

The Health Benefits of Yoga and Exercise: A Review of Comparison Studies

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Abstract

Objectives: Exercise is considered an acceptable method for improving and maintaining physical and emotional health. A growing body of evidence supports the belief that yoga benefits physical and mental health via down-regulation of the hypothalamic–pituitary–adrenal (HPA) axis and the sympathetic nervous system (SNS). The purpose of this article is to provide a scholarly review of the literature regarding research studies comparing the effects of yoga and exercise on a variety of health outcomes and health conditions.

Methods: Using PubMed® and the key word “yoga,” a comprehensive search of the research literature from core scientific and nursing journals yielded 81 studies that met inclusion criteria. These studies subsequently were classified as uncontrolled ($n=30$), wait list controlled ($n=16$), or comparison ($n=35$). The most common comparison intervention ($n=10$) involved exercise. These studies were included in this review.

Results: In the studies reviewed, yoga interventions appeared to be equal or superior to exercise in nearly every outcome measured except those involving physical fitness.

Conclusions: The studies comparing the effects of yoga and exercise seem to indicate that, in both healthy and diseased populations, yoga may be as effective as or better than exercise at improving a variety of health-related outcome measures. Future clinical trials are needed to examine the distinctions between exercise and yoga, particularly how the two modalities may differ in their effects on the SNS/HPA axis. Additional studies using rigorous methodologies are needed to examine the health benefits of the various types of yoga.

Introduction

YOGA IS AN ANCIENT discipline designed to bring balance and health to the physical, mental, emotional, and spiritual dimensions of the individual. Yoga is often depicted metaphorically as a tree and comprises eight aspects, or “limbs:” *yama* (universal ethics), *niyama* (individual ethics), *asana* (physical postures), *pranayama* (breath control), *pratyahara* (control of the senses), *dharana* (concentration), *dyana* (meditation), and *samadhi* (bliss).¹ Long a popular practice in India, yoga has become increasingly more common in Western society. In a national, population-based telephone survey ($n=2055$), 3.8% of respondents reported using yoga in the previous year and cited wellness (64%) and specific health conditions (48%) as the motivation for doing yoga.²

A growing body of research evidence supports the belief that certain yoga techniques may improve physical and mental health through down-regulation of the hypothalamic–pituitary–adrenal (HPA) axis and the sympathetic nervous system (SNS). The HPA axis and SNS are triggered as a response to a physical or psychologic demand (stressor), leading to a cascade of physiologic, behavioral, and psy-

chologic effects, primarily as a result of the release of cortisol and catecholamines (epinephrine and norepinephrine). This response leads to the mobilization of energy needed to combat the stressor through the classic “fight or flight” syndrome. Over time, the constant state of hypervigilance resulting from repeated firing of the HPA axis and SNS can lead to dysregulation of the system and ultimately diseases such as obesity, diabetes, autoimmune disorders, depression, substance abuse, and cardiovascular disease.^{3,4}

As detailed in Figure 1, numerous studies have shown yoga to have an immediate downregulating effect on both the SNS/HPA axis response to stress. Studies show that yoga decreases levels of salivary cortisol,^{5,6} blood glucose,^{7,8} as well as plasma rennin levels, and 24-hour urine norepinephrine and epinephrine levels.⁹ Yoga significantly decreases heart rate and systolic and diastolic blood pressure.^{9–11} Studies suggest that yoga reverses the negative impact of stress on the immune system by increasing levels of immunoglobulin A¹² as well as natural killer cells.¹³ Yoga has been found to decrease markers of inflammation such as high sensitivity C-reactive protein as well as inflammatory cytokines such as interleukin-6¹⁴ and lymphocyte-1B.¹⁵

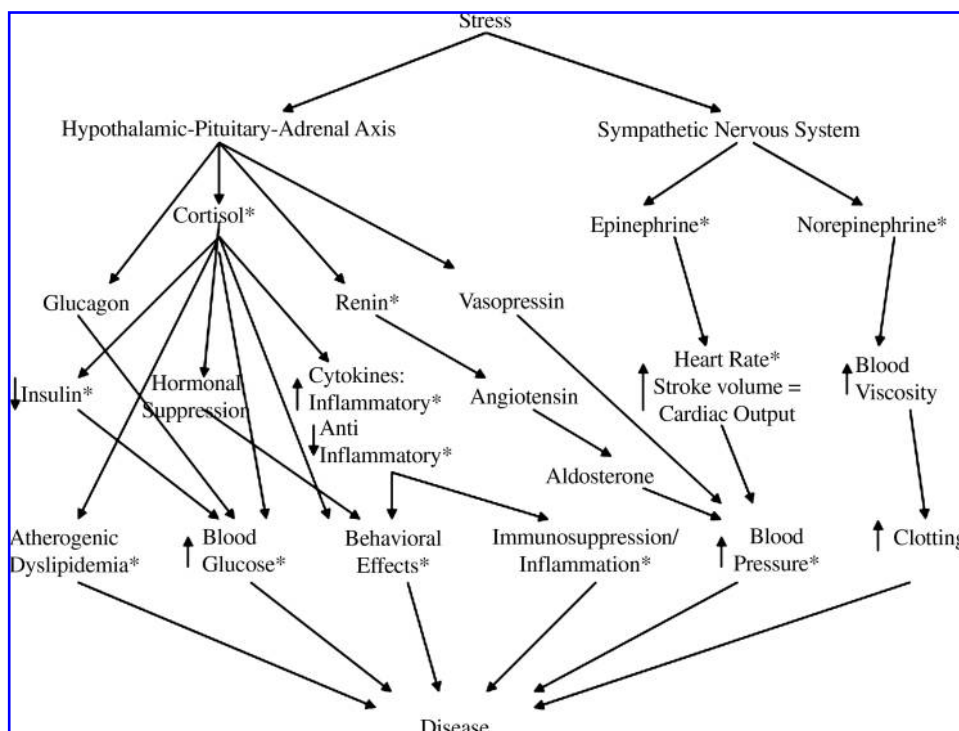


FIG. 1. The impact of stress on the hypothalamic–pituitary–adrenal axis and the sympathetic nervous system. *Yoga has been shown to have significant beneficial effects in these items.

These studies suggest that yoga has an immediate quieting effect on the SNS/HPA axis response to stress. While the precise mechanism of action has not been determined, it has been hypothesized that some yoga exercises cause a shift toward parasympathetic nervous system dominance, possibly via direct vagal stimulation.¹⁶ Shapiro et al.¹⁷ noted significant reductions in low-frequency heart rate variability (HRV)—a sign of sympathetic nervous system activation—in depressed patients following an 8-week yoga intervention. Regardless of the pathophysiologic pathway, yoga has been shown to have immediate psychological effects: decreasing anxiety^{5,6,18,19} and increasing feelings of emotional, social, and spiritual well-being.²⁰

Several literature reviews have been conducted that examined the impact of yoga on specific health conditions including cardiovascular disease,²¹ metabolic syndrome,¹⁶ diabetes,²² cancer,²³ and anxiety.²⁴ Galantino et al.²⁵ published a systematic review of the effects of yoga on children. These reviews have contributed to the large body of research evidence attesting to the positive health benefits of yoga. Many of the studies compared yoga to other treatment modalities, most commonly to exercise, meditation, and traditional medicine. However, little has been written about what distinguishes yoga from other treatment modalities. The purpose of this article is to present a comprehensive review of the literature regarding the impact of yoga compared to exercise on a variety of health outcomes and conditions.

Methods

A comprehensive search for research articles focusing on yoga interventions was completed from September until December 2008. The articles were identified using PubMed[®],

the online database of biomedical journal citations produced by the United States National Library of Medicine (NLM[®]). Using the key word “yoga” and limiting the search to core clinical and nursing journals published in English, 183 articles published after 1970 were identified. Although meditation, one of the eight limbs of yoga, and yoga interventions such as cleansing exercises arguably could be included in a scholarly review of yoga literature, studies solely focusing on these modalities were excluded. Articles were eliminated if they were editorials, anecdotal or single case studies, or of extremely poor quality.

Studies were included in the review if they were of reasonably good quality and involved yoga *asana* as the primary intervention modality. Quality of studies was determined using the criteria outlined by Greenhalgh.²⁶ Greenhalgh identified essential elements of quality research including: originality, appropriate subjects, sensible design, and minimal bias. Much of the research regarding yoga interventions has been done outside the United States with the majority of those studies, not surprisingly, done in India. Many of the early studies published in Indian journals prior to 1990 were of questionable quality, with inadequate descriptions of methodology and few randomized, controlled trials. However, the quality of more recent studies has improved noticeably. Studies completed abroad were considered if they met the inclusion criteria and were available at the NLM.

Eighty-one (81) studies met the inclusion criteria and were available at the NLM. Of these, more than half ($n = 46$) were published outside of the United States, with 29 of these published in Indian journals. These 81 studies examined a wide range of outcome measures and included numerous healthy and diseased populations. The studies were separated into three categories: uncontrolled studies, controlled

studies, and comparison group studies. Thirty (30; 37.0%) of the studies were uncontrolled quasi-experimental studies typically comparing pretest and post-test scores on a variety of outcome criteria following a yoga intervention. Sixteen (16; 19.8%) were wait list or nonintervention controlled studies, of which 12 were randomized controlled trials. The remaining 35 studies (43.2%) compared yoga to some other treatment modality. These 35 studies subsequently were classified according to the type of intervention being compared to yoga. The following categories of interventions were created: exercise, relaxation response, usual medical treatment, psychotherapy/cognitive interventions, and “other.”

The single largest category ($n = 12$) of comparison studies involved the effects of yoga being compared to exercise, and it is this category that is the focus of this article. Several studies seemed to span multiple categories, such as usual cardiac care, which often utilizes an exercise component. However, for the purposes of this article, only studies that listed exercise as the primary intervention were placed in that category.

Results

Table 1 details the populations, study methodology, and outcome measures of the 12 studies comparing the effects of yoga and exercise evaluated in this article. Five (5) of the 12 studies were conducted in the United States, 3 in India, and 1 each was completed in England, Germany, Turkey, and Cuba. Eight of the studies (66.7%) were randomized controlled trials. More than half of the studies ($N = 7$) focused on healthy populations, and the remainder focused on subjects with a wide variety of diseases and health conditions.

Table 2 provides a summary of the studies comparing yoga and exercise by outcomes measured. Nearly half of the studies have been conducted on healthy populations, and yoga interventions have yielded positive results in both healthy and diseased populations. Nearly every study utilized a yoga intervention that combined physical *asanas* (standing, seated, or inverted) and restorative or relaxation poses. Seven (7) of the 12 studies also incorporated meditation and/or breath work. Three (3) studies did not specify the type of yoga intervention used. The remaining studies utilized Hatha yoga ($N = 4$), Iyengar yoga ($N = 3$), and Integrated yoga ($N = 2$). While five of the studies provided specific sequences of yoga poses used in the intervention, the remainder offered few details.

Yoga and exercise

In research involving the health benefits of yoga, exercise is the single most common intervention used as a comparison. Twelve (12) studies were found comparing the effects of yoga and exercise (Table 1). Of these, nine focused on adults and three on seniors. Excluding studies with no information regarding gender or those involving exclusively one sex (menopausal subjects), 597 (68.4%) of the 873 subjects who participated in the 12 studies were women. Most of the studies involved some form of aerobic exercise: walking, running, dancing, or stationary bicycling, plus some form of stretching.^{5,27–35} Two (2) studies compared yoga with gentle, nonaerobic exercises and stretching.^{36,37}

Yoga appears to be equal or superior to exercise in relieving certain symptoms associated with diabetes,³³ multiple scler-

osis,³⁰ menopause,³⁶ kidney disease,³⁷ and schizophrenia.²⁹ Exercise has been recognized as having insulin-like effects on blood glucose levels.^{38–40} Yoga has recently been found to have beneficial effects on blood glucose levels in individuals with diabetes and other chronic health conditions.^{7,8,10,41} In a blinded, randomized controlled trial involving 186 type 2 diabetics, Gordon et al. (2008) compared the effects of 6 months of weekly classes plus home practice of yoga with aerobic exercise plus stretching. Compared to baseline measures and a control group, both yoga and exercise led to significant reductions at 3 and 6 months in fasting blood glucose (29.48% and 27.43%, respectively, $p < 0.0001$).³³ Both the exercise and yoga groups exhibited improvements in serum total cholesterol ($p < 0.0001$), and very low density lipoprotein ($p = 0.036$) compared with controls. One indicator of oxidative stress—malondialdehyde—significantly decreased in the yoga and exercise groups (19.9% and 18.1%, respectively, $p < 0.0001$ for both), and superoxide dismutase, a measure of oxidative status, increased by 24.08% in the yoga group and 20.18% in the exercise group, ($p < 0.05$ for both).

Yoga has been shown to be effective in relieving symptoms of mental illness including depression,^{17,42,43} anxiety,^{6,44} obsessive-compulsive disorder,⁴⁵ and schizophrenia.²⁹ Duraiswamy et al.²⁹ compared the effects of 4 months of daily yoga *asana* and *pranayama* with exercise on symptoms of psychosis in 61 schizophrenic patients receiving antipsychotic treatment. The exercise intervention involved walking, jogging, seated and standing exercises, and relaxation—activities that closely approximate yoga. Both the yoga and exercise groups exhibited significant reductions in psychotic symptom, but the yoga group improved significantly better ($F = 5.0$, $p = 0.03$). The yoga group scored significantly better than the exercise group in social and occupational functioning ($F = 7.98$, $p < 0.01$) and on psychological, social, and environmental subscales of quality of life as measured on the World Health Organization Quality of Life BREF form (all $p < 0.01$).

Other studies using exercise interventions that closely simulated the actions of yoga found clear differences between yoga and exercise. Yurtkuran et al.²⁶ conducted a single-blind, randomized trial comparing the effects of yoga with gentle range-of-motion exercises on symptoms related to hemodialysis in 37 renal failure patients. After 3 months of twice-weekly sessions consisting primarily of standing and seated *asanas* and meditation, the yoga group exhibited significant reductions in pain (37%), fatigue (55%), and sleep disturbance (25%) as measured by visual analog scales; these changes were significantly better than those in the exercise group ($p = 0.03$, $p = 0.008$, $p = 0.04$, respectively). The yoga group also noticed significant beneficial changes from baseline in grip strength (+15%) and serum levels of urea (–29%), creatinine (–14%), alkaline phosphatase (–15%), total cholesterol (–15%), erythrocytes (+11%), and hematocrit (+13%). These changes also were better than those in the control group (all $p < 0.05$).

In addition to studies comparing the efficacy of yoga to exercise in ill populations, studies have shown yoga to be effective in relieving symptoms associated with natural life events in women such as pregnancy^{46,47} and menopause.^{36,48} Yoga appears to increase maternal comfort and shorten labor time in pregnant women,⁴⁷ and decrease the number of hot flashes in menopausal women.^{36,48} However, only one study

TABLE 1. STUDIES COMPARING YOGA TO EXERCISE

| First author | Year | Population (N) | Yoga type | Exercise type | Duration | Design | Outcomes |
|--------------|------|--|--|---|----------------|------------------------------------|--|
| Bowman | 2006 | Healthy seniors (26) | <i>Asana & pranayama</i> | Stationary cycling | 6 weeks | Randomized, controlled trial (RCT) | VO ₂ max, BP, HRV, baroreflex sensitivity |
| Chattha | 2008 | Menopause (120) | <i>Asana & pranayama</i> | Walking & jogging, stretching, education | 8 weeks | RCT | Serum FSH, menopause symptoms (GCS), PSS, personality traits (EPI) |
| Duraiswamy | 2007 | Schizophrenia (61) | <i>Asana & pranayama</i> | Walking, jogging and exercises | 16 weeks | Blinded RCT | Psychotic symptoms (PANSS), social functioning (SOFs), QOL (WHOQOL-BREF) |
| Duren | 2008 | Healthy adults: yoga practitioners & exercisers (26) | <i>Asana (inversions)</i> | Walking, cycling, aerobics | N/A | Retrospective questionnaire | Carotid artery distensibility, pulse-wave velocity |
| Gordon | 2008 | Type 2 diabetes (186) | <i>Asana & pranayama</i> | Aerobics & walking | 24 weeks | RCT repeated measures | FBG, TC, LDL, VDL, oxidative stress (MDA, SOD) |
| Hagins | 2007 | Healthy yoga practitioners (20) | <i>Asana</i> | Treadmill walking | Single session | Repeated measures | VO ₂ max, HR, %MHR, METs, and energy expenditure (kcal) |
| Khatab | 2007 | Healthy adults (22) | <i>Asana</i> | Walking | 5 weeks | Repeated measures | HRV |
| Oken | 2004 | Multiple sclerosis (57) | Gentle <i>Asana</i> & meditation | Exercise class + stationary biking, walking | 6 months | Parallel group RCT | Cognitive attention, alertness, POMS, STAI, fatigue (MFI), QOL (SF-36) |
| Oken | 2006 | Healthy seniors (134) | Gentle <i>Asana</i> & meditation | Walking | 6 months | Parallel group RCT | Alertness, POMS, GHQ SF-36, fatigue (MFI), balance and flexibility |
| Sinha | 2007 | Healthy males (51) | <i>Asana, pranayama & meditation</i> | Running & stretching | 6 months | RCT | Reduced glutathione (GSS), oxidized glutathione (CSSG), glutathione reductase (GR), and total antioxidant status |
| West | 2004 | Healthy college students (69) | <i>Asana</i> | African dance | Single class | Quasi-experimental | Salivary cortisol, PSS, positive/negative affect schedule |
| Yurtkuran | 2007 | Hemodialysis (40) | <i>Asana</i> | ROM exercises | 12 weeks | RCT | Pain, fatigue, sleep (VAS), grip strength, Urea, creatinine, Ca, blood lipids, CBC |

N/A, not applicable; ROM, range of motion; VO₂ max, maximum oxygen consumption; HR, heart rate; %MHR, percentage maximum predicted heart rate; METs, metabolic equivalents; BP, blood pressure; HRV, heart rate variability; FSH, follicle-stimulating hormone; GCS, Greene Climatic Scale; PSS, Perceived Stress Scale; EPI, Eysenck Personality Inventory; PANSS, Positive and Negative Syndrome Scale; SOFS, Social Occupational Functioning Scale; QOL, quality of life; WHOQOL-BREF, World Health Organization Quality of Life Abbreviated form; FBG, fasting blood glucose; TC, total cholesterol; LDL, low-density lipoprotein; VLDL, very-low-density lipoprotein; MDA, malondialdehyde; SOD, superoxide dismutase; POMS, Profile of Mood States; STAI, State-Trait Anxiety Inventory; MFI, Multidimensional Fatigue Inventory; SF-36, 36-Item Short Form Health Survey; GHQ, General Health Questionnaire; GSS, glutathione synthetase; CSSG, cysteine-glutathione disulfide; VAS, visual analogue scale; CBC, complete blood count.

TABLE 2. OUTCOMES OF STUDIES COMPARING YOGA TO EXERCISE BASED ON HEALTH STATUS

| Outcome | First author (year) | Health status | | Comparison of yoga to exercise | | |
|--|---------------------|---------------|----------|--------------------------------|---------------------|-----------------|
| | | Healthy | Diseased | Less beneficial than | Similar or equal to | More beneficial |
| Balance | Oken (2006) | x | | | | x |
| Baroreflex sensitivity | Bowman (1997) | x | | | | x |
| Carotid artery distensibility | Duren (2008) | x | | | x | |
| Energy expenditure (kcal) | Hagins (2007) | x | | x | | |
| Fasting blood glucose | Gordon (2008) | | x | | x | |
| Fatigue (MFI) | Oken (2003) | | x | | x | |
| Fatigue: reduced activity (MFI) | Oken (2006) | x | | | | x |
| Fatigue (VAS) | Yurtkuran (2007) | | x | | | x |
| Flexibility | Oken (2006) | x | | | | x |
| Glutathione reductase (GR) | Sinha (2007) | x | | | | x |
| HR | Bowman (1997) | x | | | | x |
| HRV | Bowman (1997) | x | | | | x |
| HRV | Khattab (2007) | x | | | | x |
| Kidney function (urea, creatinine) | Yurtkuran (2007) | | x | | | x |
| Malondialdehyde | Gordon (2008) | | x | | x | |
| Menopausal symptoms | Chattha (2008) | x | | | | x |
| Metabolic equivalents | Hagins (2007) | x | | x | | |
| Mood: negative affect (PANAS) | West (2004) | x | | | x | |
| Mood: positive affect (PANAS) | West (2004) | x | | x | | |
| Pain (VAS) | Yurtkuran (2007) | | x | | | x |
| % MHR | Hagins (2007) | x | | x | | |
| Psychotic symptoms (PANSS) | Duraiswamy (2007) | | x | | | x |
| Pulse-wave velocity | Duren (2008) | x | | | x | |
| Quality of Life (SF-36) | Oken (2004) | | x | | x | |
| Quality of Life (WHOQOL-BREF) | Duraiswamy (2007) | | x | | | x |
| Reduced glutathione (GSH) | Sinha (2007) | x | | | | x |
| Sleep disturbance (VAS) | Yurtkuran (2007) | | x | | | x |
| Social and occupational functioning (SOFS) | Duraiswamy (2007) | | x | | | x |
| Strength (grip strength) | Yurtkuran (2007) | | x | | | x |
| Stress (PSS) | Chattha (2008) | x | | | | x |
| Stress (PSS) | West (2004) | x | | | x | |
| Stress (salivary cortisol) | West (2004) | x | | | | x |
| Superoxide dismutase | Gordon (2008) | | x | | x | |
| Total antioxidant status | Sinha (2007) | x | | | | x |
| Total cholesterol | Gordon (2008) | | x | | x | |
| Total cholesterol | Yurtkuran (2007) | | x | | | x |
| VO ₂ max | Bowman (1997) | x | | x | | |

MFI, Multidimensional Fatigue Inventory; VAS, visual analogue scale; HR, heart rate; HRV, heart rate variability; PANAS, Positive and Negative Affect Scale; %MHR, percentage maximum predicted heart rate; PANSS, Positive and Negative Syndrome Scale; WHOQOL-BREF, World Health Organization Quality of Life Abbreviated form; SOFS, Social Occupational Functioning Scale; PSS, Perceived Stress Scale; VO₂max, maximum oxygen consumption.

compared yoga to exercise in healthy women. In a blinded, randomized controlled trial involving 120 menopausal women, Chattha et al.³⁶ compared the effects of an 8-week regimen of daily *asana* and *pranayama* with an intervention that mimicked the activities of yoga by utilizing non-strenuous walking and stretching exercises. The yoga group scored significantly better compared to the exercisers on vasomotor symptoms ($p < 0.05$) and neuroticism ($p < 0.05$). Analysis of data from the Greene Climacteric Scale revealed that the yoga group exhibited significant improvement in

all three factors: psychologic, somatic, and vasomotor ($p < 0.001$), while the exercise group exhibited significant improvement only in the psychologic factor ($p < 0.05$). The yoga group also exhibited a significantly greater decrease in levels of stress, measured on the Perceived Stress Scale (PSS), than the exercise group ($p < 0.0001$, effect size = 1.10 and 0.27, respectively).

These findings seem to indicate that both interventions made subjects feel better, but yoga seemed to do better at relieving physical symptoms and perceptions of stress.

Only one group of researchers has compared the efficacy of yoga and exercise in both healthy and ill populations.^{30,31} Oken et al.³⁰ compared the effects of 6 months of Iyengar yoga and stationary cycling on attention, alertness, mood, anxiety, fatigue, and quality of life in 69 adult subjects (53 women) with multiple sclerosis. Both interventions produced significant improvement in fatigue compared with wait-list controls ($p < 0.01$). No significant improvements were noted in either intervention in attention and alertness or quality of life.

Similar negative results regarding cognitive function were found in a later study involving the effects of Iyengar yoga and walking in 135 healthy seniors.³¹ Again, no changes were noted in cognitive outcomes or alertness. In this study, the yoga group performed significantly better than the exercise group on levels of fatigue ($p = 0.006$) and on several measures of quality of life including pain ($p = 0.006$) and social functioning ($p = 0.015$). Only the yoga group exhibited significant improvements in flexibility ($p = 0.05$) and balance ($p = 0.05$).

While it is possible that the differences in the findings of the two studies by Oken et al. regarding quality of life was due to differences in the type of exercise or the populations involved, it is also possible that differences were related to a lack of power, as the number of subjects in the second study ($n = 134$) was nearly double the first ($n = 57$). Further studies are needed to examine whether a larger dose of the interventions (both studies used a single 90-minute classes per week) might be more likely to affect the cognitive outcomes. Secondary data analysis of the later study revealed that adherence to yoga (77%) and exercise (69%) was not significantly different in a healthy elderly population ($t = -1.95$, $p = 0.056$).⁴⁹

In research exclusively on healthy individuals, yoga has been shown to be as effective as or superior to exercise on nearly every outcome measured (Table 2). Sinha et al.,³⁵ in a study involving a convenience sample of 51 healthy males, found yoga to be superior to running plus flexibility training in improving measures of antioxidant status. Serum reduced glutathione increased in the yoga group ($p < 0.05$) and decreased in the exercise group. Similarly, glutathione reductase, an indicator of oxidative stress, increased significantly only in the exercise group ($p < 0.001$), while total antioxidant status increased significantly in the yoga group ($p < 0.001$) and decreased significantly in the exercise group. While this study seems to indicate yoga may be beneficial in reducing oxidative stress, additional research involving randomized clinical trials is warranted to provide stronger evidence.

In a study examining stress-related outcomes, West et al.⁵ compared the effects of a single class of yoga to African dance and a college lecture. Perceptions of stress were measured using the PSS, and affect was measured using the Positive and Negative Affect Schedule. Both African dance, a vigorous form of exercise, and yoga *asana* yielded significant improvements in perceived stress as measured on the PSS ($p < 0.001$ and 0.0001 , respectively) and in negative affect (both $p < 0.05$), with no significant changes noted in the lecture group. The dance intervention led to significant improvements in positive affect ($p < 0.05$), while the yoga group remained unchanged and the lecture group experienced significant worsening ($p < 0.001$). Both the yoga and dance group perceived their stress levels to be reduced and their negative moods to be enhanced; however, only the

yoga group experienced significant reductions in levels of salivary cortisol ($p < 0.05$). Levels of salivary cortisol, an indicator of activation of the HPA axis response to stress, significantly increased in the African dance group ($p < 0.0001$). These findings indicate that yoga and exercise may both improve mood but affect the HPA axis differently. The study, while intriguing, utilized a convenience sample and based the results on a one-time intervention, limiting the generalizability of the findings.

In an interesting study, Khattab et al.³⁴ used 24-hour Holter monitoring to compare HRV during a 60-minute yoga practice versus 60 minutes of park walking in a small sample ($N = 11$) of long-term Iyengar yoga practitioners as well as in healthy, age- and sex-matched control subjects who had no prior experience with yoga or meditation. The yoga practitioners exhibited greater HRV, particularly in those measures associated with parasympathetic tone, during the yoga intervention than during walking ($p < 0.001$), and during both yoga and walking than in the control group during yoga and walking ($p < 0.001$, $p < 0.05$, respectively). While no significant differences were found in the yoga practitioners and control subjects in HRV outside of the interventions, the authors of the study attributed this finding to the small sample size.

Bowman et al.,²⁸ in a randomized, controlled trial involving 26 healthy seniors, provided evidence supporting the belief that exercise and yoga exert different effects on the SNS. Heart rates significantly decreased following a 6-week (biweekly) yoga intervention, but not after aerobic cycling at 70%–80% maximal heart rate. HRV, a measure of the heart's resiliency or ability to respond to changes in demands, remained unchanged in the cycling group. The yoga group experienced significant increases in midfrequency (MF) HRV ($p < 0.01$), but not high frequency (HF) HRV. HR and HRV were subsequently used to compute the α -index, a measure thought to be indicative of sympathetic (at the MF level) versus parasympathetic (at the HF level) nervous system dominance, as well as a measure of baroreflex sensitivity. No changes occurred in the α index at MF or HF following aerobic training, but increased in the HF in the yoga group ($p < 0.01$), lending support to the notion that yoga acts on the SNS by increasing parasympathetic arousal.

Teasing out the differences between yoga and exercise with the current research has proven to be difficult. One might expect that aerobic exercise would show greater improvements in fitness outcomes. Indeed, measures of maximum oxygen consumption (VO_{2max}), an index of physical fitness, were found to be significantly different in healthy seniors who participated in 6 weeks of Hatha yoga compared to cycling at 70% of maximum heart rate ($p < 0.05$).²⁸ While the aerobics subjects performed better than the yoga subjects, VO_{2max} increased in both groups: 11% in yoga ($p = 0.01$) and 24% following cycling ($p = 0.01$). In a retrospective study comparing long-term practitioners of yoga with aerobic exercisers (running, walking, cycling) and sedentary subjects, Duren et al.³² found no significant difference between the yoga and aerobic groups in carotid artery distensibility (DC) or pulse wave velocity (PWV)—measures of arterial stiffness that typically decrease (DC) or increase (PWV) with age, but improve with aerobic conditioning. The sedentary subjects had higher PWV and lower DC than compared to either the yoga or aerobics group (both $p < 0.001$). While this study

might indicate that long-term yoga and exercise may have similar cardiac benefits, it has several methodological weaknesses, including the use of a convenience sample and not controlling for physical activity in the yoga group.

While exercise has been shown to definitively improve parameters of fitness, the fitness effects of yoga have only been examined in a handful of studies.^{27,50} Significant increases in strength, muscle endurance, flexibility, and VO_2 max occurred in 10 healthy volunteers after 8 weeks of biweekly *asana* and *pranayama* classes.⁵⁰ Metabolic expenditure in experienced yoga practitioners during a yoga session was similar to that of walking at 3.2 km/hr on a treadmill—significantly lower than the recommendations for moderate physical activity recommended at the time of the study by the American College of Sports Medicine.²⁷ Yoga practitioners had a lower maximum predicted heart rate, burned fewer calories per minute (kcal), and expended less energy metabolic equivalents while practicing yoga than while walking 4.8 km/hr ($p < 0.0001$). The authors further concluded that only sun salutations, a more strenuous form of yoga practice involving continuous movement, were comparable to walking 4.8 km/hr on a treadmill and might provide enough intensity to improve cardiorespiratory fitness in sedentary individuals.²⁷

Discussion

In the 12 studies that compared the effects of yoga and exercise, yoga interventions yielded positive results in both healthy and diseased populations (Table 2). However, with the exception of the studies by Oken et al.,^{28,38} no group of researchers has sought to compare the effects of yoga and exercise in a systematic fashion with variety of patient populations. Nevertheless, the evidence presented in the table suggests that yoga interventions appear to be equal or superior to exercise in nearly every outcome measured except those involving physical fitness.

Nearly every study reviewed utilized a combination of different yoga therapies including vigorous physical *asanas*, gentle restorative poses, breath work, and meditation. This raises an important question that has not been adequately addressed in the literature. Just as there are different specialties in the practice of medicine, there are several different styles of yoga, each with distinctive challenges and varying levels of difficulty. Some types of yoga may be gentle and meditative (Integral, *Svaroopa*), vigorous (*Ashtanga*, Power Yoga), or both (*Iyengar*, *Kundalini*). Some forms involve changes in the environment such as using heaters and humidifiers (*Bikram*). *Iyengar* yoga frequently is used for therapeutics and incorporates the use of props such as ropes, straps, and chairs to enable students to achieve poses that might not be accessible otherwise. Each style of yoga differs in the emphasis placed on the various components of yoga such as *asana*, *pranayama*, or meditation. The relative effects of these different types of yoga on the HPA axis and SNS in response to acute and chronic stress have not been adequately examined.

Only one study could be found comparing the various styles of yoga. In a convenience sample of 16 volunteers, only *Ashtanga* yoga resulted in significantly higher heart rates than either *Hatha* or gentle yoga.⁵¹ This study examined only heart rate as an outcome variable. Clearly, additional studies are called for, using larger sample sizes and better research

methodologies that compare the effects of the various types of yoga on a variety of outcome measures in a variety of populations, both healthy and diseased.

It is possible that the differences in fitness outcomes found in the comparison studies of yoga and exercise might not have been found if exercise were compared to the more vigorous forms of yoga. The differences that have been found between yoga and exercise interventions may be a result of how the two differ in their effects upon the SNS and HPA axis. Different levels of intensity of exercise have been shown to affect the HPA axis response to acute stress differently. Low-intensity exercise repeatedly has been shown to lower cortisol levels,^{52,53} while intense exercise leads to proportional increases in cortisol.⁵⁴ The critical level of intensity that leads to release of cortisol is approximately 60% VO_2 max, with the greater the exercise intensity, the greater the cortisol release.⁵⁴ Perhaps this explains why yoga, involving slow and often nonstrenuous activities, positively affects the HPA axis response to stress. Exercise stimulates the SNS, raising plasma epinephrine and norepinephrine.^{55,56} Yoga on the other hand, has been shown to lower sympathetic stimulation, significantly lowering levels of plasma norepinephrine and epinephrine.⁹

Given that the eight limbs of yoga are so multidimensional and include aspects of exercise (*Asana*), breath work (*Pranayama*), concentration (*Dharana*), and meditation (*Dhyana*), it is not surprising that researchers have found positive results regarding yoga in so many diverse areas. In three studies comparing yoga with meditation techniques such as progressive relaxation, yoga was found to be equal or superior to progressive relaxation in lowering blood pressure⁵⁷ and in improving perceptions of mood and anxiety.^{44,45} Yoga, when compared with supportive psychotherapy in randomized trials involving patients with cancer undergoing chemotherapy, has been shown to be significantly better at decreasing levels of nausea and vomiting⁵⁸ and strengthening the immune system.¹³ While the previously discussed exercise comparison studies involving yoga's effects on cognitive function led to nonsignificant results,^{30,31} yoga clearly appears to have multidimensional effects on brain chemistry and this warrants further inquiry.

Given the fact that clear evidence exists regarding the efficacy of both exercise and yoga interventions in alleviating symptoms and improving outcomes of patients with coronary artery disease,^{59,60} it is somewhat surprising that researchers have not discriminated more clearly between the effects of the two interventions in this population. Exercise has been recognized as a key component in cardiac rehabilitation. Yoga, when added to the components of usual cardiac care in randomized trials, has been shown to be significantly better than usual cardiac care at improving blood lipid levels,⁶¹ decreasing markers of inflammation¹⁴ and in reducing the number of revascular procedures.⁶¹ Mahajan et al.⁶² conducted the only clinical trial that exclusively examined the effects of a yogic lifestyle (yoga, *pranayama*, meditation, and a vegetarian diet) in comparison to usual cardiac care in patients with one or more cardiac risk factors and concluded that the yoga subjects experienced significantly lower levels of triglycerides and low-density lipoprotein cholesterol, in addition to lower body weight (all $p < 0.05$).

It is possible that yoga might be not only an acceptable additive to care, but an effective, feasible, and acceptable

alternative to exercise in heart disease populations and in other populations that have traditionally benefited from exercise such as diabetes and obesity. This is a potentially rich area for research for a variety of reasons. First, strong evidence in the form of the Whitehall epidemiological studies suggests that there is a dose-response relationship between obesity and stress.⁶³ Evidence also suggests that chronic stress leads to changes in food-seeking behavior, including increased consumption of foods high in sugar and fat, which may eventually lead to obesity.^{64,65} As yoga seems to provide many of the benefits typically associated with exercise and also strongly influences the SNS/HPA axis response to stress, it is possible that yoga might be a particularly useful weapon in the arsenal against obesity. In a recent population-based telephone survey involving 11,211 Americans, 57.4% of the 372 respondents ($N=208$) who admitted using complementary and alternative medicine during the past year reported using yoga as a form of weight control.⁶⁶ Research is needed to examine the efficacy, feasibility, and acceptability of yoga interventions for the prevention and treatment of obesity in both healthy and ill populations.

Conclusions

Overall, the studies comparing the effects of yoga and exercise seem to indicate that, in both healthy and diseased populations, yoga may be as effective or better than exercise at improving a variety of health-related outcome measures including HRV,²⁸ blood glucose,^{33,35} blood lipids,^{35,67} salivary cortisol,³ and oxidative stress.^{27,35} Furthermore, yoga appears to improve subjective measures of fatigue,^{30,31} pain, and sleep in healthy and ill populations.³⁷ However, future clinical trials are needed to further examine the distinctions between exercise and yoga, particularly how the two modalities may differ in their effects on the SNS/HPA axis. Additional studies are needed to distinguish between the different types of yoga and their various techniques. All of these studies need to use rigorous study methodologies, including the use of larger sample sizes, randomized samples, and blinding of researchers. These studies need to be replicated in a variety of populations, both sick and well, as the effects may vary depending upon the health status of the population.

Disclosure Statement

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