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Yoga and Emotion Regulation: A Review of Primary Psychological Outcomes and Their Physiological Correlates

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Discovering and promoting ways that help regulate emotions has been a recurrent concern in the field of psychology, given that how one feels and reacts to and expresses emotions can have both short- and long-term effects on physical and mental health. Many psychological strategies that can influence this process, such as reappraisal, attention allocation, and suppression, have been previously investigated. The aim of the present work was to review the emotion regulation potential of yoga practice, given that it combines techniques that foster positive psychological outcomes. The results suggest that yoga produces improvements in emotional functioning in healthy subjects and people who suffer from some physical illnesses, particularly in psychological self-reported variables. Evidence regarding behavioral and neurophysiological correlates remains less well-established. Mechanisms that possibly mediate the relationship between yoga and emotion regulation are discussed and methodologies are considered, with suggestions for future studies. In summary, emerging evidence suggests that yoga may help foster healthier psychological responses, indicating its potential as an emotion regulation strategy.

Keywords: anxiety, attention regulation, emotion regulation, yoga practice

Understanding emotion regulation and discovering ways to help people better regulate their feelings has always been a central concern in the field of psychology. Successful emotion regulation is related to greater well being (McRae, Jacobs, Ray, John, & Gross, 2012), better physical health (e.g., decreased risk of heart attacks and coronary heart disease; Kubzansky, Park, Peterson, Vokonas, & Sparrow, 2011), and psychologically healthy aging (Suri & Gross, 2012). Conversely, emotion regulation deficits are known to be involved in many mental disorders (Kanske, Heissler, Schönfelder, & Wessa, 2012; Werner & Gross, 2010).

Evidence suggests that the practice of yoga may benefit positive psychological functioning (Hagen & Nayar, 2014; Telles & Raghavendra, 2011), suggesting its potential as a strategy for developing or improving emotion regulation skills. Thus, after presenting some assumptions on emotion regulation, the aim of the present work was to review the effects of yoga on emotional variables to better understand the relationship between yoga and emotion regulation in samples with no particular psychiatric disease. The potential psychological and neuro-

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physiological mechanisms that underlie this relationship are discussed and methodological considerations are highlighted, with suggestions for future studies.

Emotion Regulation

Emotion regulation refers to the ability to modulate one or a set of emotions (i.e., the ability to control and influence the emotions we feel, when we feel them, and how we experience and express them; Gross, 1998). A key concern of the regulatory process is to cultivate emotions that are helpful and manage emotions that are harmful (Gross, 2013). Once the goal of regulating emotions is activated, different processes/strategies are recruited. According to the process model of emotion regulation (Gross, 1998; Werner & Gross, 2010), there are five types of psychological strategies that derive from the time points at which individuals can regulate their emotions: situation selection (described as approaching or avoiding certain people, places, or things to regulate emotion), situation modification (employed through adaptation to a situation to modify its emotional impact, also referred to as problem-focused coping), attention allocation (which involves selecting one or more of the many aspects of the situation on which one focuses or concentrating intensely on a particular topic or task), cognitive change (generally referred to as reappraisal, consisting of selecting and attaching to one aspect of the many possible meanings to change the interpretation of an emotionally evocative stimulus), and response modulation (generally referred to as suppression, consisting of how one influences emotion response tendencies once they are already elicited to decrease expressive behavior; for review, see Gross, 1998).

Reappraisal, attention allocation, and suppression constitute the three most commonly investigated strategies (for review, see John & Gross, 2004; Ochsner & Gross, 2005), which can produce distinct patterns, generating more or less successful outcomes (Gross, 2002). For example, reappraisal appears to take effect faster than suppression (Goldin, McRae, Ramel, & Gross, 2008). When reappraisal is compared with distraction (i.e., a form of attention allocation strategy), the latter influences an earlier stage of the emotion-generative trajectory (Thiruchselvam, Blechert, Sheppes, Rydstrom, & Gross, 2011). Likewise, compared with suppression, reappraisal produces greater deactivation of the amygdala and insula (Goldin et al., 2008), suggesting the more effective modulation of emotion generation. Compared with reappraisal, distraction shows a more significant reduction of activity in the amygdala and greater increases in activity in the right lateral prefrontal cortex and bilateral parietal cortex, which are associated with selective attention (Kanske, Heissler, Schönfelder, Bongers, & Wessa, 2011; McRae et al., 2010). Therefore, although different strategies may positively influence the regulation of emotions according to the context and time at which they are employed, these results corroborate the assumption that attention allocation may be a critical component of the regulatory process, constituting the neural basis for subsequent and more elaborate strategies (Wadlinger & Isaacowitz, 2011).

In addition to their particular mechanisms, such as temporal dynamics (Sheppes & Meiran, 2007; Thiruchselvam et al., 2011) and neural bases (Goldin et al., 2008; Kanske et al., 2011; McRae et al., 2010), other aspects may also influence distinct regulatory outcomes, such as individual differences (John & Gross, 2004). For example, a shift seems to occur toward an increasingly healthier regulation profile during adulthood, characterized by the greater use of reappraisal and decreased use of suppression (John & Gross, 2004). Individuals with high trait anxiety present more reactive brain responses, reflected by late positive potential, to negative emotional stimuli when they try to use reappraisal compared with individuals with low trait anxiety (Mocaiber et al., 2009; but see Drabant, McRae, Manuck, Hariri, & Gross, 2009).

Despite such particularities, a failure in the regulatory process has been proposed to be diminished if individuals can more easily track ongoing emotions, select the correct strategy (given that some may be more appropriate for a particular context), and maintain or flexibly adjust the strategy when circumstances change (Gross, 2013). Thus, cognitive skills may benefit the effectiveness of emotion regulation, such as monitoring, executive control, and sustaining or shifting attention. Accordingly, an effortful control temperament, described as an individual's capacity for self-regulation (e.g.,

the ability to choose a course of action under conditions of conflict, plan for the future, and detect errors), has been shown to facilitate cognitive processing in an emotional context (Kanske & Kotz, 2012).

Yoga

In the present article, we review the potential of yoga as a tool for developing emotion regulation skills. In addition to being an ancient Indian practice that seeks to foster spiritual development (Telles & Raghavendra, 2011), yoga was originally conceived as a means to cease mental fluctuations and instability (Taimini, 2006). Hence, yoga is considered a path to achieving greater balance and homeostasis, given that disease originates from imbalances in mental states from an ancient yoga perspective (Telles, 2010).

To achieve its purposes, the original form of yoga combines eight stages: *yama* (universal moral principles), *niyama* (rules for self-purification), *asana* (postures), *pranayama* (conscious voluntary regulation of breath), *pratyahara* (withdrawal of the senses), *dharana* (focusing attention on the object chosen for meditation, requiring special effort), *dhyana* (subsequent stage that consists of deeper awareness, during which there is no focusing or effort), and *samadhi* (considered a state in which the yoga practitioner "merges" with the Supreme; Telles & Raghavendra, 2011). Throughout the practice, a process of full awareness of mental and bodily states should underlie the distinct techniques, which are believed to complement each other and foster greater and deeper levels of awareness (Taimini, 2006). Therefore, yoga may be conceptualized as a meditative process per se, but one that involves a combination of skills that gradually lead to and prepare for the formal practice of meditation.

Importantly, from a psychological perspective, meditation (i.e., a type of mental training that involves the voluntary and sustained focusing of attention, as well as the monitoring of one's own mental activity in order to disengage attention from distractions) has been related to better emotion regulation (for review, see Menezes, Pereira, & Bizarro, 2012). For example, individuals who underwent focused attention meditation training, compared with individuals who participated in progressive relaxation and a wait-list control group, were better able to modulate negative emotion interference while performing an attention task. They were also better at engaging their executive attention during the task, reflected by a greater reduction of response bias after training (Menezes et al., 2013).

Considering that yoga combines numerous techniques in a more diverse way than exclusive meditation training and that psychological processes, such as self-monitoring and self-awareness, underlie the execution of each technique, one hypothesis is that yoga may be as likely to promote improved emotion regulation as an exclusive meditation intervention. Although there are distinct types of yoga (e.g., Hatha, Bhakti, Raja, and Karma) from which different schools have originated worldwide (e.g., Ashtanga, Iyengar, Kripalu, Vinyasa, Kundalini, and Integrated Yoga Therapy, among others), most types explicitly focus and combine physical postures, controlled breathing, relaxation, and meditation (Balasubramaniam, Telles, & Doraiswamy, 2012; Broad, 2012). Increasing evidence indicates that these practices can have therapeutic benefits in both the physical and mental health contexts (Broad, 2012; Telles & Raghavendra, 2011).

Method

Although the present article cannot be classified as a systematic review, the review process and results were based on the following method. We performed an electronic search of the bibliographic databases Medline, EMBASE, PsycINFO, SciELO, and PEPSIC by cross-referencing the terms ("yoga" or "yoga practice" or "yoga program" or "yoga training") and ("emotion regulation" or "self-regulation" or "emotion" or "affect" or "mood" or "mental health"). The search was limited to English and Portuguese language articles. No articles were found in Portuguese based on the aforementioned search terms. Studies were excluded if they were reviews or correlational, did not include a control group, assessed yoga in combination with other practices or treatments unrelated to one of the eight previously described stages, assessed practices or programs that are related to but not entirely equal to a formal yoga practice (e.g., Relaxation Response/Mindfulness-Based/Mind-Body Programs), assessed a

single technique in isolation (e.g., breathing, postures, relaxation, or meditation), or assessed the effects of yoga in psychiatric populations.

Notably, yoga is generally included in the mind–body therapy context (Kozasa et al., 2010; Purohit et al., 2013). Nevertheless, despite theoretical and clinical contributions from research on mind-body treatments, such as the Relaxation Response (Broad, 2012; Dusek & Benson, 2009), studies that used these types of interventions were excluded because they can be more broadly classified as wellness programs that adapt or incorporate other techniques beyond the formal practice of yoga. Moreover, studies that evaluated psychiatric conditions were excluded because this was already addressed in a recent publication (Balasubramaniam et al., 2012; Meyer et al., 2012) and because of the heterogeneous nature of mental illnesses with regard to biological, psychological, and social factors. These populations can have distinct and specific psychological and neurobiological profiles, so discussing emotion regulation in this context requires taking into account a wide range of variables, such as pharmacological treatment, time of onset, severity, comorbidities, and number of relapses, which are beyond the scope of the present work.

The search is summarized in Table 1 according to year of publication. Twenty-four articles were identified that matched our inclusion criteria. The results presented below focus on the effects of yoga on primary affective and emotional outcomes. Importantly, some of the studies that investigated these outcomes through psychological variables, such as self-report and experimental measures, also relied on the assessment of physiological correlates, such as physical symptoms, biological markers, and neurophysiological responses. Therefore, these results were also included in the present review, given that they were assessed and interpreted in the context of an emotional response.

Results

Psychological Measures: Nonclinical Population

In studies that assessed healthy samples, the results showed that yoga increased positive affect in a prison sample compared with a workout control group (Bilderbeck, Farias, Brazil, Jakobowitz, & Wikholm, 2013), increased positive mood in adults compared with a walking group (Streeter et al., 2010), increased resilience in secondary school adolescents compared with a physical education control group (Khalsa, Hickey-Schultz, Cohen, Steiner, & Cope, 2012), and increased well-being in military men compared with a physical training group (Harinath et al., 2004). Likewise, higher positive affect scores were observed in experienced adult yoga practitioners compared with nonpractitioners (Kiecolt-Glaser et al., 2010). Improvements were also reflected by reduced stress in prisoners compared with a workout control group (Bilderbeck et al., 2013) and in military men compared with a physical activity group (Rocha et al., 2012). Yoga reduced depression symptoms in elderly people compared with an Ayurveda control group (Krishnamurthy & Telles, 2007) and wait-list control group (Chen et al., 2009). Studies also reported reductions of anxiety levels in military men compared with a physical activity condition (Rocha et al., 2012) and in adults compared with a walking control group (Streeter et al., 2010). Furthermore, yoga decreased anxiety related to music performance in musicians compared with a wait-list control group (Khalsa, Butzer, Shorter, Reinhardt, & Cope, 2013). Finally, yoga increased anger control in adolescents compared with a physical education control group (Khalsa et al., 2012) and decreased verbal aggression in adults compared with a physical exercise group (Deshpande, Nagendra, & Raghuram, 2008).

Interestingly, in addition to promoting more positive psychological functioning, yoga also appears to prevent the worsening of some psychological parameters. This was demonstrated in samples of secondary school adolescents (Khalsa et al., 2012) and elderly individuals (Chen et al., 2009). In the former group, only the control group presented poorer scores on resilience, fatigue, and anger control at the postintervention assessment, which coincided with the end of scholastic term examinations. In the latter group, control participants' sleep latency, daytime dysfunction, depression state, and physical health perception worsened at the end of the 6 month intervention.

Table 1
Description of Studies Reviewed for the "Results" Section

Authors	*n*	Sample	Design	Type of yoga and yoga exercises	Duration	Control group	Type of outcome	Main results
Bilderbeck et al. (2013)	100	Prison population	RCT	Hatha yoga Breathing, postures, and relaxation	10 weeks, 1×/week, 2 h/class	Normal workout at prison	Self-report Behavioral task	Compared with control, yoga increased positive affect and reduced perceived stress and psychological distress, and practitioners committed fewer errors of omission and commission.
Khalsa et al. (2013)	135	Adolescent musicians	Quasi-experiment	Kripalu yoga Breathing, postures, and meditation	6 weeks, 3×/week, 1 h/class	WLC	Self-report	Compared with control, yoga decreased anxiety in group and solo performance and somatic/cognitive performance anxiety.
Tekur et al. (2012)	80	Low back pain patients	RCT	Integrated approach for yoga therapy (specific program for low back pain) Breathing, postures, relaxation, meditation, and lectures on yoga philosophy	Residential program: intensive 7 days, 5 AM–10 PM	Physical therapy exercises for back pain	Self-report	Yoga reduced pain, state and trait anxiety, and depression.
Rocha et al. (2012)	36	Healthy military men	RCT	Hatha yoga NI	6 months 2×/week 1 h/class	Physical activity	Self-report Biochemical marker	Compared with control, yoga decreased depression, anxiety and stress scores, and cortisol levels.

Table 1 (*continued*)

Authors	*n*	Sample	Design	Type of yoga and yoga exercises	Duration	Control group	Type of outcome	Main results
Froeliger et al. (2012)	14	Healthy practitioners and nonpractitioners	Quasi-experiment	Hatha yoga NI	Average experience > 3 years, 3–4 days/ week, > 45 min/ class	WLC	Behavioral task Brain activity	Compared with control, yoga group was less reactive in the right dlPFC while viewing negative emotional images and presented greater vlPFC activation during a cognitive task with emotionally irrelevant distractor images. Amygdala activation in response to negative emotional distractors was not associated with task-related changes in affect.
Afonso et al. (2012)	44	Postmenopausal women with a diagnosis of insomnia	RCT	Yoga HT for menopause Breathing, postures, and relaxation	4 months, 2×/week, 1 h/class	Passive stretching and WLC	Self-report	Compared with WLC, yoga reduced climacteric symptoms and insomnia severity and increased quality of life and resistance to stress. The reduction of insomnia severity in the yoga group was higher than in the control and passive-stretching groups.
Michalsen et al. (2012)	72	Distressed women	RCT	Iyengar yoga program (2 yoga groups) Postures and relaxation	3 months, 1×/week 90 min/class and 3 months, 2×/week, 90 min/class	WLC	Self-report	Compared with control, yoga improved perceived stress, state and trait anxiety, depression, psychological quality of life, and mood states.

(*table continues*)

Table 1 (*continued*)

Authors	*n*	Sample	Design	Type of yoga and yoga exercises	Duration	Control group	Type of outcome	Main results
Innes and Selfe (2012)	20	Older women with restless legs syndrome	RCT	Iyengar yoga program Breathing, postures, and relaxation	8 weeks 2×/week, 90 min/class	Educational film	Self-report	Compared with control, yoga improved multiple domains of sleep quality and mood and reduced insomnia prevalence, anxiety, and perceived stress.
Telles et al. (2012)	140	Distressed adults	Controlled trial (non-randomized)	Patanjali yoga Breathing, loosening exercises, postures, and relaxation	Residential program: 7 days, 2×/day, 2 h/class	WLC	Self-report	Compared with control, yoga decreased state anxiety, somatization of stress, and discomfort due to overbreathing and improved health-related quality of life and self-rated quality of sleep.
Khalsa et al. (2012)	111	Healthy secondary school adolescents	RCT	Yoga education program Breathing, postures, visualization, relaxation, talking points about yoga philosophy	11 weeks, 2–3×/week	Physical education activity	Self-report	Compared with control, yoga increased anger control, reduced fatigue, and increased resilience. Class attendance correlated with positive psychological attitudes and lower mood disturbances.
Gootjes et al. (2011)	24	Healthy practitioners and nonpractitioners	Quasi-experiment	Sudarshan Kriya Breathing, postures, relaxation, and meditation	Average experience of 2–60 months, 3×/week	WLC	Self-report Experimental task Brain activity	Compared with control, yoga reduced LPP during reappraisal of images. Reduced LPP correlated with yoga experience.
Smith et al. (2011)	81	Undergraduate students with mild to moderate depression, anxiety, or stress	RCT	Integrated version of Hatha yoga Breathing, postures, relaxation, and instructions of meditation on niyama and yama	7 weeks, 2×/week 1 h/class	Yoga as exercise (without meditation on yama and niyama) and WLC	Self-report Biochemical marker	Compared with control, both yoga groups exhibited decreased depression and stress and increased sense of hopefulness. Only the integrated yoga group exhibited decreased anxiety-related symptoms and cortisol levels.

Table 1 (*continued*)

Authors	*n*	Sample	Design	Type of yoga and yoga exercises	Duration	Control group	Type of outcome	Main results
Streeter et al. (2010)	34	Healthy volunteers	RCT	Iyengar yoga Postures and relaxation	12 weeks, 3×/week 1 h/class	Walking	Self-report Biochemical marker	Compared with control, yoga reduced anxiety and negative mood and increased positive mood. A marginal significant increase was observed in acute GABA levels in yoga group. A negative correlation was found between state anxiety and GABA levels across groups.
Kiecolt-Glaser et al. (2010)	50	Healthy novice and expert practitioners	Quasi-experiment	Iyengar yoga session following a stressor Postures and relaxation	Novices: 6–12 sessions, Experts: at least 2 years, 1–2×/week, 75–90 min/class	Walking on a treadmill following a stressor and passive-video control following a stressor	Self-report Stressor induction Biochemical, endocrine, and immunological markers Autonomic activity	Compared with novices, experts presented increased positive affect and lower overall serum IL-6 levels. Compared with novices, experts had lower heart rates and IL-6 in response to stressors. Compared with walking and video watching, yoga lower heart rate at the end of the intervention.
Chen et al. (2009)	128	Elderly	RCT	Silver yoga Loosening exercises, postures, relaxation, and guided imagery meditation	6 months, 3×/week, 70 min/class	WLC	Self-report	Compared with control, yoga improved daytime dysfunction, depression state, subjective sleep quality, and mental health perception.
Telles et al. (2009)	230	People with stress complaints	Quasi-experiment	Hatha yoga Breathing and postures	One 2 h session	Theoretical class about yoga	Self-report	Compared with control, yoga reduced state anxiety.

(*table continues*)

Table 1 (*continued*)

Authors	*n*	Sample	Design	Type of yoga and yoga exercises	Duration	Control group	Type of outcome	Main results
Vadiraja et al. (2009)	75	Breast cancer patients	RCT	Integrated yoga program Breathing, postures, meditation, and relaxation	6 weeks, 3×/week, 1 h/class	Supportive therapy as individual sessions	Self-report Biochemical marker	Compared with control, yoga decreased anxiety, depression, perceived stress, and salivary cortisol.
Danhauer et al. (2009)	27	Breast cancer	RCT	Restorative yoga Breathing, postures, relaxation, and emphasis on "ahimsa" (non-violence)	10 weeks, 1×/week, 75 min/class	WLC	Self-report	Compared with control, yoga improved mental health, depression, positive affect, and spirituality. Class attendance correlated with well-being and sleep quality.
Deshpande et al. (2008)	173	Healthy volunteers	RCT	Integrated yoga Breathing, postures, meditation, and lectures on yoga philosophy	8 weeks, 6×/week, 1 h/class	Physical exercises and lectures	Self-report	Compared with control, yoga decreased verbal aggression scores.
Streeter et al. (2007)	19	Healthy practitioners	Quasi-experiment	Hatha yoga Assessment after a 1 h class Postures and meditation	Average experience of 2–10 years, at least 2×/week	Magazine reading	Biochemical marker	27% increase in GABA levels in the yoga group after the yoga session.
Krishnamurthy and Telles (2007)	69	Geriatric sample	RCT	Integrated approach yoga Breathing, postures, relaxation, and devotional songs	24 weeks, 6×/week, 75 min/class	Ayurveda and WLC	Self-report	Compared with control, yoga showed linear decrease in depression scores at 3 and 6 month assessment.
Culos-Reed et al. (2006)	38	Breast cancer survivors	RCT	NI Breathing, postures, and relaxation	7 weeks, 1×/week, 75 min/class	WLC	Self-report	Compared with control, yoga improved general quality of life and emotional function.

Table 1 (*continued*)

Authors	*n*	Sample	Design	Type of yoga and yoga exercises	Duration	Control group	Type of outcome	Main results
Michalsen et al. (2005)	24	Distressed women	Controlled trial (non-randomized)	Iyengar yoga Breathing, postures, and relaxation	3 months, 2×/week, 90 min/class	WLC	Self-report Biochemical marker	Compared with control, yoga improved perceived stress, state and trait anxiety, well-being, vigor, fatigue, and depression and decreased cortisol after class.
Harinath et al. (2004)	30	Healthy military men	RCT	Hatha yoga Breathing, postures, loosening exercises, and meditation	3 months, 7×/week, 2×/day, 1 h/class	Physical training	Self-report Autonomic activity Biochemical marker	Yoga reduced mean arterial blood pressure and increased orthostatic tolerance, expiratory volume control, maximum voluntary ventilation, and well-being. Mean nighttime melatonin levels increased after yoga and meditation. Rise in melatonin levels correlated with well-being in the yoga group.

Note. RCT = randomized controlled trial; WLC = wait-list control; NI = not informed; fMRI = functional magnetic resonance imaging; LPP = late positive potential.

Psychological Measures: Clinical Populations

For different unhealthy samples yoga also produced changes that represent psychological improvements. For people with low back pain, yoga helped reduce state and trait anxiety and depression scores compared with a physical therapy control group (Tekur, Nagarathna, Chametcha, Hankey, & Nagendra, 2012). People with restless legs syndrome exhibited improvements in mood, anxiety, and perceived stress scores after a yoga intervention compared with a control group (Innes & Selfe, 2012). Two studies evaluated the effects of yoga in patients with breast cancer (Danhauer et al., 2009; Vadiraja et al., 2009), and one study evaluated breast cancer survivors (Culos-Reed, Carlson, Daroux, & Hately-Aldous, 2006). The results showed that this practice helped decrease anxiety, depression, and stress scores in patients compared with a supportive therapy control group (Vadiraja et al., 2009) and decreased depression in patients compared with a wait-list control group (Danhauer et al., 2009). Increases in positive affect and spirituality were also found in patients (Danhauer et al., 2009), and quality of life scores improved in survivors (Culos-Reed et al., 2006) compared with control groups. Finally, many studies evaluated the effects of yoga in adults with complaints of distress, demonstrating a reduction of perceived stress, state and trait anxiety, and depression scores compared with a wait-list control group (Michalsen et al., 2005, 2012; Smith, Greer, Sheets, & Watson, 2011; Telles, Singh, Yadav, & Balkrishna, 2012; Telles, Gaur, & Balkrishna, 2009). Likewise, these participants also exhibited an increase in quality of life (Michalsen et al., 2012; Telles et al., 2012) and well being (Michalsen et al., 2005) compared with the wait-list control group. One study compared yoga with a passive stretching control condition and wait-list control group and found that improvements in quality of life and a reduction of stress scores following yoga training were significantly higher compared with only the wait-list and not passive stretching group (Afonso et al., 2012). One hypothesis for this result is that yoga training comprised a specific approach called Hormonal Yoga Therapy, which focuses on specific sequences for menopausal women. Thus, this training may have characteristics that might not produce distinct effects from a passive stretching condition. Alternatively, passive stretching may constitute a control group that produces more similar effects to yoga than a physical exercise control condition.

Physiological Measures: Physical Symptoms

Postmenopausal women in the yoga group presented a greater reduction of climacteric symptoms and insomnia severity compared with an active control group and wait-list control group (Afonso et al., 2012). Quality of sleep and insomnia also improved among distressed adults (Telles et al., 2012), patients with restless legs syndrome (Innes & Selfe, 2012), and healthy elderly people (Chen et al., 2009) compared with a control group.

Physiological Measures: Biological Markers

Some studies found that yoga produced a greater reduction of salivary cortisol levels among distressed adults (Michalsen et al., 2005), breast cancer patients (Vadiraja et al., 2009), and healthy military men (Rocha et al., 2012) compared with control groups. However, Kiecolt-Glaser et al. (2010) did not find significant differences in cortisol levels after a yoga class following experimental stress induction between experienced and naive yoga practitioners. These results indicate that the effects of yoga on cortisol after acute stress remain inconclusive. Another study demonstrated that cortisol levels decreased in distressed undergraduates only after Integrated Yoga Training, which also included the stages of *yama* and *nyama*, but not after exercise-like yoga training (Smith et al., 2011). Acute levels of γ-aminobutyric acid (GABA), an inhibitory neurotransmitter in the central nervous system that is known to have anxiolytic effects (Chen, Yang, & Tobak, 2008), increased by 27% after a yoga class in experienced practitioners, although this difference was only significant within group and not compared with a reading control condition in nonpractitioners (Streeter et al., 2007). A subsequent yoga study by Streeter et al. (2010) performed a randomized trial and observed only a marginal and nonsignificant increase in acute GABA levels in the yoga group. No significant differences in tonic GABA levels were observed, but a significant correlation was found between changes in

tonic GABA levels and reductions of anxiety in the yoga group.

In another investigation, night plasma melatonin levels increased in healthy military men who underwent yoga training compared with a physical training group (Harinath et al., 2004). Another study found that expert practitioners presented significantly lower baseline serum interleukin-6 (IL-6) levels and lower IL-6 levels in response to an experimental stressor compared with novices, indicating a reduced inflammatory response to stress (Kiecolt-Glaser et al., 2010).

Physiological Measures: Behavioral and Neurophysiological Responses

Regarding behavioral responses, two studies investigated these outcomes using interference of emotional images (Froeliger, Garland, Modlin, & McClernon, 2012) or words (Kiecolt-Glaser et al., 2010) in an attention task. Both studies failed to detect significant effects of yoga on such behavioral parameters compared with controls. However, Froeliger et al. (2012) demonstrated that brain activity in response to negative images and their interference during the task showed significant patterns. Experienced practitioners exhibited a decrease in dorsolateral prefrontal cortex (dlPFC) activity when simply viewing negative images and an increase in ventrolateral prefrontal cortex (vlPFC) activity when processing these images as distractors during the attentional task compared with matched nonpractitioners. In yoga experts, amygdala (AM) activation in response to negative emotional distracters was not associated with task-related changes in negative affect (Froeliger et al., 2012). In another study, experienced practitioners exhibited a reduction of the late positive potential (LPP) response to negative images (Gootjes, Franken, & Van Strien, 2011). Altogether, these brain patterns indicate that yoga practitioners were less reactive or influenced by the negative emotion.

With regard to autonomic measures, Kiecolt-Glaser et al. (2010) reported that expert yoga practitioners exhibited lower heart rates following stress induction in the cold pressor test and an arithmetic test compared with novices, and heart rates were lower at the end of a yoga class compared with the end of two control conditions (i.e., walking and watching a video). However, another study did not observe significant changes in mean heart rate after a 3-month yoga intervention in healthy military men (Harinath et al., 2004), although these participants presented lower systolic, diastolic, and mean arterial pressure, indicating a reduction of sympathetic activity, and improved orthostatic tolerance and respiratory performance compared with a wait-list control group (Harinath et al., 2004).

Length and Frequency of Practice

Positive results were found with yoga practice ranging from as little as one single session (Kiecolt-Glaser et al., 2010; Michalsen et al., 2005; Telles et al., 2009) to 7 days (Tekur et al., 2012; Telles et al., 2012), 6–10 weeks (Culos-Reed et al., 2006; Danhauer et al., 2009; Deshpande et al., 2008; Innes & Selfe, 2012; Khalsa et al., 2013; Smith et al., 2011; Vadiraja et al., 2009), 3–4 months (Afonso et al., 2012; Bilderbeck et al., 2013; Chen et al., 2009; Harinath et al., 2004; Khalsa et al., 2012; Michalsen et al., 2005, 2012; Streeter et al., 2010), and 6 months (Chen et al., 2009; Krishnamurthy & Telles, 2007; Rocha et al., 2012). Three studies demonstrated that the frequency of practice was associated with lower mood disturbances (Khalsa et al., 2012), reduced LPP in response to negative images (Gootjes et al., 2011), and greater well being and quality of sleep (Danhauer et al., 2009).

Discussion

The results reported herein provide preliminary evidence that yoga may help promote more positive and adaptive psychological functioning, particularly fewer symptoms of anxiety, depression, and stress, and improved well being and quality of life. There is some indication that aggression may also be reduced by yoga practice, but few studies investigated this outcome. The evidence of behavioral and physiological measures remains less well established because of some heterogeneous results.

To scientifically corroborate the philosophical claims on the effects of yoga practice (Telles, 2010), we suggest that further research should test whether yoga can positively influence different levels of mind-body responses and foster a greater balance between them (see

Figure 1). Based on these claims and the reviewed evidence, Figure 1 presents a framework for the hypothesis that this balance might facilitate healthier interactions between such levels of responses, which might constitute possible psychological and neurophysiological mechanisms that underlie the relationship between yoga and emotion regulation. Further studies should also systematically investigate whether these effects and the suggested framework differ or significantly vary according to distinct types of yoga.

Potential Psychological and Neurophysiological Mechanisms

Based on the reviewed psychological improvements, we suggest that these effects may occur through an interplay between the activities that yoga incorporates, such as controlled breathing, mindful postures, relaxation, and, in some cases, formal meditation, which may lead to the development or enhancement of emotion regulation skills. Consistent with this proposition, the use of physical exercise as a control condition (Bilderbeck et al., 2013; Deshpande et al., 2008; Khalsa et al., 2012; Rocha et al., 2012; Streeter et al., 2010) indicates that the effects of yoga on emotion regulation, which were superior to the control groups, were not attributable to physical activity only. Moreover, the use of active control conditions that involve group activity (Harinath et al., 2004; Innes & Selfe, 2012; Tekur et al., 2012) refutes the hypothesis that the effects of yoga occur because of extrinsic factors that can influence emotion regulation, such as group support (Gross, 2013).

One of the aspects that distinguishes yoga from other exercises and group activities is its spiritual teachings (Telles & Raghavendra, 2011). Based on the process model of emotion regulation (Gross, 1998; Werner & Gross, 2010), one hypothesis is that these spiritual teachings might generate reappraisal strategies and facilitate the regulation of emotions. Accordingly, in some of the reviewed studies, the interventions were complemented by lectures or discussions on yoga philosophy (Danhauer et al., 2009; Deshpande et al., 2008; Khalsa et al., 2012; Krishnamurthy & Telles, 2007; Smith et al., 2011; Tekur et al., 2012). For example, greater reductions of anxiety and cortisol were found in a yoga group that received explicit instructions on how to meditate on spiritual principles compared with an exercise yoga group (Smith et al., 2011). Furthermore, another study explicitly measured spiritual well-being, demonstrating an improvement in this variable after a 10-week yoga intervention (Danhauer et al., 2009). Thus, spiritual teachings might have laid the groundwork for reappraisal processes, which may have played a role in the observed outcomes. However, one study that compared a single yoga session with a lecture on yoga principles showed that only the formal practice produced a reduction of anxiety levels (Telles et al., 2009). Therefore, one hypothesis is that the practitioner may need time to develop reappraisal skills, or spiritual teachings may not always result in reappraisal strategies, which is consistent with the fact that many of the presented studies that showed positive emotional outcomes did not incorporate philosophical teachings but did generate more adaptive emotional responses.

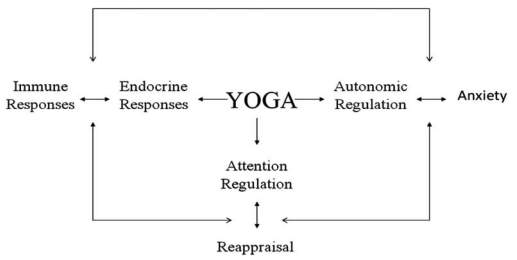

Figure 1. Diagram of the hypothesized effects that might underlie the relationship between yoga and emotion regulation.

Therefore, an alternative hypothesis is that the combination of yoga techniques may help foster another regulatory skill that is commonly investigated in the process model of emotion regulation, namely, attention allocation (Ochsner & Gross, 2005). Accordingly, yoga training participants exhibited significant improvements in a behavioral task that evaluated executive attention and inhibition compared with the control group (Bilderbeck et al., 2013). This improvement in executive function is consistent with another finding in which experienced practitioners exhibited a greater response in the left vlPFC in a condition in which negative distractors were presented during an attentional task and decreased activity in the dlPFC in a context of exposure to this class of images

(Froeliger et al., 2012). Both regions have been related to executive function, such as inhibition and self-regulation (Ochsner & Gross, 2005). Therefore, increased vlPFC activity indicated that yoga practitioners were better able to engage in the attention task and inhibit the emotional distractions, and the reduction of dlPFC activation suggested that yoga practitioners were less reactive to the emotional content (Froeliger et al., 2012). Thus, yoga may facilitate better attention allocation strategies by either not engaging in negative stimuli or disengaging faster from them, strategies that are normally impaired in depressive, stressed, and anxious states (Bishop, 2007).

Although cognitive changes were not the primary focus of the present review, studies that investigated yoga (Chattha, Nagarathna, Padmalatha, & Nagendra, 2008) or one isolated technique, such as breathing (Telles, Singh, & Puthige, 2013) or meditation (Lutz, Slagter, Dunne, & Davidson, 2008; Menezes et al., 2013), found that these practices can enhance attention regulation. Moreover, compared with a wait-list control group, participants who underwent an 8-week yoga program exhibited a significant increase in dispositional mindfulness, particularly in two domains: attention to the present moment and acceptance and open attitudes toward experience (Shelov, Suchday, & Friedberg, 2009).

We suggest that acceptance, another key component of the mindfulness operational definition, in addition to attention regulation (Bishop et al., 2004), might improve emotion regulation by functioning as an antagonist of suppression and rumination. This is based on studies that showed that less use of suppression partially mediated the relationship between orientation to positive behavior and reduced anxiety (Llewellyn, Dolcos, Iordan, Rudolph, & Dolcos, 2013), and rumination accounted for the attentional bias, uncoupled from the decision-making component, to negative information (Pe, Vandekerckhove, & Kuppens, 2013).

Thus, attention regulation and acceptance, which characterize the concept of mindfulness, may be important and interrelated skills that could explain why experienced yoga practitioners are less reactive to negative emotional stimuli (Froeliger et al., 2012; Gootjes et al., 2011). We also suggest that these skills may be equally important for the observed reduction of aggression (Deshpande et al., 2008; Khalsa et al., 2012), which likely reflects the ability to be less reactive to negative stimuli. Additionally, these findings contribute to discussions in the field of emotion regulation, given that they support the role of attention in emotion regulation (Ochsner & Gross, 2005; Pourtois, Koster, & De Raedt, 2013).

Another potential mechanism that mediates the effects of yoga on positive functioning is the reduction of anxiety and regulation of autonomic activity (Chaya & Nagendra, 2008; Telles, 2009). Some of the studies reviewed herein showed a reduction of anxiety symptoms (Innes & Selfe, 2012; Khalsa et al., 2013; Michalsen et al., 2005, 2012; Rocha et al., 2012; Smith et al., 2011; Streeter et al., 2010; Tekur et al., 2012; Telles et al., 2012; Vadiraja et al., 2009) and a reduction of sympathetic activation (Harinath et al., 2004) after yoga training. Notably, both state anxiety scores (Telles et al., 2009) and heart rate (Kiecolt-Glaser et al., 2010) decreased after a single yoga session, suggesting the state effect of the practice.

From a neurocognitive perspective, higher levels of anxiety can facilitate bias toward negative emotions (Bishop, 2007), impair disengagement from negative stimuli (Sheppes, Luria, Fukuda, & Gross, 2013), and interfere with the cognitive regulation of emotions (Mocaiber et al., 2009). Moreover, anxiety-eliciting stimuli (i.e., stimuli previously paired with mild shock) can impair inhibitory performance (Pessoa, Padmala, Kenzer, & Bauer, 2012). In the same direction, some authors reported that individuals with low heart rate variability showed greater orientation toward negative emotion and slower attentional disengagement from these type of stimuli, indicating that the worse regulation of cardiac vagal tone negatively interacts with the bottom-up and top-down processing of emotions (Park, Van Bavel, Vasey, & Thayer, 2013). Indeed, some physiological systems seem to underlie the relationship between attentional regulation and affective processes, with the potential to integrate these functions in the service of self-regulation (Thayer & Lane, 2000). Accordingly, evidence indicates that the influence of arousal, such as reduced noradrenergic activation, may account for the better control of emotional reactivity (Gujar, McDonald, Nishida, & Walker, 2011).

Therefore, in addition to being a positive emotion regulation outcome per se, reductions of anxiety and arousal may also function as a mechanism for a broader and perhaps long lasting successful cognitive regulation of emotion. It likely facilitates inhibition or attentional disengagement from negative feelings and cognition, allowing a shift to more positive reappraisals or the extinction of negative appraisals.

Consistent with this possibility, reduced anxiety scores correlated with increases in GABA levels (Streeter et al., 2010), corroborating the anxiolytic effect of this neurotransmitter (Chen et al., 2008), and correlated with reduced morning cortisol levels (Vadiraja et al., 2009). Another interesting finding was the positive correlation between melatonin levels and well-being scores in participants who received 3-month yoga training (Harinath et al., 2004). Supporting this result, skin sympathetic nerve activity, mean arterial pressure, and heart rate in response to mental stress were attenuated after melatonin ingestion, indicating the influence of this hormone on the attenuation of sympathetic activity (Muller, Sauder, & Ray, 2013). These findings are particularly relevant when considering the idea that autonomic, endocrine, and inflammatory responses in negative emotional situations influence the impact of stressors on the individual (Kiecolt-Glaser et al., 2010).

Methodological Considerations and Suggestions

Although encouraging, the amount of evidence is limited, and many results come from studies that presented some methodological weaknesses. In general terms, these include the exclusive use of a wait-list control group and no sample size justification or power analysis. Concerning controlled trials, although blinding is difficult for behavioral treatments, there were no references to the use of blinding in the analyses. Some studies did not randomize the participants, did not report follow-up assessments after completing the intervention, or did not discuss yoga's potential adverse effects. We understand that quasi-experimentation (i.e., cross-sectional designs that compare groups whose participants are not randomly allocated) that evaluates the long-term effects of yoga in expert practitioners can make a significant contribution, and that longitudinal evaluations of regular personal practices can be time-consuming and expensive and constitute a methodological challenge. However, attempts should be made to replicate the results from quasi-experiments using subsequent prospective assessments. Likewise, most of the findings derive from studies that have not been replicated, so the results need to be interpreted with caution.

From a psychological methodology perspective, another observation was the overuse of self-report measures, which can be influenced by demand bias and social desirability. There was also a paucity of studies that evaluated emotion regulation using behavioral and experimental paradigms or the regulatory process per se, which could provide more objective measures of emotional responses. Importantly, the use of different methodological protocols or instruments may also hinder explanations of divergent results. For example, distinct self-report scales that measure the same construct but are not analyzed using standardized scores or do not present effect sizes do not allow comparisons of baseline scores between studies, thus hampering the ability to determine whether the lack of posttreatment change is attributable to initial baseline scores that are already lower. Accordingly, one study demonstrated that participants with higher negative affect and lower emotional well-being scores at baseline derived greater benefit from the yoga intervention compared with individuals with similar values at baseline in the control group (Danhauer et al., 2009).

Finally, the reviewed results, combined with these methodological considerations, elicit some possibilities for future research. Future studies should investigate whether sleep quality mediates the effects of yoga on emotion regulation. Different results contributed to this proposition. First, individuals who exhibited a rapid-eye-movement sleep phase were less reactive to emotional stimuli, and such an effect was explained by reduced noradrenergic activation during this phase (Gujar et al., 2011; but see Minkel et al., 2012). Second, higher levels of epinephrine in a subsample of expert yoga practitioners was only correlated with significantly fewer hours of sleep before the visits required by the experiment and not to differences in affect, other health behaviors, or inflammation (Kiecolt-Glaser et al., 2010). Third, improved

sleep quality is an effect that is observed with some types of yoga training (Afonso et al., 2012; Innes & Selfe, 2012; Khalsa et al., 2012; Patra & Telles, 2010; Telles et al., 2012).

Another suggestion is to compare yoga and another physical activity intervention on mindfulness scores. Although evidence suggests that physical activities can enhance emotional functioning (Matta Mello Portugal et al., 2013), the effects of yoga were superior to exercise (Bilderbeck et al., 2013; Deshpande et al., 2008; Khalsa et al., 2012; Rocha et al., 2012; Streeter et al., 2010), and mindfulness scores appeared to increase as a result of yoga practice (Shelov et al., 2009). Thus, whether increased mindfulness accounts for the difference between yoga and exercise remains unexplored.

The study of emotion regulation should also consider two main aspects, namely whether the results refer to the outcomes of emotion regulation or the regulatory process itself (Wadlinger & Isaacowitz, 2011). Most of the studies reviewed herein evaluated outcomes that are interpreted as indices of emotion regulation. Only three studies investigated how yoga affects the regulation process itself through behavioral and physiological responses to emotional images (Froeliger et al., 2012; Gootjes et al., 2011) and stressors, such as in the cold pressor test and an arithmetic test (Kiecolt-Glaser et al., 2010). Therefore, more studies should investigate how yoga affects practitioners' regulation of emotional stimuli as they occur. Moreover, considering the role of attention in emotion regulation, paradigms should be designed to investigate the modulation of emotion by attentional demands (Froeliger et al., 2012; Menezes et al., 2013; Pe et al., 2013). Experimental methods derived from the field of psychology can thus contribute to the investigation of yoga, making the study of yoga another means to understand the psychological processes that are involved in the regulation of emotions.

Lastly, despite some evidence (Balasubramaniam et al., 2012), still unclear is whether the effects of yoga on emotion regulation extend to individuals with diverse mental health problems. Further studies should investigate whether yoga contributes to better mental health in psychiatric patients, whether yoga is more beneficial or contraindicated for one or some psychiatric conditions, and whether yoga prevents the onset of some psychiatric conditions. Some yoga modules are likely better suited for specific diseases, but more systematic clinical trials are necessary to determine which patients, which medical conditions, and which types of yoga practice are the most suitable (Burton, 2014).

Conclusions

This article sought to scientifically discuss what has always been the philosophical rationale for yoga (i.e., that yoga and its combination of stages and not a particular technique or stage help maintain a state of physical and mental balance; Taimini, 2006). The claim is that through greater awareness of physical and mental processes, which may be fostered by the types of techniques that yoga combines, the practitioner can better regulate imbalances, particularly at the mental level, that are believed to be the cause of diseases (Telles, 2010).

Some evidence supports the role of yoga in helping improve psychological outcomes in healthy subjects and people who suffer from some physical illnesses. However, the effects of yoga on behavioral and physiological outcomes remain inconclusive. From a psychological point of view, the data reviewed herein suggest that yoga may be able to foster emotion regulation skills through such mechanisms as reappraisal, attention regulation, self monitoring, self awareness, and autonomic regulation. Based on its potential benefits and the ancient perspective that yoga may be an effective strategy for counteracting mental and physical imbalances, more studies should attempt to replicate or extend these findings and discuss the potential of yoga for enhancing emotion regulation.

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