The Effects of Different Components of Yoga: A Review of Comparative Studies and Meta-Analyses

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We have no known conflict of interest to disclose.

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Contributions: KM wrote the first draft of the manuscript. PS and HCB collaborated on the editing process. All authors approved the final version of the manuscript.

Acknowledgments: We thank Anita Todd for her valuable comments on a previous version of this manuscript.

Funding: This work was supported by Karl and Veronica Carstens Foundation under Grant Number KVC 0/098/2018.

Abstract

Traditional yoga encompasses a variety of practices, such as physical postures, breathing techniques, meditation practices, and ethical teachings. Numerous studies and meta-analyses have demonstrated yoga's efficacy in promoting mental and physical health. Conversely, little is known about how the diverse components of yoga contribute to its overall effect. In this review, we summarize the current evidence on the differential and incremental effects of yoga components. We evaluated 18 comparative studies and 16 meta-analyses that conducted relevant subgroup analyses. These studies and meta-analyses examined a multitude of variables and varied greatly with regard to population, study design, and yoga components under investigation. Some meta-analyses included other mind-body interventions, such as Mindfulness-Based Stress Reduction (MBSR). Nonetheless, combined interventions incorporating multiple components consistently outperformed simpler interventions. Adding breathing and/or meditation practices to yoga interventions proved particularly beneficial in this regard. However, specific components or combinations were more effective in enhancing certain variables or clinical conditions, suggesting a need for custom-tailored programs. Similarly complex mind-body interventions, such as yoga and MBSR, were often equally efficient. Still, most findings remain preliminary and more research is needed. The ethical component of yoga is particularly underresearched. Future studies should isolate and compare all of yoga's components and evaluate additive effects by investigating different combinations of components. We encourage researchers to refer to theoretical frameworks, use rigorous methodology, and take into account individual factors.

Keywords: yoga components, mind-body interventions, postures, breathing practices, meditation, ethics

Introduction

Yoga is one of the most widely practiced mind–body interventions in the West—with more and more people joining the trend (Clarke et al., 2015; Eardley et al., 2012). Commonly, it is used for preventive purposes such as relaxation or stress relief (Park et al., 2016, 2019). Indeed, a growing number of studies are acknowledging the positive effects of yoga on alleviating stress (Breedvelt et al., 2019; Pascoe et al., 2017) and promoting mental and physical health (Büssing et al., 2012; Hendriks et al., 2017; Ross & Thomas, 2010). However, yoga encompasses a variety of practices, and it is unclear how these practices relate to the overall effect of yoga. The ancient discipline of yoga originated in India and includes diverse practices such as physical postures (*asana*), breathing techniques (*pranayama*), meditation techniques (*pratyahara*, *dharana*, *dhyana*, *samadhi*), and ethical teachings (*yamas* and *niyamas*) (Feuerstein, 2012; Telles & Singh, 2013). Research has shown that these practices can yield quite different effects (Peng et al., 2004; Sauer-Zavala et al., 2013). Conversely, comparative and in-depth studies into the differential and incremental effects of yoga components are still scarce. Furthermore, past research has often suffered from poor methodological quality and high heterogeneity among yoga interventions. Thus, there have been repeated calls to evaluate and disentangle the effects of different components of yoga (Gard et al., 2014; McCall, 2013; Riley & Park, 2015; Schmalzl et al., 2015).

Recent theoretical proposals have delineated possible working mechanisms of various yoga components. Gard et al. (2014) proposed an integrative framework and neurophysiological network model of yoga focusing on the enhancement of top-down and bottom-up self-regulatory mechanisms. The authors posited that yoga can be broken down into a skill set of four main tools, namely, ethics, postures, breath regulation, and meditation. All four tools contribute to an optimization of self-regulation and the development of an adaptive stress response. In their model, ethical beliefs promote the top-down initiation, monitoring, and maintenance of behavioral change. Postures, breath regulation, and meditation, on the other hand, elicit both top-down and bottom-up processes. The sustained practice of meditation and “meditation in motion” during posture and breath practice facilitates top-down attention control, which in turn supports behavioral change. Additionally, the embodied aspect of these practices enhances bottom-up processes of sensory

awareness, viscerosomatic integration, and parasympathetic control. With continued practice, these regulatory pathways are thought to become more automatized, leading to increased cognitive, emotional, and behavioral regulation and psychological and physical well-being.

Two other proposals have described yoga as either a modern psychophysiological therapeutic practice consisting of movement-, breath- and attention-based techniques (Schmalzl et al., 2015) or an ethically grounded, transformational process of exploring values, causes of suffering, and eudaemonic well-being (Sullivan et al., 2017). Schmalzl et al. (2015) outlined the bottom-up neurophysiological and top-down neurocognitive processes that are affected by yoga movement, breath, and attention practices, independent of traditional or ethical background. In contrast, Sullivan et al. (2017) delineated how the ethical first-person inquiry through *yamas* and *niyamas* can lead to an intentional reorientation of identity, meaning, and purpose in life. Postures, breath regulation, and meditation can support this process of shifting from the experience of suffering to the experience of eudaemonic well-being.

All of these proposals strongly encourage the empirical investigation and systematic testing of the hypothesized links and mechanisms. Specifically, they suggest conducting longitudinal, comparative, or dismantling studies. However, the heterogeneity of yoga styles and the multitude of possible “active ingredients” in yoga makes the investigation of its components challenging. Modern styles of yoga vary considerably in the emphasis they place on various components of yoga. While some styles focus primarily on postures and breathing practices (e.g., Iyengar, Hatha), others comprise mainly breathing practices (e.g., Surdashaan Kriya) or meditation (Sahaja). Some styles include mantras and chanting (e.g., Kundalini), and still others try to integrate and synthesize as many aspects and components as possible (e.g., Kripalu). Almost all styles end their yoga practice with a period of deep relaxation in a supine position (*shavasana*). For an overview of different yoga styles, see McCrary (2013). Scientific yoga interventions mirror this diversity of styles, making it hard to draw reliable conclusions about the relative effects or importance of each yoga component.

The aim of this review is to summarize the current evidence on the differential and incremental effects of various yoga components. We first look at intervention studies contrasting different yoga components. Then, we review all available meta-analyses that have conducted subgroup analyses based on the inclusion or exclusion of specific yoga components. With this, we hope to shed light on the undeniable diversity in yoga research and ease future research efforts on evaluating yoga components.

Comparative Intervention Studies

The yoga studies reviewed here examined and, in part, compared postures, breathing techniques, relaxation, chanting, meditation, and ethical education. The degree of specificity and disassembling of components and practices under investigation varied greatly among studies. While some compared, for example, very specific breathing practices to each other, others compared rather complex yoga interventions to meditation or relaxation techniques. Studies also varied regarding outcome variables, duration of treatments, methodological quality, sample size, and population. Table 1 gives an overview of the reviewed comparative studies. We indicate all components of yoga interventions (postures, breathing, relaxation, meditation, education) that we were able to identify in the respective articles. The education component refers to any type of lecture on health, stress management, or ethics participants received during their treatment.

Table 1*Results of Previous Studies That Compared Different Components of Yoga*

Study	Sample	Format	Intervention groups	Duration of treatment	Results	Conclusion
Bhat et al. (2012)	Healthy adults (<i>n</i> = 400)	RCT	1) Yoga (P, B, R) 2) Physical training 3) Yoga + physical training 4) Control: No treatment	3 months (45 min—in Group 3: 90 min—5 days a week)	Yoga (1) had greater positive effects on well-being, anxiety, and stress compared to physical training (2) and control (4), but yoga + physical training (3) yielded the strongest effects	Combined intervention more effective
Bhavanani et al. (2017)	Healthy college students (<i>n</i> = 134)	RCT	1) Physical yoga (P, R) 2) Yoga breathing (B) 3) Control: No treatment	1 week (5 sessions of 60 min each)	Both yoga postures (1) and breathing (2) resulted in significant increases in reaction time to simple visual and auditory stimuli compared to control; breathing (2) was associated with more pronounced changes, specifically in visual reaction time	Breathing more effective than physical yoga
Bhagal et al. (2016)	Healthy college students (<i>n</i> = 45)	RCT	1) Supine meditation (M) 2) Shavasana relaxation (R) 3) Control: Unguided relaxation (R)	30 days (30 min, 6 days a week)	Supine meditation (1) and shavasana relaxation (2) both increased memory scores compared to control (3), with supine meditation (1) showing a higher magnitude of change	Meditation more effective than relaxation
Bowden et al. (2011)	Healthy adults (<i>n</i> = 33)	RCT	1) Brain Wave Vibration (BWV) training (P, B, M, specific rhythmic exercises)	5 weeks	All interventions improved mood, well-being, and stress, but the mind-	Combined intervention more effective

Study	Sample	Format	Intervention groups	Duration of treatment	Results	Conclusion
			2) Iyengar Yoga (P, B, R) 3) Mindfulness (M, E)	(75 min, twice weekly)	fulness intervention (3) enhanced absorption and the BWV training (1) improved depression and sleep latency	
Gorvine et al. (2019)	Healthy college students (<i>n</i> = 92)	Quasi-experiment	1) Yoga (P, B, R) 2) Meditation (3 forms of M)	10 weeks (50 min, twice weekly)	The two interventions equally increased mindfulness and self-compassion; a positive effect on stress reduction was observed only when both groups were taken together in calculation	No difference between yoga and meditation
Granath et al. (2006)	Stressed individuals (<i>n</i> = 33)	RCT	1) Kundalini Yoga (P, B, R, E) 2) Stress management/cognitive behavioral therapy (CBT)—(E, R)	1) 10 weeks 2) 10 sessions over 4 months	Both treatments yielded the same beneficial effects on stress-related psychological and physiological variables; yoga (1) had a stronger effect on noradrenaline and CBT (2) on adrenaline levels	No difference between yoga and stress management
Melville et al. (2012)	Healthy adults (<i>n</i> = 20)	Randomized within-subjects design	1) Chair-based yoga (P, B, R) 2) Guided meditation (M) 3) Control: No treatment	3 days (15 min every day)	Both treatments significantly reduced psychological and physiological markers of stress, including respiration rate; yoga (1) resulted in a greater number of physiological benefits than meditation (2)	Combined intervention more effective

Study	Sample	Format	Intervention groups	Duration of treatment	Results	Conclusion
Park et al. (2017)	Healthy female college students (<i>n</i> = 34)	RCT	1) Kripalu Yoga (P, B, R, M, E) 2) Cognitive-behavioral stress management (CBSM)—(E, R) 3) Control: No treatment (waitlist)	8 weeks (60 min, twice weekly)	Yoga (1) significantly increased interoceptive awareness, emotion regulation, and self-regulation compared to CBSM (2) and control (3) and was perceived as more helpful; both treatments increased physical function and activity, with yoga (1) having a more timely effect; no effects were found on stress, depression, anxiety	Combined intervention more effective
Peng et al. (2004)	Experienced meditators (<i>n</i> = 10)	Within-subject design	1) Baseline: Sit quietly 2) Mantra meditation (M) 3) Rapid breathing (<i>kapalabhati</i> , B) 4) Segmented breathing (B/M)	1 day (10 min per condition)	Compared to baseline (1), mantra meditation (2) and segmented breathing (4) induced similarly low-frequency heart rate oscillations and high coherence between heart rate and breathing, whereas rapid breathing (3) increased heart rate and decreased HRV and coherence	Breathing and meditation differ
Quach et al. (2016)	Healthy adolescents (<i>n</i> = 198)	RCT	1) Yoga (P, B, R, E) 2) Mindfulness meditation (M, B, E) 3) Control: No treatment (waitlist)	4 weeks (45 min, twice weekly)	Mindfulness meditation (2) significantly improved working memory capacity, in contrast to yoga (1) or control (3); Surprisingly, all groups reported decreased levels of stress and anxiety	Meditation more effective than yoga

Study	Sample	Format	Intervention groups	Duration of treatment	Results	Conclusion
Raghuraj et al. (1998)	Healthy male adults ($n = 12$)	Within-subject design	1) Rapid breathing (<i>kapalabhati</i> , B) 2) Alternate nostril breathing (<i>nadi shodana</i> , B)	2 days 1) 1 min 2) 15 min	Alternate nostril breathing (2) did not affect HRV, whereas rapid breathing (1) increased sympathetic activity with reduced vagal activity	Breathing techniques differ
Rohini et al. (2000)	Adults with major depressive disorder ($n = 30$)	RCT	1) Full Sudarshan Kriya Yoga (3 forms of B) 2) Partial Sudarshan Kriya Yoga (2 forms of B)	Daily for 4 weeks	Depression and anxiety scores decreased for both groups, but with a trend for superiority of the full program (1)	Combined intervention more effective
Shankarapillai et al. (2012)	Healthy dental students ($n = 100$)	RCT	1) Yoga (B, P, R)—home practice: breathing 2) Stress management (E)—home practice: listening to ocean wave sounds	1 week (one 60 min lecture, daily home practice)	In contrast to stress management, yoga significantly reduced anxiety directly before and after students performed first periodontal surgical procedure	Yoga (breathing) more effective than stress management
Shannahoff-Khalsa et al. (1999)	Patients with obsessive-compulsive disorder ($n = 21$)	RCT	1) Kundalini Yoga (B, M, P) 2) Mantra and observing-thoughts meditation (M)	3 months (60 min weekly)	Yoga (1) was more effective in improving obsessive-compulsive pathology and mood than meditation (2)	Combined intervention more effective

Study	Sample	Format	Intervention groups	Duration of treatment	Results	Conclusion
Shannahoff-Khalsa et al. (2019)	Patients with obsessive-compulsive disorder (<i>n</i> = 52)	RCT	1) Kundalini Yoga (B, M, P) 2) Mantra meditation (M)	4.5 months (60 min weekly)	Compared to mantra meditation (2), yoga (1) was more effective in improving obsessive-compulsive pathology, mood, depression, and anxiety	Combined intervention more effective
C. Smith et al. (2007)	Stressed adults (<i>n</i> = 131)	RCT	1) Yoga (P, B, R) 2) Progressive muscle relaxation (R)	10 weeks (60 min weekly)	Both treatments significantly reduced stress and anxiety and improved health status; yoga was more effective in improving mental health at the end of the intervention, but relaxation outperformed yoga during follow-up; no changes in blood pressure	No difference between yoga and relaxation
J. A. Smith et al. (2011)	Healthy college students (<i>n</i> = 69)	RCT	1) Ethical yoga (P, B, M, R, E) 2) Nonethical yoga (P, B, R, M) 3) Control: No treatment	7 weeks (60 min, twice weekly)	Both treatments decreased depression and stress and increased hopefulness and flexibility; only ethical yoga (1) decreased anxiety and salivary cortisol	Combined intervention more effective
Wolever et al. (2012)	Stressed adults (<i>n</i> = 239)	RCT	1) Viniyoga (P, B, M, R, E) 2) Mindfulness-based intervention (M, E) 3) Control: No treatment	12 weeks (60 min weekly)	Both treatments decreased perceived stress and sleep difficulties and improved heart rhythm coherence; yoga (1) significantly decreased pain levels compared to control (3); no effects on	No difference between complex interventions

Study	Sample	Format	Intervention groups	Duration of treatment	Results	Conclusion
					mood, blood pressure, or work productivity	

Note. B = Breathing; E = education; HRV = heart rate variability; M = meditation; P = postures; R = relaxation; RCT = randomized controlled trial.

Although the specific interventions and treatments varied greatly between the studies in Table 1, combined interventions were generally more effective than simple interventions. Most comparative treatments in each study were equal in length. Nonetheless, outcomes were usually better for treatments combining several elements of yoga practice (Bowden et al., 2011; Melville et al., 2012; Park et al., 2017; Rohini et al., 2000; Shankarapillai et al., 2012; Shannahoff-Khalsa et al., 1999, 2019; J. A. Smith et al., 2011). Complex treatments helped improve depression, anxiety, mood, sleep latency, interoceptive awareness, emotion and self-regulation, and physiological markers of stress.

Conversely, findings were not always consistent, particularly when two equally complex interventions were compared to each other. Some studies reported no difference between complex yoga interventions and progressive muscle relaxation (C. Smith et al., 2007), stress management (Granath et al., 2006; Wolever et al., 2012), or three forms of (mindfulness) meditation (Gorvine et al., 2019) on similar outcome variables. Additionally, a complex mindfulness intervention had a greater effect on working memory capacity than a complex yoga intervention (Quach et al., 2016). Interestingly, in the latter study, stress and anxiety scores improved for all conditions, even the waitlist control. Thus, this amelioration could not be attributed to the “active ingredients” of the two treatments. Nonetheless, when simple meditation treatments were compared to complex yoga interventions, the latter were more effective in improving obsessive-compulsive pathology and mood (Shannahoff-Khalsa et al., 1999, 2019). This adds to the impression that combined interventions seem to have stronger impacts than simple ones. In another study, the combination of yoga and physical exercise outperformed both single treatments in enhancing well-being and reducing anxiety and stress (Bhat et al., 2012). However, in this study, this might have also been due to the higher dosage and exercise time in the combined treatment.

Frequently, the combined yoga treatments mentioned above included some form of yoga postures or breathing techniques. The latter seems to be particularly relevant. Bhavanani and colleagues (2017) found that yoga breathing practice was more effective than yoga postures in enhancing reaction to visual stimuli. Breathing practice also helped dental students stay calm during their first surgical procedure more than a short stress-management lecture (Shankarapillai et al.,

2012). Yoga incorporates a collection of diverse breathing techniques that can have quite different, sometimes even opposing effects on practitioners (Peng et al., 2004; Raghuraj et al., 1998). Brown and Gerbarg (2005) provided an overview of different breathing techniques and their psychological, physiological, and neurological effects and proposed an integrative neurophysiologic model.

Commonly, studies compared rather different treatments to each other, such as complex yoga programs and stress-reduction or mindfulness programs. Only some truly contrasted isolated components of yoga practice, such as yoga postures versus breathing practice (Bhavanani et al., 2017), or supine meditation versus supine relaxation (Bhagal et al., 2016). Two studies used an incremental design, comparing the same intervention but removing or adding a specific component to it. In both cases the more complex treatment was superior to the reduced one (Rohini et al., 2000; J. A. Smith et al., 2011). The latter was also the only study explicitly examining the effects of adding an ethical education component to a yoga intervention. They reported a higher efficiency of the ethical yoga intervention in decreasing anxiety and salivary cortisol. According to traditional yoga experts, yoga should be practiced in its entirety, including its ethical aspects (Varambally & Gangadhar, 2016). Likewise, a panel of experienced yoga teachers deemed the cultivation of positive values, attitudes, and behaviors as very important or essential for alleviating mental health conditions (de Manincor et al., 2015). Thus, future studies should evaluate yoga in its completeness and disentangle the specific effects of yoga ethics, postures, breathing practices, and meditation.

Meta-Analyses Comparing Different Subgroups of Interventions

Next, we looked at meta-analyses comparing yoga interventions, basing our review on their inclusion of diverse practice components. Numerous meta-analyses and reviews have tried to synthesize the vast number of yoga studies but have consistently criticized the heterogeneity of studies and the lack of methodological rigor. Only a few explicitly conducted subgroup analyses of studies with varying yoga components. Table 2 gives an overview of these meta-analyses. They vary with regard to outcome variables, population, sample size, study design of included studies, control groups, and yoga components under investigation in subgroup analyses.

Some of these meta-analyses included studies on yoga as well as studies on mindfulness-based interventions, such as Mindfulness-Based Stress Reduction (MBSR; Kabat-Zinn, 1982) or its derivatives. We noted these as such in Table 2. MBSR is one of the most researched mind-body interventions to date. It combines mindfulness meditation and Buddhist philosophy with yoga postures and movement practices. Thus, it is equally complex as yoga. Lately, there have been several attempts to dismantle and evaluate single components of MBSR interventions. Two studies asked participants to log their respective daily practice times of each component. In one study (Carmody & Baer, 2008), yoga practice time was more strongly related to improvements in mindfulness, perceived stress, anxiety, and psychological well-being than formal sitting meditation. Gallegos et al. (2013) found that yoga practice and sitting meditation time were both associated with higher posttreatment insulin-like growth factor, but only yoga significantly increased positive affect. Other studies evaluated different components of MBSR by comparing active treatment groups and found differential effects for yoga postures and diverse meditation techniques (Colgan et al., 2016; Hunt et al., 2018; Kropp & Sedlmeier, 2019; Sauer-Zavala et al., 2013; Stein & Witkiewitz, 2020). In two of these studies, the yoga component was found to decrease stress or increase well-being more than meditative components (Hunt et al., 2018; Sauer-Zavala et al., 2013). Therefore, it seems promising to compare and evaluate the components of mind-body interventions that share similar practices, such as yoga and mindfulness-based interventions.

Table 2*Results of Previous Meta-Analyses That Compared Different Components of Yoga*

Meta-analysis	Condition	Sample	Overall effects	Subgroup analyses	Conclusion
Breedvelt et al. (2019)	Depression, anxiety, and stress in college students	23 RCTs (<i>n</i> = 1,373)	<i>Yoga, meditation, mindfulness, and MBSR interventions</i> <i>g</i> = 0.61 (overall) <i>g</i> = 0.42 (depression) <i>g</i> = 0.46 (anxiety) <i>g</i> = 0.42 (stress) <i>g</i> = 0.52 (waitlist control) <i>g</i> = 0.39 (no treatment) <i>g</i> = 0.13 (active control, n.s.)	No differences between yoga, meditation, mindfulness, and MBSR interventions	No differences between complex interventions
Chimiklis et al. (2018)	Youth with ADHD	11 studies (<i>n</i> = 251)	<i>Yoga, meditation, and mindfulness-based interventions</i> <u>ADHD symptoms:</u> <i>g</i> = 0.57 (parent report)/ <i>g</i> = 0.23 (teacher report) <u>Inattention and attention problems:</u> <i>g</i> = 0.35/ <i>g</i> = 0.31 <u>Hyperactivity:</u> <i>g</i> = 0.39/ <i>g</i> = 0.22 <u>On-task behavior:</u> <i>g</i> = 1.22 (researcher report)	Mindfulness-based interventions (e.g., MBSR, MBCT) had a greater effect on hyperactivity than yoga interventions alone or combined yoga plus meditation interventions; other measures improved across all types of interventions	Combined intervention more effective

Meta-analysis	Condition	Sample	Overall effects	Subgroup analyses	Conclusion
			<u>Executive function (teacher report):</u> $g = 0.31$ (metacognitive; n.s.) $g = 0.67$ (behavioral) <u>Child-parent relationship:</u> $g = 0.50$ (child report) <u>Parent mindfulness:</u> $g = 0.31$ (n.s.) <u>Parent stress:</u> $g = 0.44$		
Cramer et al. (2019)	COPD	11 RCTs ($n = 586$)	<u>Yoga compared to no treatment:</u> $SMD = 0.57$ (quality of life, n.s.) $SMD = -0.23$ (dyspnea, n.s.) $SMD = 0.54$ (exercise capacity) $SMD = 0.47$ (forced expiratory volume in one second, n.s.) Positive effects on quality of life, exercise capacity, and predicted forced expiratory volume in one second when analyses were limited to studies using the same COPD assessment test	Breathing-based yoga interventions had positive effects on dyspnea, exercise capacity, and predicted forced expiratory volume in one second compared to no treatment; complex yoga interventions had positive effects only on exercise capacity	Breathing more effective than other combinations
Cramer, Haller, et al. (2014)	Hypertension	7 RCTs ($n = 452$)	<u>Yoga compared to usual care:</u> $MD = -9.65$ (systolic BP) $MD = -7.22$ (diastolic BP)	One breathing-based yoga intervention that did not include postures	Breathing more effective than postures

Meta-analysis	Condition	Sample	Overall effects	Subgroup analyses	Conclusion
			<u>Yoga compared to exercise:</u> No difference	tures (without P) was more effective than interventions that did (with P)	
Cramer et al. (2017)	Chronic neck pain	3 RCTs (<i>n</i> = 188)	<u>Yoga compared to usual care:</u> <i>SMD</i> = -1.28 (pain intensity) <i>SMD</i> = -0.97 (pain-related disability) <i>SMD</i> = 0.57 (quality of life) <i>SMD</i> = -1.02 (mood)	No differences in effects between exercise-based (with P) and meditation-based (without P) yoga interventions	No difference between yoga postures and meditation
Cramer et al. (2013)	Depression	12 RCTs (<i>n</i> = 619)	<u>Yoga compared to usual care:</u> <i>SMD</i> = -0.69 (depression) <i>SMD</i> = -0.00 (anxiety, n.s.) <u>Yoga compared to relaxation:</u> <i>SMD</i> = -0.39 (depression) <i>SMD</i> = -0.79 (anxiety) <u>Yoga compared to aerobic exercise:</u> <i>SMD</i> = -0.59 (depression)	Yoga interventions based on meditation and/or breathing (without P) were more effective for reducing depressive symptoms than exercise-based or complex yoga interventions (with P)	Meditation and/or breathing more effective than postures
Cramer, Posadzki, et al. (2014)	Asthma	14 RCTs (<i>n</i> = 824)	<u>Yoga compared to usual care:</u> Risk ratio = 10.64 (asthma control) <i>SMD</i> = -0.37 (asthma symptoms) <i>SMD</i> = 0.86 (quality of life) <i>SMD</i> = 0.49 (peak expiratory flow) <u>Yoga compared to psychological interventions:</u> <i>SMD</i> = 0.61 (quality of life)	Yoga interventions were only effective when they included breathing techniques	Combined interventions (especially breathing) more effective

Meta-analysis	Condition	Sample	Overall effects	Subgroup analyses	Conclusion
			<p><i>SMD = 2.87 (peak expiratory flow rate)</i></p> <p><u>Yoga compared to stretching or breathing exercises:</u></p> <p>No difference</p>		
Ewais et al. (2019)	Inflammatory bowel disease	8 RCTs (<i>n</i> = 501)	<p><i>Mindfulness-based, mindfulness, and yoga interventions</i></p> <p><u>Stress:</u></p> <p><i>SMD = -0.48 (short term)/ SMD = -0.55 (long term)</i></p> <p><u>Depression:</u></p> <p><i>SMD = -0.29 (n.s.)/ SMD = -0.36</i></p> <p><u>Quality of life:</u></p> <p><i>SMD = 0.22 (n.s.)/ SMD = 0.38</i></p> <p><u>Anxiety:</u></p> <p><i>SMD = -0.19 (n.s.)/ SMD = -0.27 (n.s.)</i></p> <p>No effect on physical outcomes</p>	Yoga and mindfulness interventions were both effective in reducing stress and improving quality of life, but one yoga study outperformed three mindfulness studies in decreasing depression and anxiety scores	Yoga more effective than MBSR
Gong et al. (2015)	Prenatal depression	6 RCTs (<i>n</i> = 375)	<p><u>Yoga compared to active control:</u></p> <p><i>SMD = -0.59 (prenatal depression)</i></p>	Complex yoga interventions (P + R/ B/ M) significantly reduced the level of prenatal depression, whereas exercise-based yoga (P) did not	Combined interventions more effective
Gothé & McAuley (2015)	Cognitive function	15 RCTs and 7 repeated-	<p><u>RCTs:</u></p> <p><i>g</i> = 0.33 (overall)</p> <p><i>g</i> = 0.29 (attention, processing speed)</p>	Breathing and meditative exercises, but not physical exercises,	Meditation and breathing more effective than postures

Meta-analysis	Condition	Sample	Overall effects	Subgroup analyses	Conclusion
		measures studies (<i>n</i> = 1,894)	g = 0.27 (executive function) g = 0.18 (memory, n.s.) <u>Repeated measures (acute effects):</u> g = 0.58 (overall) g = 0.49 (attention, processing speed) g = 0.39 (executive function) g = 0.78 (memory)	were consistently associated with improved cognitive performance	
Hagins et al. (2013)	Hypertension	17 controlled studies (<i>n</i> = 1,013)	<u>Overall effect:</u> MD = -4.17 (systolic BP) MD = -3.62 (diastolic BP) <u>Yoga compared to usual care/ no treatment:</u> MD = -7.96 (systolic BP) MD = -5.52 (diastolic BP) <u>Yoga compared to physical exercise or active control:</u> No difference	Significant reductions in BP only in yoga interventions that incorporated three components of practice (P, B, M), and not in interventions with fewer components	Combined interventions more effective
Hendriks et al. (2017)	Positive mental health in healthy adults	17 RCTs (<i>n</i> = 1,901)	<u>Yoga compared to no treatment:</u> SMD = 0.69 (well-being) No effects on life satisfaction, social relationships, or mindfulness <u>Yoga compared to physical exercise:</u> No difference	Positive effect of yoga on well-being was comparable to the effects of meditation or physical exercise; mindfulness meditation had a greater effect on mindfulness than yoga	No difference between yoga and meditation

Meta-analysis	Condition	Sample	Overall effects	Subgroup analyses	Conclusion
Kumar et al. (2016)	Type II diabetes mellitus	17 RCTs (<i>n</i> = 1358)	<u>Yoga compared to control:</u> <i>SMD</i> = -1.40 (fasting blood sugar) <i>SMD</i> = -0.91 (postprandial blood sugar) <i>SMD</i> = -0.64 (glycosylated hemoglobin)	No effect on any of the three measures for interventions that incorporated only breathing exercises (compared to standard care)	Combined interventions more effective
Pascoe et al. (2017)	Stress-related physiological measures in diverse populations	42 RCTs (<i>n</i> = 2,944)	<i>Yoga and MBSR</i> <u>Compared to active controls:</u> <i>MD</i> = -1.51 (waking cortisol) <i>MD</i> = -0.60 (afternoon cortisol) <i>MD</i> = -0.88 (evening cortisol) <i>MD</i> = -3.66 (resting diastolic BP) <i>MD</i> = -6.82 (resting mean arterial pressure) <i>MD</i> = -3.20 (resting heart rate) Positive effects also on heart-rate variability, fasting blood sugar, cholesterol, low density lipoprotein No effects on other measures	Positive effects of MBSR over yoga on decreasing interleukin-6 and systolic blood pressure; both types of interventions reduced salivary cortisol, BP, and cytokine levels to a greater extent than active controls	MBSR more effective than yoga
Thind et al. (2017)	Type II diabetes mellitus	21 controlled studies (<i>n</i> = 2,473)	<u>Yoga compared to control:</u> <i>d+</i> = 0.58 (fasting blood sugar) <i>d+</i> = 0.40 (post prandial blood sugar) <i>d+</i> = 0.36 (glycosylated hemoglobin) <i>d+</i> = 0.51 (total cholesterol) <i>d+</i> = 0.67 (triglyceride)	Yoga interventions were more successful in reducing triglyceride levels and lowering body weight when they included meditation practice; inclusion of relaxation techniques was associated	Combined interventions more effective

Meta-analysis	Condition	Sample	Overall effects	Subgroup analyses	Conclusion
			$d+ = 0.22$ (systolic BP, n.s.) $d+ = 0.73$ (diastolic BP) $d+ = 0.64$ (fasting cortisol) $d+ = 0.52$ (body mass index) $d+ = 0.28$ (weight) $d+ = 0.36$ (waist-to-hip ratio, n.s.) Positive effects also on very-low, low, and high-density lipoproteins	with lower body mass index; no differences in other variables	
Wu et al. (2019)	Hypertension prevention/ BP	49 controlled studies ($n = 3,517$)	<u>Yoga compared to passive control:</u> $SMD = -0.47$ (for both systolic and dias- tolic BP)	Yoga interventions that included either breathing techniques (B) or meditation/mental relaxation (M/R) led to larger decreases in BP than interventions that did not	Combined interven- tions more effective

Note. ADHD = attention-deficit/hyperactivity disorder; B = breathing; BP = blood pressure; COPD = chronic obstructive pulmonary disease; $d+ =$ weighted mean effect size with positive values favoring the intervention relative to control; g = Hedges's g ; M = meditation; MBCT = Mindfulness-Based Cognitive Therapy; MBSR = Mindfulness-Based Stress Reduction; MD = mean difference; P = postures; R = relaxation; SMD = standardized mean difference. Reported effects are significant unless otherwise stated.

The meta-analyses summarized in Table 2 are very diverse. Most of them investigated clinical populations with conditions such as depression, hypertension, chronic pain, asthma, chronic obstructive pulmonary disease (COPD), inflammatory bowel disease, type II diabetes, and attention-deficit/hyperactivity disorder. Three meta-analyses used mixed samples including healthy as well as clinical populations. These three examined the effect of yoga on cognition (Gothé & McAuley, 2015), on stress-related physiological measures (Pascoe et al., 2017), and on the prevention of and therapy for hypertension (Wu et al., 2019). Only two meta-analyses investigated healthy populations. One of them looked at depression, anxiety, and stress in college students (Breedvelt et al., 2019), and the other explored positive mental health (Hendriks et al., 2017). The latter concluded that there was a scarcity of studies investigating the effects of yoga on healthy populations, and specifically a lack of studies measuring positive outcomes. This is surprising as yoga initially was developed as a spiritual path for healthy people and not as a treatment for clinical conditions (Sedlmeier & Srinivas, 2019).

Nevertheless, most meta-analyses found favorable effects of yoga (and other mind–body interventions) on depression, anxiety, stress and stress-related physiological measures, well-being, mood, quality of life, cognitive function, and a majority of (other) clinical symptoms. Most effects were small to moderate and usually larger when yoga was compared to passive control or usual care. Compared to active control, yoga/mind–body interventions had a moderate effect on several physiological measures (Pascoe et al., 2017) and on levels of depression in clinical samples (Cramer et al., 2013; Gong et al., 2015). However, yoga's positive effects diminished compared to physical exercise or other active controls in healthy populations (Breedvelt et al., 2019; Hendriks et al., 2017), and in populations with asthma (Cramer, Posadzki, et al., 2014) or hypertension (Cramer, Haller, et al., 2014; Hagins et al., 2013). There have been numerous other meta-analyses substantiating the positive effects of yoga. Yet, in this review, we focused on those that conducted subgroup analyses for different components of yoga.

In an earlier summary of reviews, Büssing and colleagues (2012) concluded that yoga postures might be particularly beneficial for fitness, physical flexibility, and mental state. Breathing, relaxation, and meditation techniques, on the other hand, might lead to greater awareness, less

stress, and higher well-being and quality of life. This conclusion might also apply to the more recent meta-analyses displayed in Table 2.

A majority of the meta-analyses determined that combined interventions led to greater effects than simpler yoga interventions or yoga postures (Chimiklis et al., 2018; Cramer et al., 2013; Cramer, Posadzki, et al., 2014; Gong et al., 2015; Gothe & McAuley, 2015; Hagins et al., 2013; Kumar et al., 2016; Thind et al., 2017; Wu et al., 2019). This seemed to apply specifically to clinical samples. Again, breathing and meditation techniques were particularly beneficial in this regard. Interventions based on these practices were more effective than yoga postures in increasing cognitive performance (Gothé & McAuley, 2015), reducing depressive symptoms (Cramer et al., 2013), and downregulating blood pressure (Cramer, Haller, et al., 2014). Similarly, including breathing and/or meditation practices in yoga interventions increased their effectiveness in reducing prenatal depression (Gong et al., 2015) and elevated blood pressure (Hagins et al., 2013; Wu et al., 2019). Unsurprisingly, yoga interventions that were based on or included breathing practices were particularly helpful in alleviating respiratory diseases, such as asthma (Cramer, Posadzki, et al., 2014) and COPD (Cramer et al., 2019). In contrast, breathing-based yoga was not as effective in improving glycemic control and other diabetes-related measures (Kumar et al., 2016; Thind et al., 2017). The latter meta-analysis found that including meditation or relaxation practices was more helpful in this respect. No differences were found between exercise-based and meditation-based yoga interventions in alleviating chronic neck pain (Cramer et al., 2017).

Consequently, specific clinical conditions or objectives might require specific combinations of yoga practices to elicit the greatest benefits. Future research should examine these combinations in more detail and evaluate what combinations suit what condition/objective best. This could eventually lead to the development of programs tailored to the needs of specific populations (Gard et al., 2012; Riley & Park, 2015; Schmalzl et al., 2015).

Meta-analyses on healthy populations found no differences between meditation, mindfulness-based, or yoga interventions (Breedvelt et al., 2019; Hendriks et al., 2017). However, these two meta-analyses did not differentiate components of yoga or mindfulness-based practices and

are, thus, less informative than other meta-analyses that do. Still, they suggest that equally complex interventions such as yoga and mindfulness-based treatments yield similar effects. Conversely, MBSR was more effective than yoga in reducing stress-related physiological measures (Pascoe et al., 2017) and hyperactivity (Chimiklis et al., 2018), and yoga was more effective than MBSR in decreasing depression and anxiety in patients with inflammatory bowel disease (Ewais et al., 2019). Consequently, findings are inconclusive. More research is needed to determine the unique contribution of each component to the globally positive effect of combined interventions.

Discussion

Overall, the yoga studies and meta-analyses reviewed here vary greatly with regard to population, yoga components under investigation, intervention length, and control intervention(s). This seems to be symptomatic of yoga research, in general (Cramer, Lauche, et al., 2014; Elwy et al., 2014). To increase transparency and replicability of intervention studies, an extensive framework for developing yoga treatment protocols has been proposed and recommended (Sherman, 2012). Still, a systematic empirical investigation into the various components of yoga practice is missing.

One finding that was consistent throughout the reviewed literature was the superiority of combined over simple interventions. Treatments that included more components of traditional yoga, such as ethical education, postures, breathing, or meditation, were more effective than treatments that were based on fewer components. Particularly breathing and meditation practices enhanced the efficacy of yoga treatments. However, some combinations of yoga practices were more useful for specific study populations or outcome variables than others—what combinations exactly has to be determined in future studies as the available evidence on this matter is still sparse.

None of the meta-analyses we reviewed examined the additive value of including the ethical aspect of yoga in intervention studies. Likewise, only a few comparative investigations explicitly studied the effects of (ethical) education. Obviously, this is one of the major shortcomings of previous yoga research. The idea of integrating more philosophical or ethical components into mind-body interventions has recently been discussed in the mindfulness literature (Baer, 2015; Gordon et al., 2015; Monteiro et al., 2015; Purser, 2015). Chen and Jordan (2020) compared an

ethically enriched intervention with a standard mindfulness intervention and found that both interventions reduced stress and increased life satisfaction. However, the ethical intervention also enhanced personal growth and prosocial behavior. Similar results were obtained in the above-mentioned ethical yoga study (J. A. Smith et al., 2011). Recent theoretical proposals (see above: Gard et al., 2014; Sullivan et al., 2017) also suggest evaluating yoga in its entirety, including its ethical aspects. Therefore, it is essential to carve out the impact of ethical education on outcomes of yoga treatments. The recently developed mind–body intervention Meditation-Based Lifestyle Modification (Bringmann et al., 2020) might be useful in this regard as it explicitly incorporates lectures on yogic *yamas* and *niyamas*.

Our review suggests that comparably complex mind–body interventions, such as yoga and mindfulness-based interventions produce similar effects. Although the two types of interventions originate from different spiritual traditions (Hindu and Buddhist, respectively), they share similar exercises. Both yoga and MBSR (but not necessarily other mindfulness-based interventions) include yoga postures, relaxation, meditation, and an educational component. Recently, two studies dismantled MBSR treatments and found differential effects for its components (Hunt et al., 2018; Sauer-Zavala et al., 2013). Still, more research is necessary to understand thoroughly how each component contributes to the efficacy of combined treatments. Additionally, current research has demonstrated that Hindu and Buddhist meditators show very distinct preferences for specific meditation techniques (Matko et al., 2020). These differences between traditions might ultimately influence the outcomes of both related interventions and might account for the observed differences reviewed above.

To disentangle the components of yoga and other mind–body interventions, future studies should aim at either comparing specific, isolated components to each other or using additive designs to evaluate incremental effects of different combinations of yoga practices. Moreover, it is essential to evaluate yoga in its entirety, including postures, breathing, meditation, and ethics. This is particularly relevant in light of the undeniable diversity of yoga studies and interventions reviewed above. To understand the basic working mechanisms of yoga, comparative studies should rely on healthy populations and aim for representative samples. Clinical studies, on the

other hand, could evaluate diverse combinations of yoga practices to find the ones most suited to specific clinical conditions.

Future studies should also take personality factors into account, as several authors have pointed out that individual differences might tremendously influence the effects of yoga and other mind–body interventions (Gard et al., 2014; Hölzel et al., 2011; Schmalzl et al., 2015). Researchers could achieve this by employing more elaborate research designs that offer a higher time resolution and keep better track of individual responses. Single-case research designs (Barlow et al., 2009) or ecological momentary assessment (Shiffman et al., 2008) seem to be promising approaches in this regard.

Most studies reviewed here investigated the effects of yoga on depression, anxiety, stress, well-being, and mood. Although yoga interventions, particularly combined ones, commonly yielded positive effects on these variables, future studies should focus more on positive outcome variables (Hendriks et al., 2017). This could lead to a holistic understanding of yoga and move the discipline away from a deficiency-oriented and toward a more flourishing-oriented perspective. Furthermore, many variables in previous research were chosen *ad hoc* without referring to specific theoretical frameworks. This is another issue that is symptomatic of yoga research (Gard et al., 2014; Schmalzl et al., 2015). Accordingly, future studies should not only compare different yoga components but also base these comparisons and the selection of appropriate variables on existing traditional or contemporary theoretical proposals.

Overall, there is a lot of variability and ambiguity in yoga research with repeated calls to investigate differential effects of yoga components systematically. One particularly underresearched area of interest is the incorporation of yoga ethics into intervention studies. Our research team recently evaluated four different combinations of yoga components and found that the ethical component significantly enhanced well-being (Matko et al., 2021). We encourage researchers to use rigorous and elaborate research designs to examine all components of yoga, individually and in diverse combinations. In the end, these research efforts could contribute substantially to a deep understanding of the manifold effects of the multifaceted practice of yoga.

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