga and coherent breathing in depression. She also was co-investigator for the study of BBM training for caregivers following the Gulf Horizon oil spill. She provided the data analysis and descriptions for that study. In addition, she proofread this entire paper and contributed her comments.

Dr. Martin Katzman and Dr. Monica Vermani were co-investigators and co-authors for the BBM trial in GAD, 2012. They collected and analysed the data, provided the descriptions, and made it

available for this paper. They also conducted the evaluations of programs given by Dr. Brown and Dr. Gerbarg for first responders and others affected by the 9/11 World Trade Center attacks.

Competing Interests

Dr. Patricia L. Gerbarg and Dr. Richard P. Brown teach Breath-Body-Mind programs for academic institutions, schools, non-profits, and for-profit organizations. In addition to pro-bono service projects, they sometimes receive lecture fees, honoraria, and travel expenses. Some of their books include educational information about mind-body practices.

Dr. Chris C. Streeter is a trained Breath-Body-Mind instructor and has no financial disclosures. Dr. Monica Vermani has no conflicts of interest in relation to this study. She is a trained Breath-Body-Mind instructor

Dr. Martin A Katzman has been a consultant or advisory board member of GlaxoSmithKline, Lundbeck, Eli Lilly, Boehringer Ingelheim, Organon, Astra Zeneca, Jannsen-Ortho, Solvay, Bristol- Myers Squibb, Shire, Sunovion, Pfizer, Purdue, Merck, Astellas, and Bedrocan. He has undertaken research for GlaxoSmithKline, Lundbeck, Eli Lilly, Organon, AstraZeneca, Jannsen-Ortho, Solvay, Genuine Health, Shire, Bristol-Myers Squibb, Takeda, Pfizer, Hoffman La Roche, Biotics, Purdue, Astellas, Jannsen-Ortho, and Forest. He has received honoraria from GlaxoSmithKline, Lundbeck, Eli Lilly, Boehringer Ingelheim, Organon, Astra Zeneca, Janssen-Ortho, Solvay, Bristol-Myers Squibb, Shire, Sunovion, Pfizer, Purdue, Merck, Astellas, and Bedrocan. He has received research grants from CIHR, Sick Kids Foundation, Center for Addiction and Mental Health Foundation, Canadian Psychiatric Research Foundation, Canadian Foundation for Innovation, and the Lotte & John Hecht Memorial Foundation.

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