Thieme

A Systematic Review of Mechanisms of Change in Body-Oriented Yoga in Major Depressive Disorders

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ABSTRACT

Introduction Despite empirical evidence for the efficacy of body-oriented yoga as add-on treatment for major depressive disorder (MDD), the specific mechanisms by which yoga leads to therapeutic changes remain unclear. By means of a systematic review, we evaluate how the field is progressing in its empirical investigation of mechanisms of change in yoga for MDD.
Methods To identify relevant studies, a systematic search was conducted.
Results The search produced 441 articles, of which 5 were included, that empirically examined 2 psychological mechanisms (mindfulness, rumination) and 3 biological mechanisms (vagal control, heart rate variability [HRV], brain-derived neurotrophic factor [BDNF], cortisol). 2 studies found that decreased rumination and 1 study that increased mindfulness was associated with the effect of yoga on treatment outcome. In addition, preliminary studies suggest that alterations in cortisol, BDNF, and HRV may play a role in how yoga exerts its clinical effect.
Discussion The results suggest that body-oriented yoga could work through some of the theoretically predicted mechanisms. However, there is a need for more rigorous designs that can assess greater levels of causal specificity.

Introduction

Current pharmacological treatment methods are not beneficial for all patients with major depressive disorder (MDD) and are associated with significant side effects, such as metabolic disorders affecting quality of life and individual adherence to medication [1]. Some patients choose not to seek treatment or be medicated, and there is increasing interest in complementary mind-body-spirit approaches such as yoga, which are based on the idea that physiological states affect emotions, thoughts, and attitudes [2, 3]. The form of yoga that is practiced most commonly outside of India is hatha yoga, a body-oriented variant that includes mostly body postures, controlled breathing exercises, and meditation [4, 5]. When healthcare professionals talk about yoga, they usually discuss either its usefulness as a lifestyle intervention or as a potential treatment for physical and psychological problems. Hence, the focus is less on the mystical and spiritual aspects of yoga and more on its measurable/interventional and physical and psychological aspects. The holistic goal of yoga to promote physical and mental health and also spiritual and social consciousness is attractive to those patients who are concerned about the symptom reduction-based focus of psychopharmacology [2, 3]. The costs and barriers to access are low, and the diversity of practice styles and settings (e. g., home-based or in a gym) allows for a considerable degree of personalization [1]. A systematic review and meta-analysis suggests that the frequency and severity of yoga-associated adverse events in randomized controlled trials (RCTs) are comparable to those in physical activity or usual care. However, yoga may be associated with a higher frequency of non-serious adverse events than psychological or educational interventions without any physical activity. Despite the limitations of the available evidence, the authors conclude that

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▶ **Table 1** Proposed mechanisms through which yoga reduces depression in reviews.

	Outcome effects of yoga	Description of mechanism(s)
Kinser et. al., 2012 [10]	Decreased depressive symptomatology	Biobehavioral paradigm focusing on the cyclic interplay of stress, stress appraisal/responses, and allostatic overload/depression, hormonal regulation (decreased cortisol), hypothalamic-pituitary-adrenal (HPA) axis, increased levels of gamma-aminobutyric acid (GABA), vagus nerve stimulation via neurotransmitter, behavior modification and group effect on mood
Dunn, 2008 [21]	Improved mood disorders, relaxation and wellbeing, decreased perceived stress and anxiety	Improved cardiorespiration (decreased basal metabolic rate), cortisol regulation, increased feelings of satisfaction and self-control, stimulation of parasympathetic nervous system (PNS) and decrease of sympathetic nervous system (SNS) activity and HPA axis, increased bioavailability and blood levels of nitric oxide, vasodilation of the CV system, increased levels of total antioxidant status and decrease of other oxidate stress markers
Streeter et al., 2012 [12]	Symptom improvement in epilepsy, depression, post-traumatic stress disorder (PTSD), and chronic pain	Depression, epilepsy, PTSD, and chronic pain are exacerbated by stress, have low heart rate variability and GABAergic activity and respond to pharmacologic agents that increase activity of the GABA system. Stress induces (1) imbalance of the autonomic nervous system (ANS) with decreased PNS and increased SNS activity, (2) underactivity of GABA, and (3) increased allostatic load. Yoga reduces allostatic load in stress response systems and restores optimal homeostasis; increases PNS and GABA activity; decreases HPA axis; stretches receptors in the alveoli, baroreceptors, chemoreceptors, and other sensors throughout the respiratory structures sends information about the state and activity of the respiratory system through vagal afferents and brainstem relay stations to other CNS structures
Pascoe and Bauer, 2015 [13]	Decreased depressive and anxious symptoms in a range of populations	Yoga has mood-enhancing properties possibly related to its inhibitory effects on physiological stress and inflammation; better regulation of SNS and HPA system indicated by biological changes in blood pressure, heart rate, cortisol, or cytokine levels

yoga presents a generally safe intervention [6], follows a clear biological rationale in altering the stress diathesis model that may influence the onset and relapse of MDD and has utility as a self-management technique that empowers the person as a whole rather than (narrowly) affecting just symptomatology [2, 5, 7–13]. Regarding research trends, the number of publications on yoga since 2000 has continually increased significantly. McCall [14] found that more than 200 titles mostly focusing on pain, stress, anxiety, depression, and cancer were added to the literature every year since 2011. Another bibliometric analysis of papers published between 1975 and 2014 included 366 papers on 312 RCTs from 23 different countries with 22 248 participants [15]. This analysis highlights significant heterogeneity and variability of yoga studies on every methodological aspect in reporting interventions by type of yoga, duration, settings, and population characteristics limiting the generalizability of results, and there appear to be no replication studies. Meta-analysis and systematic reviews demonstrate the mood-enhancing effects of yoga as treatments for depressive symptoms and clinical depression [1, 2, 4, 6, 16–18] and indicate that yoga and meditative therapies are equally effective as conventional antidepressants (AD) in the treatment of MDD [4, 17]. Three of the reviews evaluated RCTs only [1, 4, 16], and da Silva et al. included both RCTs and non-randomized studies [17]. Little further empirical research exists on the hypothesized mechanisms by which yoga exerts its mood-enhancing effects compared with extensive neuroscientific publications on mindfulness and meditation practices [8–13, 19]. Several reviews propose possible mechanisms underlying the effects of yoga on stress and mental health outcomes [8, 9, 11, 13, 19, 20] and on depression, in particular [10, 12, 13, 21], including neurological, biochemical, and psychological underpinnings (See ▶ **Table 1**). However, only a few empirically studies have tested a priori hypotheses about specific mechanisms underlying the effects of yoga in MDD with appropriate statistical methods like mediator analysis as recommended by Kazdin [22]. Viewed as a holistic stress management technique, yoga can be regarded as a form of complementary and alternative medicine that produces a physiological sequence of events in the body that reduce the stress response and have positive psychological effects by empowering self-management of stress. The most commonly proposed mechanisms are related to the reduction of stress and allostatic load, the balancing of sympathetic (SNS) and parasympathetic (PNS) functions of the autonomic nervous system (ANS) including gamma-aminobutyric acid, and the downregulation of the hypothalamic-pituitary-adrenal (HPA) axis [10–13, 19, 20]. From an evidence-based health-care perspective, the hypothetical underlying mechanisms to explain the potential effects of yoga are in the early stages of investigation. As research initiatives on treatment mechanisms in yoga have increased, so there is a need for a review that can identify, synthesize, and evaluate the studies that have investigated possible treatment mechanisms in yoga treatment of MDD. Given the heterogeneous nature of psychiatric conditions regarding biological, psychological, and social factors and given that MDD is 1 of the 2 most com-

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mon mental health disorders being treated with complementary and alternative medicine (particularly yoga) [3], the purpose of this literature review is to synthesize current hypotheses and empirical evidence for yoga as part of an integrative approach for treating and preventing MDD. Knowledge of how yoga affects depression will provide more credibility to the field of yoga research [19], and health-care professionals may be more comfortable recommending yoga to patients in need if the mechanisms through which it operates are better known.

Method

Eligibility criteria

To examine the empirical evidence regarding the mechanisms through which yoga reduces depression, we conducted a systematic review of the literature. We followed the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) guidelines for conducting systematic reviews [23]. Given the previously expressed concerns about the limited evidence base, we carefully considered how best to define our eligibility criteria to reflect the current evidence of mediators of yoga in the population with MDD. The studies were selected based on the following criteria of eligibility:

- **Type of studies:** Clinical trials on mediation or mechanisms in yoga treatment of MDD, reported in English or German, were included.
- **Type of participants:** Studies involving participants aged 18 years or above and diagnosed with MDD according to a formal diagnostic classification system (diagnosed by ICD or DSM criteria) were included. Studies involving participants with comorbid physical or mental disorders and studies that assessed depression as a comorbid symptom of a specific physical or mental disorder or condition (e. g., depression in cancer patients, pregnant women) were excluded. Studies of non-clinically depressed adults have unclear implications for patients with MDD and thus were also excluded.
- **Type of interventions**: Body-oriented yoga with movement asanas and pranayama delivered by a teacher (not only home-based or delivered by DVD) were included. Yoga studies without an exercise component were excluded.

Because we found only 2 studies fulfilling the original inclusion criteria (only RCTs), we broadened our inclusion criteria, which yielded 5 studies. It was post-hoc decided to also include studies in which the majority of participants (≥ 75 %) were diagnosed with MDD and the remaining participants with other depressive disorders.

Identification of studies

We conducted a multi-database literature search utilizing the following databases: Medline via PubMed, PsycINFO, EMBASE, and the Cochrane Library. Databases were searched for the occurrence of keywords/phrases at any place in the record: "depression AND yoga AND (mechanism OR mechanisms OR mediator OR mediators)." We inspected the reference sections of retrieved studies and conceptual/theoretical articles on yoga and depression for additional manuscripts.

Evaluation of the methodological quality of studies

The methodological quality of study reports was assessed using modified Jadad criteria adopted from Coelho et al. [24], which assess appropriate randomization and description, blindness, and number and reasons for dropouts [25]. As double blindness of participants and therapists, as required by the original Jadad criteria, is not possible, the modified Jadad score allocates 1 point for single blinding of the outcome assessor. This enables a score ranging from 0 to 4, with 4 being the highest quality measure available. 2 assessors undertook the study selection and coding (KM, GJ). Disagreements were resolved by consensus discussions.

Evaluation of the causal specificity of studies investigating proposed mechanisms

Causal specificity of the employed designs was evaluated according to the framework by Kazdin [22, 26, 27]. Mechanisms provide explanations of how and why an intervention translates into the events that lead to the outcome; in this case, "mechanism" refers to those processes caused by yoga that lead to reduction in depression. In other words, they are causal links between treatment and outcome [26].

Results

Study selection

The search produced 441 potentially relevant report titles at initial screening. Studies were screened using title and abstract, and when required full texts were accessed, 33 reports met the eligibility criteria and were considered likely candidates for inclusion. The main reasons for exclusion (n = 28) were participants not suffering from MDD, no validated MDD or prenatal MDD (n = 17), no physical exposure as part of the yoga intervention (asanas, n = 10), or the study not investigating potential mechanisms of change (n = 2). Thus, 5 trials were included in the final review.

Empirical evidence concerning biological mechanisms

Characteristics of included studies tables

In the measurement of depression outcome, all studies used clinician-based ratings measures and 3 included objective measures. The studies suffered from methodological limitations: only 1 study used randomization, 2 studies did not use comparison control groups, and all studies had groups with fewer than 54 participants (some as low as 10). The mean Jadad score was 1.8 based on all the included studies. The studies varied in terms of specificity in the investigation of potential mechanisms. 2 studies used correlation analyses; the other studies used simple group comparisons (e.g. t-test, chi-squared test) (▶ **Table 2**).

HPA axis, cortisol

Two studies tested the relationship between yoga, cortisol levels, and declines in depression. One RCT [28] with 60 inpatients found no evidence for a more pronounced downregulation of HPA axis

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▶ **Table 2** Empirically studied mechanisms concerning how yoga may reduce depression.

Study	Intervention	Intervention dosage	Control group	Participants	Measures	Mechanism	Design, analysis	Findings	Jadad [a]
Sarubin et al., 2014	Hatha Yoga plus quetiapine fumarate extended release (QXR) or escitalopram (ESC), n = 22	60 min/wk/for 5 wks	AD alone either QXR or ESC, n = 31	60 inpatients with MDD (SCID) SDR n = 7/60	21-HAMD at day 0, 4, 7,14, 21, 28, and 35, Serum cortisol after 1 and 5 wks of treatment	Biological: salivary cortisol	RCT, pre-post design and after 1 wk of treatment, correlation analysis	Stepwise long-term cortisol reduction and significant reduction in 21- HAMD in both medication groups, irrespectively of yoga add-on, no mediation effects.	∑1
Naveen et al, 2013, 2016; Thirthalli et al., 2013	Manualized yoga therapy only (YT-only), n = 19	First daily for 10 days, then 1 h once per wk for the next 2 wks, booster training session in 2nd and 3rd months of the study, home practices monitored by a family member	n = 16 AD only, n = 19 YT with AD (Y-TAD)	54 drug-naïve yoga-naïve non-suicidal outpatients with MD (MINI; HDRS ≥ 11) SDR n = 8/54 IDR n.a.	HDRS, serum BDNF and cortisol	Biological: cortisol, BDNF	3-group non-RCT, pre-post design with 3 months follow-up, chi-square test for group comparisons on cortisol, correlations between serum BDNF and cortisol levels	Both yoga groups had greater reduction in HDRS scores and in serum cortisol than AD. BDNF rose in the total sample in the 3-month period without group differences. Significant positive correlation between fall in HDRS and rise in BDNF and significant negative correlation between change in BDNF (pre-post) and cortisol (pre-post) only in YT-only group. Yoga may facilitate neuroplasticity through stress reduction.	∑2
Ueb-elacker et al., 2010	Vinyasa yoga, free mat and copy of a book entitled Yoga for Depression, n = 10	1 individual and 12 group sessions within 8 wks, incentive of US$10 when classes attended at suggested frequency (3 classes every 2 wks)		10 persistently depressed female yoga naïve outpatients (PHQ-9 ≥ 10 and ≤ 20 and QIDS ≥ 11) with ADs[c] IDR = 1/10 SDR n = 1/10	QIDS, PHQ-9, RSS, BADS, FFMQ	Psychological: increased mindfulness, activation of behavior, and reduction of rumination	Single-group outcome study, pre-post design and telephone calls at 2, 4, and 6 wks, t-tests	Over 8-wk period significant improvements in QIDS, PHQ-9 and FFQ (activation and non-judging).	∑1
Kinser et al., 2013, 2014	Manualized hatha yoga, daily home practice with DVD and handouts, n = 15	75 min/wk/for 8 wks, average of 6.9 ± 1.2 classes	Attention-control activity 75 min/wk/for 8 wks n = 12	27 female outpatients with dysthymia or MDD (MINI) IDR n = 9/27 SDR 9/27, SDR 1-yr 18/27	PHQ-9, RRS, STAI-state, PSS, semi-structured interviews, daily logs with feelings before and after yoga home practice, only self-ratings	Psychological: reduction of rumination, increased connectedness, gaining a coping strategy	RCT, pre-post design and after 2, 4, 6, 8, and 52 wks of treatment, qualitative and quantitative analysis, multilevel models, mixed effects linear models	No significant group differences in adherence. Decrease PHQ-9 in both groups, trend towards decreased RRS postintervention only in yoga group. One-year post-intervention (n = 9) trend towards decreased PHQ-9 and RRS only in yoga group. Yoga group reported connectedness, gaining a coping strategy and self-care resource enhancing mindfulness, embodied self-reflexivity, empowerment and self-acceptance. No dose-response-relation.	∑4

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▶ **Table 2** Continued

Study	Intervention	Intervention dosage	Control group	Participants	Measures	Mechanism	Design, analysis	Findings	Jadad [a]
Shapiro et al., 2007	Iyengar yoga, n = 37	20 classes 60–90 min over 8 wks		37 patients with MDD in partial remission (MINI) IDR n = 16/37, ≥ 6 sessions n = 21/37 SDR n = 20/37	HAMD (remission < 7), QIDS, SCL, ANGIN, ANGOUT, STAI, CMHS, SLEEP, SF-36 mood-self-ratings before and after each class, ANS measures [b]	Biological: polyvagal theory on the role that vagal tone plays in social behavior and regulation of emotions. Psychological: increased mindfulness	Single-group outcome study, pre-post design, only completer analysis (n = 17/37), general linear models, random regression models	Significant reductions pre-post in HAMD, SCL, ANGOUT, STAI, SF-36, LF-HRV, and improved mood-self-ratings from before to after yoga class, remission rate n = 11/17, 65 %. Significant baseline differences between remitted vs. non-remitted patients: they had less formal education, spent more hours a wk in regular exercise, and had higher levels of HF-HRV, lower levels of LF-HRV, and higher BRS, suggesting that non-remitters had reduced capacity for emotional regulation.	∑1

[a] The Jadad criteria assess appropriate randomization and description, blinding of the outcome rater, and number and reasons for dropouts [25]

[b] ANS measures included blood pressure (BP), heart rate (HR), derived indices of heart rate variability (HRV) in 2 frequency bands: low frequency (LF-HRV, 0.075–0.125 Hz) and high frequency (HF-HRV, 0.125–0.50 Hz); LF-HRV measures both sympathetic (SNS) and parasympathetic (PNS) activity; HF-HRV measures PNS influences on the heart and baroreflex sensitivity (BRS). BRS indicates how the ANS adapts to fast changes in BP by measuring the slope of the change in the cardiac inter-beat interval to a successive increase or decrease in BP over a minimum of 3 beats.

[c] the diagnostic procedure was considered an equivalent to a formal diagnosis instrument as the QIDS assesses the 9 criterion symptom domains from the American Psychiatry Association Diagnostic and Statistical Manual of Mental Disorders, 4th edition (DSM-IV)

MDD: major depressive disorder; AD: antidepressants; SDR: Study drop-out; IDR: Intervention drop-out; BDNF: brain-derived neurotrophic factor; QIDS: Quick Inventory of Depression Symptoms-Clinician Rating; PHQ-9: Patient Health Questionnaire-9; RSS: Rumination Response Scale; FFMQ: 5-Facet Mindfulness Questionnaire; RRS: Ruminative Response Scale; BADS: Behavioral Activation for Depression Scale; ANGIN: Spielberger Anger Expression Scale; ANGOUT: Anger Out (expression of anger STAI: Spielberger Trait Anxiety Inventory; CMHS: Cook-Medley Hostility Scale (indirect hostility); SLEEP: Pittsburgh Sleep Scale; MINI: Mini International Neuropsychiatric Interview; HDRS/HAMD: Hamilton Depression Rating Scale; SF-36: short-form health survey; n.a. not applicable

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activity in the yoga group (5 × 60 min over 5 weeks) as add-on treatment to AD compared with the group with AD alone. Both groups showed a significant reduction in depressive symptoms and stepwise long-term cortisol reduction. Thus, the authors were unable to directly compare the mediators of interventions. Since AD alone were seen to decrease cortisol levels over time, it is possible that the additive effects of yoga were too small to be detected or the yoga intervention was too short to result in endocrinological changes. The authors discuss that an integrated yoga practice involving meditation, exercise, and spiritual teaching may provide additional benefits [29]. Smith et al. reported that cortisol levels decreased by approximately 31 % in people who practiced integrative yoga compared with those who practiced yoga as a form of physical exercise [29]. One non-randomized study with a 3-months follow-up [30, 31] examined the association between serum BDNF, cortisol levels, and depressive symptoms in 54 outpatients treated with AD, yoga therapy, or both. BDNF is a key modulator of neuroplastic changes and abnormal decreased neuroplasticity in the hippocampus and has been proposed as an important pathophysiological mechanism underlying depression through the stress pathway. Depression is known to be associated with low serum BDNF [32]. Serum cortisol was higher in depressives compared with healthy comparison subjects (n = 18) and had an inverse correlation with the severity of depression [33, 34]. In the total sample, the cortisol level dropped significantly and serum BDNF rose at the end of treatment without group differences. There was a significant negative correlation between change in serum BDNF and cortisol levels only in the yoga-only group, suggesting that levels of serum BDNF and cortisol are reciprocal [30]. The positive correlation between the fall in depression scores and rise in serum BDNF in the yoga-only group [30] is consistent with previous antidepressant-related studies on serum BDNF levels [35]. In contrast to Sarubin et al. [28], both yoga groups showed a cortisol reduction compared with the AD-only group [34], and the cortisol drop correlated with the drop in depression scores. Adherence to treatment, irrespective of the treatment method, was associated with a drop in cortisol level, suggesting a cause-effect relationship [34]. The correlation between reduction in cortisol as a marker for stress and increase in BDNF levels as a marker for neuroplasticity suggests a link between stress reduction and facilitation of neuroplasticity, which may play a role as a potential mechanism of antidepressant effects [36]. The authors conclude [31, 34] that yoga may act at the level of the hypothalamus by its anti-stress effects (reducing the cortisol) and facilitate neuroplasticity through stress reduction. Limitations of the study include a non-randomized design, evidence of key baseline differences between the groups, and a lack of statistical controlling for symptom change.

ANS: polyvagal theory, HRV, and baroreflex sensitivity (BRS)

Shapiro et al. [37] examined individual characteristics affecting response to a yoga intervention (20 classes senior Iyengar yoga) regarding HRV and mood enhancement in 27 women and 10 men with MDD in partial remission. HRV refers to changes in the heart's beat-to-beat intervals. Vagal control allows more rapid adjustments in heart rate and thus greater HRV than does SNS control, which takes longer to turn on and longer to turn off. Accordingly, high HRV implies vagal dominance and is a sign that the stress response system has greater flexibility to respond to challenges [12]. A previous study of 28 depressed patients from the same sample showed in comparison to 28 matched healthy controls autonomic function imbalance as indicated by higher low-frequency HRV (LF-HRV) and ratio of low to high (LF/HF) frequency HRV, reduced HF-HRV and lower baroreflex sensitivity (BRS), higher blood pressure (BP) and HR [38]. All 17 completers showed significant reductions in depression and in LF-HRV, and their moods improved from before to after the yoga classes. Remitted patients (HAMD < 7, n = 11/17, 65 %) in comparison to non-remitted patients showed greater reduction in HF-HRV and HFTOT-HRV compared with increases in the non-remitted group and a small increase in LF/HF-HRV compared with a small decrease in the non-remitted patients. These counterintuitive HRV findings are explained by higher levels of HRV at intake for the remitted group and may reflect the phenomenon of regression to the mean. The authors discuss that patients with higher intake resting vagal tone could have become actively engaged in coping with their depression while patients with initial lower resting vagal tone (non-remitters) may need a longer period of yoga treatment to increase vagal tone to a level needed to sufficiently improve their condition.

Psychological mechanisms

Mindfulness

We identified 1 uncontrolled study [2] that assessed the efficacy of Vinyasa yoga in 10 women not responding to antidepressant medication suggesting a mediating effect of mindfulness. Over the 2-month period, significant improvements in depression and in the hypothesized mediators of change "behavioral activation" and "non-judgment" as components of mindfulness were found. From the qualitative feedback, the following aspects of yoga classes emerged as helpful: (a) a kind and caring instructor; (b) the combination of the physical and meditative aspects of the yoga intervention; the intervention's additional attention on breath; (c) emotional benefits (i. e., increased relaxation), physical benefits (i. e., better sleep), and social benefits (i. e., socially connecting with others in class); and (d) many participants wanted more classes and felt that the 8-week intervention was too short.

Depressogenic cognition: rumination

Rumination is a process of thinking in which one repeatedly focuses on negative feelings and depression symptoms, including their causes, and is associated with the onset and maintenance of depression. Both the cultivation of mindfulness and physical activity during yoga practice may serve to decrease rumination by giving participants an alternative attention focus. We identified 1 RCT [39] and 1 uncontrolled study [40] that both used the Ruminative Response Scale (RRS) [41] to examine whether decreased rumination was associated with reduced post-treatment symptoms of depression. Uebelacker et al. [40] did not find significant reductions in rumination and thus could not confirm rumination as a hypothesized mechanism of action. Kinser et al. [39] compared an 8-week yoga intervention with an attention-control activity in 27 yoga-naïve women, the majority of whom were diagnosed with MDD (81.5 %).

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Even though both groups had the same degree of decreased depression over time, yoga appeared to be uniquely helpful for decreasing ruminations after controlling for baseline stress. Only the yoga group sustained a decrease in depression and ruminations 1 year after completion of the intervention [42] and reported experiencing increased connectedness and gaining a coping strategy. Two non-specific treatment mechanisms may account for decreased depression in the attention-control group: (1) engagement in an activity with social support and encouraged self-care and (2) connectedness from talking with others, whereas the yoga group experienced connectedness transcendent of dialogue. Connectedness or a general sense of self in the world has been shown to be a more powerful and enduring mediator for decreasing depression than direct social support [2]. Generalizability is limited due to the small sample size, volunteer bias, and differential dropout between groups (n = 3/15 in the yoga group and n = 6/12 in the attention-control group).

Discussion

The literature describing potential mechanisms is growing rapidly, yet we found only 5 studies that empirically examined 2 psychological mechanisms (mindfulness ↑, rumination ↓) and 3 biological mechanisms (vagal control ↑ and HRV ↑, BDNF ↑, cortisol ↓). In line with the theoretical predicted mechanisms, 2 studies found decreases in rumination [39, 40] and 1 study [2] found increases in mindfulness associated with positive treatment outcome, but none of the studies employed mediation analysis. One RCT found no group difference between yoga and AD alone and thus were unable to examine salivary cortisol as a potential mediator [28]. One study found evidence that yoga therapy, either with AD or solely, in comparison to AD therapy alone was significantly correlated with better reductions in cortisol levels but not improvement in BNDF [30, 31]. However, negative correlation was observed between change in BDNF and cortisol level in the yoga-only group and could therefore not be due to medication confound. However, due to these contradictory findings, it is unclear whether yoga alters cortisol more than control treatments. One single-group outcome study [37] noted significant reductions in low-frequency HRV. In line with theoretical predictions, there is an increasing body of clinical trials suggesting that alterations in mindfulness, rumination, and cortisol are associated with reduction in post-treatment depressive symptoms and thus could be key contributory factors to the beneficial effects of yoga in the treatment of MDD. A number of additional psychological, neural, and genetic factors have been suggested to be potential mechanisms and are worthy of further investigation. Currently, there is a lack of replicated studies that can convey the specific and non-specific mechanisms responsible for change. Future studies need to employ more rigorous designs that can assess a greater level of causal specificity of the potential mechanisms of change. If yoga is to be integrated into mainstream medicine, more research is necessary to identify the most effective components of yoga-based interventions and their mechanisms of action and what levels of severity of depression are likely to respond to this approach [43]. Although the lifestyle benefits and usefulness of yoga as a complementary therapy in mild depression are apparent, good quality evidence is required in psychiatric illnesses to come to any conclusion. Considering the recognized benefits of yoga to achieve positive health, its role in relieving psychiatric disorders is being put to use by several psychiatrists [44]. Rao et al. [44] point out that the Western psychiatric classification is based on allopathic understanding of body-mind dualism and differs from the yogic concept of body-mind interaction, which carries the risk of being not acceptable to the majority of medical practitioners. Yoga practitioners need to consider an alternate comprehensive (but closely matched to allopathic categories) diagnostic system to develop specific treatment packages. Reddy and Vijay [44] also point out the need to conceptualize the new problematic interdisciplinary interfaces between yoga, philosophy, and religion, which may emerge through future research on the meditative component. For complex multifactorial interventions like yoga with potentially different therapeutic mechanisms, different individuals may benefit from different components and mediator analyses may not have the power to reveal these variations. Another problem is that proposed mediators in some studies are outcomes in other studies [19]. Future studies on yoga should be driven by specific hypotheses about the mechanisms of change that are being targeted and a comprehensive theory-driven selection of mediators measured preceding that of outcomes to strengthen a causal interpretation [22]. Hypotheses about the interaction between bottom-up physiological and top-down cognitive processes should be systematically tested with multidisciplinary approaches across the domains of physiology, neuroscience, and psychology [9]. Further RCTs should ensure rigorous methodology including a priori sample-size calculations to prevent negative results due to lack of power, active control groups, longer interventions, and long-term follow-ups, and additional information about yoga-associated adverse events and the feasibility and acceptability of long-term continuation of yoga are recommended [5, 6, 8–10, 13, 19, 20, 45]. The dose response of yoga with varying frequency, duration, intensity, and type should also be explored as well as if severity of depressive symptoms plays a role in the efficacy of yoga interventions (e. g., whether more active styles of yoga would be more efficacious for mild to moderate levels of depression than gentler forms of yoga). The heterogeneity of yoga interventions makes it difficult to determine which specific components or combination of components are responsible for any outcome obtained as yoga interventions may have differential effects on physiological stress responses, biomechanics, and other pathways through which yoga may work [20, 46]. A way of classifying yoga interventions can be addressed with the Essential Properties of Yoga Questionnaire [47] and in a Delphi process a consensus statement on the application of yoga for reducing anxiety and depression was achieved from experienced yoga teachers [48] while the Yoga Self-Efficacy scale [49] may provide insight into barriers to maintain yoga practice. Challenges in yoga research for psychiatric conditions include limited objective biomarkers. However, demonstration of change in biomarkers with yoga could bring in more objectivity to clinical research on yoga for mental health and may answer the critique that yoga is merely a faith effect and not biological. Considering the heterogeneity of MDD, an improved understanding of moderating patient characteristics could enable improved targeting. Mechanisms of change may be directionally affected by moderators (e. g., gender, age, ethnicity, level of education, religiosity, spirituality, mo-

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tivation for spiritual growth, patient preferences or the level of positive expectancy, therapist competence and adherence, and practice motivation) [8].

Conflict of Interest

The authors declare no conflict of interest.

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