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# Effects of *Shambhavi Mahamudra Kriya*, a Multicomponent Breath-Based Yogic Practice (*Pranayama*), on Perceived Stress and General Well-Being

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## Abstract

Stress-induced disorders such as anxiety represent the leading causes of adult disability worldwide. Previous studies indicate that yoga and other contemplative practices such as *pranayama*, or controlled yogic breathing techniques, may be effective in the treatment of mood disorders and stress. In this study, 142 individuals (mean age = 43 years; SD = 13.90) participated in a 3-day retreat program during which they learned *Shambhavi Mahamudra kriya*, which is a yogic practice that includes both deep breathing and meditation techniques. Participants were instructed to practice the *kriya* each day for 21 minutes. After 6 weeks of daily practice, participants reported subjectively lower levels of perceived stress (Perceived Stress Scale) and higher levels of general well-being (General Well-Being Scale) compared to baseline. These results support the notion that *Shambhavi Mahamudra kriya* may represent a natural treatment for stress reduction.

## Keywords

meditation, yoga, pranayama, kriya, breathing, stress, well-being, integrative health

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Stress-induced disorders such as anxiety represent the leading causes of adult disability worldwide[1,2] and account for an estimated 60% to 80% of physician office visits.[3] Stress can also exacerbate disorders such as cardiovascular disease, obesity, and chronic pain as well as mental health, gastrointestinal, and sleep disorders. Similarly, anxiety is the strongest risk factor for depression, and both conditions are associated with anomalies in mood-related areas of the brain.[4]

Stress is a state of disharmony caused by perceived threat and other intrinsic or extrinsic adverse factors that is counteracted by multiple behavioral and physiological responses, which represent an adaptive response to reestablish homeostasis. Chronic stress involves a prolonged or repeated threat to homeostasis that may result in dysregulation of the hypothalamic-pituitary-adrenal axis and autonomic nervous system.[5] Chronic stress can lead to premature aging, immunosuppression, mental disorders, reproductive suppression, and a decreased ability to terminate the stress response.[6] Chronic stress and increased inflammation may cause or aggravate anxious and depressive disorders.[7-9] Stress, hypothalamic-pituitary-adrenal axis deregulation, and increased oxidative stress, or heightened inflammatory burden, have an interconnected relationship and are associated with mood disorders such as anxiety and depression.[10] Studies on tricyclic medication used to treat depression and some anxiety symptoms have suggested the mechanism of action to include the modulation of inflammatory cytokines.[11-13]

Numerous studies have associated yoga- and meditation-based practices with positive psychological and physiological outcomes in both clinical and nonclinical populations.[14-17]

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Increasing evidence suggests that mediation and yoga practices have positive effects on the regulation of the hypothalamic-pituitary-adrenal axis and inflammatory processes.[18-20] Studies have suggested that yoga and other contemplative practices may be equally effective as pharmacotherapy in the treatment of mood disorders such as anxiety and depression.[21,22]

Controlled yogic breathing or *pranayama* is 1 of 8 practices used in the traditional system of yoga, which also includes meditation and yogic postures. While relatively few studies have been conducted on *pranayama*, such breathing techniques have been shown to elicit significant changes in both human physiology and psychology. Studies using *pranayama* interventions have reported changes that include reduction in hypertension, breathing frequency, and stress as well as increased heart rate variability, sympathovagal balance, cognitive performance, central neural processing, dexterity, and motor coordination.[23-28] While the burgeoning study of *pranayama* has been recently established, the full efficacy of various breathing techniques and especially the biological mechanisms mediating the effect of yogic breathing are largely unknown.

*Shambhavi Mahamudra kriya* is a protocol within the Isha Yoga lineage that includes both *pranyanama* and meditation-based techniques. A *kriya* is a yogic action, or inner technique, such as breath control. *Shambhavi Mahamudra* is an integrative system of several breathing techniques that incorporate multiple limbs of traditional *Raja Yoga* or the yoga described by Patanjali in the *Yoga Sutras*.[29] The *Shambhavi Mahamudra* practice is taught by a nonprofit international humanitarian organization. The practice is performed for 21 minutes daily whereby multiple deep, controlled breathing techniques and the engagement of *bandhas*, or muscular locks in the abdomen and pelvic floor, are applied for 15 minutes; the practice concludes with about 5 minutes of open-monitoring meditation.

Currently, very few studies exist on the *Shambhavi Mahamudra* practice specifically. However, one study on Isha Yoga in expert practitioners using a set of 6 yogic practices that included the *Shambhavi Mahamudra kriya*, reported increased heart rate variability and sympathovagal balance in practitioners compared with controls.[26] The increased heart rate variability in the absence of increased heart rate revealed balance in vagal afferents during supine rest and deep breathing in the yoga practitioners compared with controls. The authors concluded that the expert yoga practitioners may have improved long-term cardiac responses to daily stresses. In addition, a small pilot study performed real-time electrocardiogram monitoring in expert practitioners during their practice of *Shambhavi Mahamudra*.[30] The authors reported that the various *pranayama* techniques employed during the *kriya* elicited unique profiles in terms of vagal and sympathetic tone. Thus, *Shambhavi Mahamudra kriya* may represent a natural, low-cost breath-based intervention with the potential to decrease stress and increase general well-being.

The present protocol differs from commonly used techniques in mental health improvement such as cognitive behavioral therapy. Cognitive behavioral therapy seeks to alter behavior by focusing on the sensations, thoughts, images, and beliefs of the patient and how these experiences relate to emotional responses and coping. Mind-body practices employ a slightly different approach whereby the patient focuses on only what arises naturally while objectively observing, which leads to personal insight and self-regulation of behavior and thought. Some data suggests a synergistic opportunity in the application of combination therapies that consist of mind-body practices such as yoga with cognitive behavioral therapy for mood disorders such as anxiety.[31,32]

Yogic breathing practices such as *Shambhavi Mahamudra* may represent efficacious therapies with few side effects for stress and its associated disorders. To date, the efficacy and biological mechanisms mediating the beneficial effects of *pranayama* practices on the stress response and mood are not fully understood. Very limited data are currently available on the *Shambhavi Mahamudra kriya* specifically, and additional studies are warranted. Given that yogic breathing induces relaxation responses,[33] it was hypothesized that the *Shambhavi Mahamudra* practice promotes decreased stress and increased levels of subjective well-being. The present study reports the effects of a daily 21-minute *Shambhavi Mahamudra* practice for 6 weeks on perceived stress and general well-being in a healthy population.

## Materials and Methods

### Intervention

Participants attended a nonresidential retreat program in October 2012 in a major Midwestern city hosted by the Isha Foundation for 3 full days. Participants engaged in the *Jnana Yoga* or knowledge-based educational components of the program, were introduced to *Isha Kriya*, which is a guided yogic practice, and were taught the self-guided *Shambhavi Mahamudra kriya*, which was developed by Sadhguru Jaggi Vasudev, in detail. Most of each day was spent listening to lectures on various yogic topics and precepts used to calm the mind. Vegetarian meals were served to all attendees. Participants were encouraged to establish a daily meditation practice and perform the *Shambhavi Mahamudra kriya* twice daily on completion of the program.

Prior to the start of the practice of *Shambhavi Mahamudra kriya*, a minute of reflection on the basic precepts presented during the program is then observed followed by the performance of 5 minutes of 3 gentle, preparatory yoga *asanas* (postures). Subsequently, the 21-minute *kriya* (inner action) begins and is practiced in *Siddhasana* (accomplished pose), which is a cross-legged posture with left heel pressing the perineum. *Shambhavi Mahamudra* begins with *pranayama* (controlled yogic breathing) called *Sukha Kriya* or *Nadi Shodhana,* which is an alternate-nostril breathing technique (ie, a slow-paced *pranayama*) to encourage balance in the mind for 6 to 7 minutes, followed by 21 long repetitions of the *bija mantra* (root syllable) *Om* chanted aloud with the thumb and forefinger touching in *jnana* (wisdom) *mudra* (seal). Next, the breathing exercise *Viparita Swasa* or *Bhastrika pranayama* (ie, a fast-paced *pranayama*) is practiced for 3 to 4 minutes and concludes with breath retention (*kumbhaka* or vessel) on both the inhalation and the exhalation while actively engaging the *bandhas* (muscular and energetic contraction) on the pelvic floor (*moola bandha*), lower abdomen (*uddiyana bandha*), and throat (*jalandhara bandha*). Finally, the *Shambhavi kriya* practice concludes

**Table 1.** Factor Analysis Using the General Well-Being Scale.

| | 12 Items | | | | 8 Items[a] | |
|---|---|---|---|---|---|---|
| Items | Component 1 | Component 2 | Component 3 | Total Initial Eigen Value | Component 1 | Total Initial Eigen Value |
| I have excellent mental clarity | 0.768 | −0.283 | 0.012 | 5.289 | 0.796 | 4.711 |
| My ability to stay on task is excellent | 0.725 | −0.324 | 0.049 | 1.213 | 0.759 | 0.764 |
| I'm emotionally balanced | 0.776 | −0.189 | −0.049 | 1.004 | 0.797 | 0.630 |
| I have deep inner peace | 0.764 | −0.147 | −0.035 | 0.848 | 0.776 | 0.501 |
| I rarely get up in the middle of the night | 0.480 | 0.575 | −0.388 | 0.739 | — | — |
| My energy level is excellent | 0.759 | 0.144 | 0.042 | 0.604 | 0.739 | 0.471 |
| It is easy for me to fall asleep | 0.548 | 0.554 | −0.239 | 0.528 | — | — |
| I have excellent self-confidence | 0.768 | −0.170 | 0.005 | 0.465 | 0.786 | 0.347 |
| My productivity is excellent | 0.788 | −0.140 | 0.015 | 0.416 | 0.799 | 0.311 |
| I rarely feel anxious | 0.694 | 0.065 | 0.056 | 0.336 | 0.679 | 0.264 |
| I rarely get colds/flu | 0.396 | 0.417 | 0.253 | 0.307 | — | — |
| I have frequent headaches | 0.179 | 0.292 | 0.849 | 0.251 | — | — |

[a]Used for analyses.

with a 5-minute period of *Vipassana* meditation (*dhyana*) or open-monitoring meditation. The *Shambhavi Mahamudra kriya* takes approximately 21 minutes to complete. Please note that this outline of the *kriya* is intended for research purposes only; the *Shambhavi Mahamudra* practice should be learned under the instruction and observation of a qualified teacher.

The 3-day program in which *Shambhavi Mahamudra* is taught incorporates *Jnana Yoga*, or the yoga of the intellect, using simple precepts that calm and center the mind taught over multiple days in a lecture series. The participants spend about 16 hours in didactic lecture on yogic topics and precepts over the course of the program. The precepts encourage personal growth and empowerment through the acceptance of responsibility for the uncertain circumstances encountered throughout the human experience. Participants perform about 10 hours of guided, gentle Isha Hatha Yoga over the course of the retreat program. Participants are also introduced to a guided *kriya* yoga meditation called *Isha Kriya*, which focuses on seated meditation and an internal action or *kriya*, which is a specific thought in this case. Over the 3 days, participants receive about 26 hours of instruction, which includes teacher demonstration, on the *Shambhavi Mahamudra kriya*. Before the conclusion of the program on day 3, participants complete the *Shambhavi Mahamudra kriya* twice for about 21 minutes with minimal guidance. The total dosage of the full *Shambhavi Mahamudra kriya* for this study was 21 minutes performed twice on day 3 of the retreat program (total n = 42 minutes), then at least 21 minutes daily for 6 weeks postretreat.

## Survey Setting and Distribution

Survey data were originally collected for quality improvement purposes by the organization that developed and teaches *Shambhavi Mahamudra kriya* and *Isha Kriya*; the Isha General Well-Being Surveys were not originally designed for research purposes. The Perceived Stress Scale is one of the most commonly used psychological and psychosomatic research instruments to assess and report perceived stress level.[34] Prior to completing the surveys, participants were informed that deidentified survey data may possibly be used in future publications. Institutional review board approval was obtained from Quorum Review in July 2015 for this data to be analyzed for research purposes in accordance with the guidelines of the study of human subjects.

Participants were invited to voluntarily complete baseline and follow-up surveys on SurveyMonkey.com. Two weeks prior to the program, baseline survey links were sent via email to all individuals who had registered to attend. The survey contained demographic questions, including name, age, gender, past meditation experience, frequency and duration of current meditation, and the measures described below (see Outcome Measures section). Baseline survey collection ended 4 days prior to the start of the program.

The follow-up survey was emailed 6 weeks after the program to all persons who attended and for whom baseline data were obtained. Identical measures were used in the follow-up survey with the addition of questions regarding how often respondents practiced *Shambhavi Mahamudra* or *Isha Kriya* and the amount of time they meditated each day.

## Outcome Measures

*Perceived Stress Scale.* The Perceived Stress Scale (PSS)[35] includes 10 questions devised to ascertain the degree to which respondents perceive their lives to be "unpredictable, uncontrollable, and overwhelming." Sample items include: "In the past month, how often have you felt that you were on top of things?" and "In the past month, how often have you felt things were going your way?" Items are answered on a 5-point Likert-type scale ranging from 1 = never to 5 = very often; 4 items are reverse scored. The final score is a sum of all items and can range from 10 to 50 with higher scores indicating greater perceived stress.

The PSS has demonstrated good internal validity ($\alpha = .78$) and good construct validity when compared with other measures of stress.[36] The PSS demonstrated high internal reliability within the current sample (baseline $\alpha = .907$, n = 461; follow-up $\alpha = .874$, n = 135). Moreover, the PSS has shown predictive validity for symptoms of depression and common physical symptomology.[35]

*General Well-Being Scale.* The General Well-Being Scale (GWBS) was created for the quality improvement surveys, and includes 12 items, one of which is reverse scored. Factor analyses of follow-up

**Table 2.** Ordinal Scales and Values for Duration and Frequency of Meditation Practice at Baseline.

| Meditation Descriptor[a] | Value |
|---|---|
| Meditation duration, minutes per day | |
| 1-20 | 1 |
| 21-40 | 2 |
| 40+ | 3 |
| Meditation frequency, times per week | |
| 1-2 | 1 |
| 3-5 | 2 |
| 6-7 | 3 |
| 7+ | 4 |

[a]Respondents could select more than one descriptor; the lowest value descriptor was considered.

responses indicate a single factor scale when 4 items are excluded (see Table 1). The 8 remaining items include statements about mental clarity, self-confidence, inner peace, and productivity. Respondents indicate how true each item is for them on a 5-point Likert-type scale ranging from 1 = never true to 5 = always true. Scores are based on a sum of all items, ranging from 10 to 50. In the current sample, the GWBS demonstrated high internal validity (baseline $\alpha = .899$, n = 467; follow-up $\alpha = .913$, n = 139).

### Statistical Analyses

Paired samples *t* tests and cross-tabs chi-squares were used to compare those who completed a baseline and follow-up survey (survey responders) to those who only completed a baseline survey (survey nonresponders). To compare frequency and duration of meditation practices across these groups at baseline, data were organized into ordinal scales (see Table 2). Paired samples *t* tests were used to compare baseline and follow-up scores for the final sample. Repeated-measures analyses of variance were used to compare meditation intensity groups at follow-up while controlling for baseline characteristics. Post hoc analyses included Bonferroni correction to reduce likelihood of type I error (false positive) and to probe intensity group comparisons for significance; planned contrasts were used to further probe intergroup differences when appropriate.

## Results

### Participants

*Survey Response Rate.* Baseline surveys were sent via email to 1003 individuals, all of whom had registered for the retreat program; 470 registrants did not respond to the survey, 32 opted out, 10 invites generated a mail delivery failure message, and 491 took the survey of which 483 completed the survey in full.

Six weeks after the conclusion of the program, follow-up surveys were sent to 483 individuals who had completed a baseline survey and had attended the program; 327 did not respond, 7 opted out, 3 invites generated a delivery failure message, and 146 took the survey of which 144 completed the survey in full. Using email addresses as the identifying link between baseline and follow-up surveys, completed baseline and completed follow-up surveys were successfully paired for 142 participants; it is presumed that 2 individuals reported differing email addresses at baseline and follow-up.

*Survey Responders and Nonresponders.* Of the 483 individuals who completed a baseline survey, 142 completed a baseline and follow-up survey (survey responders, 29.39%) and 341 individuals completed only a baseline survey (survey nonresponders, 70.60%). At baseline, survey responders and nonresponders significantly differed in general well-being, percentage that had no meditation experience, and percentage that were practicing *Isha Kriya* (see Table 3).

*Final Sample.* The final 142 participants, who had fully completed both the baseline and follow-up survey, ranged in age from 16 to 77 years, with a mean age of 43.19 years (SD = 13.719) and the majority were female (54.2%). At baseline, 33 participants (23.2%) reported having no meditation experience, 49 (34.5%) stated they had meditated in the past, and 83 (58.5%) indicated they currently meditated in some way (see Table 4).

*Practice Intensity Groups.* At follow-up, participants were asked to select an option that described the frequency, duration, and type of meditation they practiced following the program (see Table 4). Participants were divided into 3 groups based on the descriptor they selected: optimum *kriya* practice intensity, moderate practice intensity, or low practice intensity. The optimum practice intensity group included those who practiced *Shambhavi* 6 or more times per week (96 participants, 67.6%); the moderate practice intensity group included participants who practiced *Shambhavi* 1 to 6 times per week (33 participants, 23.2%); and the low practice intensity group included those who practiced *Isha Kriya* or other practices besides *Shambhavi* regardless of frequency (13 participants, 9.2%).

At baseline, *kriya* practice intensity groups differed significantly at baseline in gender, percentage with prior meditation experience, and percentage who had meditated in the past (see Table 5). At follow-up, program participants reported lower perceived stress (change mean = −4.05, SD = 6.529), $t(141) = -7.393$, $P < .001$) and a higher level of general well-being (change mean = 2.39, SD = 5.128), $t(141) = 5.564$, $P < .001$).

### Practice Intensity Group Comparisons

*Change in Perceived Stress.* Controlling for baseline differences, participants, overall, experienced a significant reduction in perceived stress from baseline to follow-up, $F(1, 139) = 14.076$, $P < .001$, and practice intensity group had a significant effect on this change, $F(2, 139) = 3.466$, $P = .034$; however, post hoc analyses indicated that no 2 practice intensity groups significantly differed from one another in how much their perceived stress had changed. Further examination of these findings in a line plot (see Figure 1) suggested a significant difference may exist between the low practice intensity group and the moderate and optimum practice groups combined, $F(1, 140) = 6.389$, $P = .013$.

**Table 3.** Comparison of Post-Retreat Survey Responders and Nonresponders at Baseline.

| | Survey Responders | | | Survey Nonresponders | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| Characteristic | n | Mean | SD | n | Mean | SD | *df* | *t* | *P* |
| Age, years | 142 | 43.19 | 13.719 | 338 | 41.84 | 13.829 | 478 | 0.976 | .329 |
| PSS score | 142 | 26.67 | 7.736 | 341 | 27.82 | 7.459 | 481 | −1.520 | .129 |
| GWBS score | 142 | 26.28 | 5.644 | 341 | 25.14 | 5.717 | 481 | 2.006 | .045 |
| | Frequency | Percentage | | Frequency | Percentage | | *df*, n | $\chi^2$ | *P* |
| Gender | | | | | | | 1, 479 | 0.152 | .697 |
| Male | 64 | 45.4 | | 160 | 47.3 | | | | |
| Female | 77 | 54.6 | | 178 | 52.7 | | | | |
| Meditation duration, minutes per day | | | | | | | 2, 109 | 8.273 | .016 |
| 1-20 | 24 | 48.0 | | 43 | 72.9 | | | | |
| 21-40 | 19 | 38.0 | | 9 | 15.3 | | | | |
| 40+ | 7 | 14.0 | | 7 | 11.9 | | | | |
| Meditation frequency, times per week | | | | | | | 3, 136 | 4.666 | .198 |
| 1-2 | 15 | 30.6 | | 36 | 41.4 | | | | |
| 3-5 | 17 | 34.7 | | 26 | 29.9 | | | | |
| 6-7 | 7 | 14.3 | | 17 | 19.5 | | | | |
| 7+ | 10 | 20.4 | | 8 | 9.2 | | | | |
| No meditation experience | | | | | | | 1, 483 | 5.739 | .017 |
| Selected | 33 | 23.2 | | 117 | 34.3 | | | | |
| Did not select | 117 | 76.8 | | 224 | 65.7 | | | | |
| Meditated in past | | | | | | | 1, 483 | 0.000 | .984 |
| Selected | 49 | 34.5 | | 118 | 34.6 | | | | |
| Did not select | 93 | 65.5 | | 223 | 65.4 | | | | |
| Practice *Isha kriya* | | | | | | | 1, 483 | 9.119 | .003 |
| Selected | 33 | 23.2 | | 42 | 12.3 | | | | |
| Did not select | 109 | 76.8 | | 299 | 87.7 | | | | |

Abbreviations: PSS, Perceived Stress Scale; GWBS, General Well-Being Scale.

*Change in General Well-Being*. Controlling for baseline differences, participants overall experienced a significant improvement in general well-being from baseline to follow-up, $F(1, 139) = 4.469$, $P = .036$. Practice intensity group had a significant effect on this change, $F(2, 139) = 5.608$, $P = .005$; however, post hoc analyses indicated that no 2 practice intensity groups significantly differed from one another in how much their general well-being had changed. Further examination of these findings in a line plot (see Figure 2) suggested a significant difference exists between the low intensity group and the moderate and optimum groups combined, $F(1, 140) = 11.274$, $P = .001$.

## Discussion

The dysregulation of the stress response may lead to mental disorders such as anxiety or depression as well as chronic inflammatory processes. The present study investigated the effects of *Shambhavi Mahamudra* practice, which is essentially composed of a simple 21-minute protocol of breath regulation techniques, on perceived stress and general well-being in a healthy population. Participants in a yogic retreat program, which included *Shambhavi Mahamudra* training, who subsequently practiced the kriya daily, reported significantly reduced perceived stress and increased general well-being at 6-weeks follow-up compared with baseline. These results support the notion that *Shambhavi Mahamudra kriya* may represent a complementary therapy in the treatment of anxiety and stress reduction as well as for general well-being enhancement. Thus, further studies on this *kriya* and the associated *pranayama*, or yogic breathing techniques, are warranted.

Conventional drug treatment for stress-related disorders such as anxiety and depression can lead to a number of undesirable side effects. Both chronic stress and selective serotonin reuptake inhibitor drug treatment for depression and anxiety are associated with the development of obesity and metabolic disorders.[37,38] In addition, patients presenting with a high inflammatory burden may exhibit reduced response to drug intervention.[39] These treatment risks as well as conditions of nonresponse to conventional treatments suggest that integrative therapies for stress and related disorders are needed.[40,41] Studies have demonstrated that yoga practice can, at least in part, reduce stress responses and related cardiovascular, immunological, and endocrine changes as well as promote an improved psychological response to stress.[20,42]

Previous studies suggest that yoga and other contemplative practices such as the yogic breath-based techniques may be equally effective compared to conventional treatments for anxiety and depression.[21,22,43] Several studies employing yoga or meditation interventions report improvement in mood

**Table 4.** Meditation Practice Duration and Frequency at Baseline and Follow-up (n = 142).

| Descriptor[a] | n | Percentage |
|---|---|---|
| Baseline | | |
| No meditation experience | 33 | 23.2 |
| Meditated in past | 49 | 34.5 |
| *Isha kriya* | 33 | 23.2 |
| 1-20 minutes per day | 24 | 16.9 |
| 21-40 minutes per day | 19 | 13.4 |
| 40+ minutes per day | 7 | 4.9 |
| 1-2 times per week | 15 | 10.6 |
| 3-5 times per week | 17 | 12.0 |
| 6-7 times per week | 7 | 4.9 |
| 7+ times per week | 10 | 7.0 |
| Follow-up | | |
| *Shambhavi* 6+ times per week | 96 | 67.6 |
| *Shambhavi* 1-6 times per week | 33 | 23.2 |
| Did not practice *Shambhavi* | 8 | 5.6 |
| *Isha kriya* 4+ times per week | 11 | 7.7 |
| *Isha kriya* 1-3 times per week | 7 | 4.9 |
| 10-30 minutes per day | 74 | 52.1 |
| 31-60 minutes per day | 54 | 38.0 |
| Other practice | 17 | 12.0 |
| Did not meditate | 14 | 9.9 |

[a]Respondents could select more than one descriptor.

disorders, physiology, stress response regulation, and well-being.[44-48] For example, a breath-based *kriya* yoga intervention in patients diagnosed with mood and/or anxiety disorders utilized a similar set of breath practices as those employed in *Shambhavi Mahamudra*. The authors reported a significant reduction in anxiety and depression related symptoms postintervention.[49] Another *kriya* yoga intervention using these breath-based techniques reported reduced perception of stress and pain in breast cancer patients compared with controls.[50]

In addition, these *pranayama* techniques promoted improved stress regulation and antioxidant status in healthy participants practicing a set of breathing techniques similar to *Shambhavi Mahamudra*.[51] Another study using these techniques reported improved stress regulation, sympathovagal balance, and workload tolerance compared with controls.[52] A randomized controlled trial using this set of practices also reported that the controlled breathing techniques were also shown to reduce examination stress and improve blood lipid profiles in stressed college students compared with controls.[53] Interestingly, a *Qigong* intervention incorporating a similar *bandha*, or abdominal retraction technique, reported increased mood, comfort, and sociability following the practice.[54] Studies also indicate that *Isha Yoga* and *Iyengar* yoga practices restore balance to autonomic nervous system

**Table 5.** Comparison of Practice Intensity Groups at Baseline.

| | Optimum Intensity | | | Moderate Intensity | | | Low Intensity | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Characteristic | n | Mean | SD | n | Mean | SD | n | Mean | SD | *df* | *F* | *P* |
| Age, years | 96 | 42.44 | 12.738 | 33 | 43.18 | 15.735 | 13 | 48.77 | 15.117 | 2,139 | 1.223 | .297 |
| PSS score | 96 | 26.73 | 7.462 | 33 | 26.88 | 9.226 | 13 | 25.77 | 5.862 | 2,139 | 0.102 | .903 |
| GWBS score | 96 | 26.41 | 5.812 | 33 | 25.39 | 5.825 | 13 | 27.62 | 3.477 | 2,139 | 0.792 | .455 |
| | Frequency | Percentage | | Frequency | Percentage | | Frequency | Percentage | | *df*, n | $\chi^2$ | *P* |
| Gender | | | | | | | | | | 2, 141 | 8.128 | .017 |
| Male | 51 | 53.7 | | 9 | 27.3 | | 4 | 30.8 | | | | |
| Female | 44 | 46.3 | | 24 | 72.7 | | 9 | 69.2 | | | | |
| Meditation duration, minutes per day | | | | | | | | | | 4, 50 | 8.800 | .066 |
| 1-20 | 19 | 47.5 | | 2 | 28.6 | | 3 | 100.0 | | | | |
| 21-40 | 17 | 42.5 | | 2 | 28.6 | | 0 | 0.0 | | | | |
| 40+ | 4 | 10.0 | | 3 | 42.9 | | 0 | 0.0 | | | | |
| Meditation frequency, times per week | | | | | | | | | | 6, 49 | 10.829 | .094 |
| 1-2 | 6 | 17.6 | | 7 | 63.6 | | 2 | 50.0 | | | | |
| 3-5 | 14 | 41.2 | | 2 | 18.2 | | 1 | 25.0 | | | | |
| 6-7 | 6 | 17.6 | | 0 | 0.0 | | 1 | 25.0 | | | | |
| 7+ | 8 | 23.5 | | 2 | 18.2 | | 0 | 0.0 | | | | |
| No meditation experience | | | | | | | | | | 2, 142 | 7.222 | .027 |
| Selected | 21 | 21.9 | | 12 | 36.4 | | 0 | 0.0 | | | | |
| Did not select | 75 | 78.1 | | 21 | 63.6 | | 13 | 100.0 | | | | |
| Meditated in past | | | | | | | | | | 2, 142 | 8.533 | .014 |
| Selected | 32 | 33.3 | | 8 | 24.2 | | 9 | 69.2 | | | | |
| Did not select | 64 | 66.7 | | 25 | 75.8 | | 4 | 30.8 | | | | |
| Practice *Isha kriya* | | | | | | | | | | 2, 142 | 1.345 | .510 |
| Selected | 25 | 26.0 | | 6 | 18.2 | | 2 | 15.4 | | | | |
| Did not select | 71 | 74.0 | | 27 | 81.8 | | 11 | 84.6 | | | | |

Abbreviations: PSS, Perceived Stress Scale; GWBS, General Well-Being Scale.

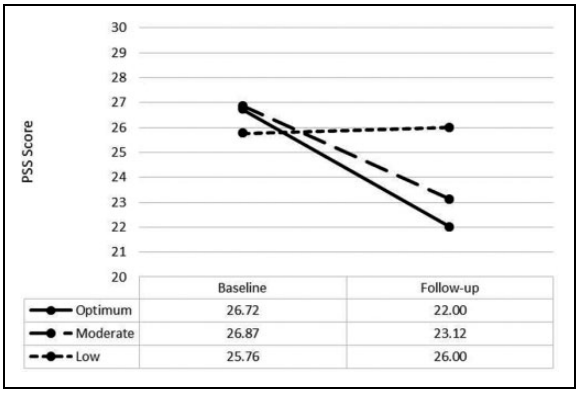



**Figure 1.** Perceived Stress Scale (PSS) scores at baseline and follow-up by meditation intensity group. PSS scores range from 10 to 50.

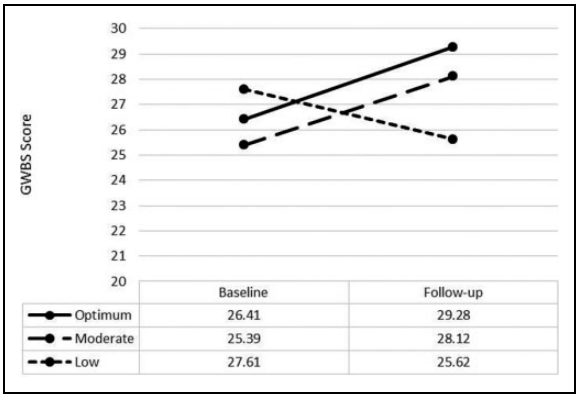



**Figure 2.** General Well-Being Scale (GWBS) scores at baseline and follow-up by meditation intensity group. GWBS scores range from 10 to 50.

function by modulating vagal afferents.[26,42] Deep breathing, specific breath patterns, and the engagement of these abdominal and pelvic floor muscular locks (*bandhas*) may stimulate the vagus nerve, a key mediator of the stress response, and thus help correct reduced parasympathetic nervous system activity[55-57]; however, additional studies are needed to elucidate these mechanisms.

Previous research has also focused separately on the fast- and slow-breathing techniques in the context of perceived stress. *Shambhavi Mahamudra* incorporates both fast- and slow-*pranayama* methods, which are both considered deep breathing techniques practiced at different frequencies of respiration. Different types of *pranayama* techniques promote beneficial effects yet distinct physiological responses in healthy populations.[58] A study in healthy students compared the effects of slow, fast, and no *pranayama* for 12 weeks on cardiovascular parameters and stress.[59] The results demonstrated that both the fast and slow *pranayama* promoted significant decreases in perceived stress as measured by the PSS, which was also employed in the current study; however, only the slow *pranayama* was reported to promote a statistically significant decrease in heart rate, blood pressure, rate pressure product and double product thus indicating increased parasympathetic dominance and vagal tone in the slow compared with the fast and no practice groups. Another study in healthy students comparing slow, fast, and no *pranayama* for 12 weeks on perceived stress and cognitive functions reported improved executive function, perceived stress, and reaction time in both *pranayama* groups compared with controls.[27] Perceived stress negatively affects executive functions such as memory, concentration, and information retrieval.[60] The authors concluded that since perceived stress alters signaling in the prefrontal cortex during cognitive tasks, the perception of reduced stress as measured by the PSS in both *pranayama* groups compared with controls may promote the observed improved cognitive function in the domains of attention, visuomotor speed, and memory retention capacity. Therefore, while yogic breathing techniques promote beneficial effects, specific types and sequences of *pranayama* appear to produce more distinct effects. Additional research is needed to further compare the physiological and psychological effects of various types of *pranayama* separately and specific sequences of *pranayama*.

To date, the biological mechanisms by which yogic breathing practices facilitate stress reduction or mood alteration are not fully known and represent an area in need of further research. *Pranayama* increase thoracic volume, which produces inhibitory signals that may induce changes in the autonomic nervous system to increase parasympathetic dominance.[61] While engaging the abdominal bandha (*uddiyana bandha*), both the volume and the hydrostatic pressure in the large intestine decreases.[54] We speculate that these controlled breath practices and the engagement of the *bandhas*, or muscular and energetic locks, also stimulate the vagus nerve and thus facilitate correction of the reduced parasympathetic nervous system activity observed in stress-related disorders such as anxiety. One of the key pathways for the bidirectional signaling between the viscera and the brain is via the vagus nerve. The majority of the vagal nerve fibers are afferent, and communicate peripheral information, including signals from the gut and gut microbiota, to the brain.[62] Moreover, gut-brain signaling affects homeostasis and may modulate behavior, mood, and mental health disorders.[63] Accordingly, the neurobiological mechanisms of the beneficial effects of *pranayama* practices should be investigated in greater depth to facilitate a broader understanding of their potential clinical application as integrative therapies.

One of the main limitations of the current study is that the survey questionnaires were not created for research purposes, although the PSS is a commonly used instrument in psychology. The surveys include inherent methodological weaknesses, including that participants may select multiple and sometimes contradictory descriptors of their home practice after the program. Although factor analysis demonstrated that the GWBS, when shortened, displayed a single factor and good internal validity in the current sample, there is currently no other measure of the reliability or validity of the scale. Another limitation of the study was a high frequency of survey nonresponse or noncompletion; of the 1003 individuals

who were sent a survey, baseline data was collected from only 491 participants, and complete follow-up data was collected from only 142 of those participants since many participants did not choose to complete a survey. Additionally, the number of participants in each practice intensity group varied widely (n = 96, 33, 13 individuals), which may have affected inter-group comparisons, and there was not a no-treatment control group included in the study. This study should be replicated in a large randomized controlled trial to ensure equal groups and include additional standard psychological questionnaires as well as assessment of biological markers of stress, anxiety, and inflammation.

In conclusion, participation in a yogic retreat program that included *pranayama* training and the subsequent practice of *Shambhavi Mahamudra kriya* for 6 weeks led to significant reductions in perceived stress and anxiety as well as increases in general well-being. *Shambhavi Mahamudra kriya* and other breath-based practices may represent potentially efficacious natural treatments for stress reduction and the promotion of general well-being. Yoga research is underrepresented and additional studies regarding clinical utility and mechanistic bases should be conducted. Further research is also needed to confirm the reported effects of these breathing practices on mood and the stress response. Future studies are also required in the field of *pranayama* research to fully understand the efficacy of the various techniques and the biological mechanisms involved.

## Authors' Note

The views expressed in this article are those of the authors and do not necessarily represent the views of the Department of Veterans Affairs.

## Author Contributions

RJK designed and ran the study. SMB processed the data and performed statistical analyses. CTP wrote the manuscript. CTP, RJK, SMB, DC, and PJM performed data analysis, wrote, and edited the manuscript.

## Declaration of Conflicting Interests

The authors declared the following potential conflicts of interest with respect to the research, authorship, and/or publication of this article: CTP is a postdoctoral fellow at the University of California, San Diego partially funded by the Chopra Foundation. DC is a founder of the Chopra Foundation and Chopra Center and a co-owner of the Chopra Center. PM is the Scientific Director of the Chopra Foundation.

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## Ethical Approval

Institutional review board approval was obtained from Quorum Review in July 2015 for these data to be analyzed for research purposes in accordance with the guidelines of the study of human subjects. This study was carried out in accordance with the recommendations of the Quorum Review committee.

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