



How does yoga reduce stress? Embodied cognition and emotion highlight the influence of the musculoskeletal system



Alisha L. Francis*, Rhonda Cross Beemer

Northwest Missouri State University, United States

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ABSTRACT

Yoga is an increasingly popular activity, perhaps because of its association with stress reduction and relaxation – an association that is generally supported by empirical evidence. Understanding of the mediating variables is, however, limited. Given that, the purpose of this paper is to present a theoretical perspective that encourages systematic research regarding the relationship between yoga, stress, and musculoskeletal activity. This embodied perspective parallels popular interest in the mind-body connection and emphasizes the influence of body position on thinking as well as emotion. Those influences take on added meaning in the context of the Cognitive Appraisal Theory and the Biopsychosocial Model of Challenge and Threat. Investigations of embodied cognition suggest that yoga may reduce stress by affecting the way individuals appraise stressors. The combination of body position and common components of yoga practice may also contribute to that effect, particularly when considering thoughts about the self and feelings of confidence. Findings regarding embodied emotion make a similar contribution to understanding the implications of previous research findings and common yoga practices. Considering yoga and stress from an embodied perspective also highlights the role of the musculoskeletal system in the stress process, leading to the question of whether yoga influences stress by directly influencing the musculoskeletal system, indirectly by influencing awareness of that system, or through a combination of the two. Those questions, in turn, highlight the importance of expanding investigations of psychological processes, body position, musculoskeletal activity during yoga, and the interactions between those variables.

1. Introduction

Yoga is increasingly visible and popular. Between 2012 and 2016, the number of Americans practicing increased by almost 75% with over 36 million people reporting they practiced yoga in 2016.¹ That increase has steadily grown over the last decade and there is little evidence the pattern will change.^{1,2} This growth may reflect the value of the perceived benefits of yoga practice as a large majority of Americans agree that it is beneficial for physical and psychological health.^{1,2}

One of the benefits commonly cited by yoga practitioners and aspiring practitioners is stress reduction or relaxation.^{1,2} Despite the fact that interest in the relationship between yoga and stress spans nearly seven decades, the empirical evidence for those benefits is more ambiguous.^{3,4} While a number of studies do provide evidence that yoga can be effective at reducing stress, the effect is comparable to that found with other stress reduction techniques.^{5,6} In addition, publication biases may limit understanding of the effects of specific types of yoga practice.⁷ This combination of popular belief and mixed results magnifies the importance of understanding the process through which yoga can

influence stress.⁸

The lack of a common theoretical framework may add to the challenges of identifying those processes. Like the term yoga, the concept of stress has substantial popular recognition and equally substantial variation in operationalization – so much so that researchers have argued that the term “stress” should be eliminated from use in scholarly work.^{9,10} Based on this information, studies without a theoretical context may offer little insight. The purpose of this paper is to discuss findings regarding the relationship between yoga and stress within a theoretical perspective that encourages systematic research. This perspective, referred to in psychology as “embodiment,” parallels popular interest in the mind-body connection and suggests that yoga may influence stress by influencing the musculoskeletal system. Fig. 1 depicts the resulting process.

2. Method

This paper is the product of two different scholarly PsycINFO searches. The first search identified studies applicable to developing

* Corresponding author at: 800 University Drive, Maryville, MO, 64468, United States.

E-mail address: alishaf@nwmissouri.edu (A.L. Francis).

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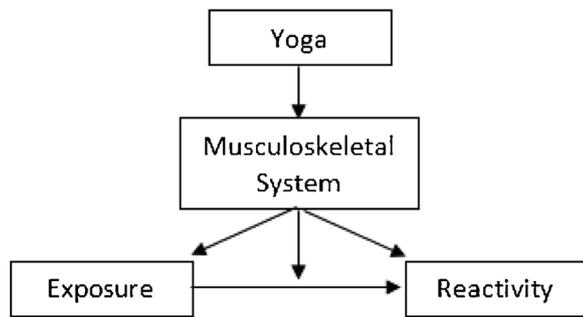


Fig. 1. An embodied perspective on the relationship between yoga and stress.

yoga practice sequences. The search was limited to articles using the terms “yoga” and “stress” in the titles and excluded keywords related to Posttraumatic Stress Disorder. The results included a number of articles cited in the previous section, collectively highlighting a gap in knowledge. The second search used the term “stress” in the title with the same exclusions as the other search, adding limiters to identify articles available in full text in the English language. The results included the article by Nair et al¹¹ that included postural manipulations.

The postural manipulation in Nair et al¹¹ exemplified many common instructions and positions from yoga class, suggesting the theories of embodied emotion and cognition that provided context for that study were also applicable to understanding the relationship between yoga and stress. That premise – that yoga practice, embodiment, and stress were interrelated – prompted a series of literature searches and resulted in this review. Those searches were initially limited to titles and abstracts of publications indexed in PsycINFO. A search for the terms “yoga” and variations on the word “embodiment” resulted in additional consideration of the role of body awareness as the variable was frequently mentioned in the search.

In order to expand the review, we reviewed results of a search for variations on the word “embodiment” without a second keyword to identify theoretical and empirical articles published in the last 10 years and with a focus relevant to yoga. For example, we excluded studies focused on facial muscles. Older articles and those from publications not included in PsycINFO were added to the review if they were repeatedly cited in contemporary work. After identifying robust findings related to embodied cognition and emotion, we investigated related findings regarding the musculoskeletal effects of yoga using all databases available via Ebscohost.

The Cognitive Appraisal Theory¹² and contemporary work echoing that theory provided a framework for organizing findings from the diverse perspectives represented in the searches. That framework was selected because it is commonly accepted across a number of disciplines, as evidenced by the numerous citations for related publications reported in Google Scholar.

3. Perspectives on stress

Theoretically, the stress process has been described using a number of terms representing two general components: exposure and reactivity.¹³ Exposure represents the potentially stressful event or condition in an otherwise objective situation, sometimes referred to as “stimuli” or “stressors”.^{12,14} Reactivity represents the interpretation of the event or condition to which the individual has been exposed.¹⁴ Collectively, then, the experience of stress is the product of the interaction between the environment and the individual– the inherent “struggle to manage the pressures of daily living”.¹⁵

One dominant theory of the stress process, the Cognitive Appraisal Theory,¹² defines reactivity in terms of appraisal and coping. According to that model, individuals are constantly appraising their transactions with their environment. Contemporary research focuses on the degree to which a stressor is considered a threat or a challenge (i.e. ^{16,17}).

Threat represents the potential for future harm resulting from the stressor while challenge represents the potential for growth or other benefit. Coping refers to the processes used to alter the stressor, the appraisal, or the results of the appraisal.¹⁸

Appraisal and coping are part of a dynamic process that requires multiple levels of analysis (Folkman, 2009; Folkman & Lazarus, 1985). One contemporary theory, the Biopsychosocial Model of Challenge and Threat,¹⁹ suggests that the degree to which a situation is goal relevant is an important variable. When situations are goal relevant, evaluation of the situational demands and personal resources influence appraisals. Variations in appraisal are, in turn, associated with variations in autonomic nervous system (ANS) reactivity.

Considering the role of appraisal in the stress process suggests a number of ways that yoga can influence stress. Riley and Park⁸ identified five articles testing mediating variables between yoga and stress. The psychological variables represented by those studies – positive affect, mindfulness, and self-compassion – can be associated with appraisal processes. For example, self-compassion may reduce stress by allowing the individual to see lack of success as a normal opportunity to continue to improve (a challenge appraisal) rather than a failure (a threat appraisal). The remaining studies identified in the Riley and Park⁸ review considered biological mechanisms, including activity in the posterior hypothalamus, inflammatory, and endocrine responses, which are associated with other aspects of reactivity.

The number of biological mechanisms included in studies of stress and yoga implicitly acknowledges a reciprocal mind-body connection. Psychological theory and research regarding other topics explicitly emphasizes the importance of that connection in developing a dynamic, comprehensive understanding of behavior. Work from that perspective, referred to as “embodied” or “embodiment,” considers the interrelationship between psychological processes and activity in the perceptual, somatosensory, and motor systems.²⁰ Interactions between bodily states, thoughts, and feelings highlight the reciprocal nature of the mind-body connection.²¹ This view presents a contrast to the common belief that “the only function of the motor system is to dutifully execute the central executive’s commands”.^{22(p. 185)}

Emphasizing the reciprocal relationship between the musculoskeletal system and psychological activity can enhance understanding of the stress process given the relationship between stress and muscular tension.²³ For example, when individuals report that they are experiencing stress the muscle fibers in the trapezius are also activated despite the absence of a physical demand.²⁴ Findings related to embodiment suggest other circumstances that activate the trapezius may lead to the perception of psychological stress. Collectively, that line of thinking and others flowing from related research suggests a number of mechanisms by which yoga can reduce stress during the practice and over time (see Table 1, for a summary of findings related to potentially stressful events or conditions).

4. Body position and thinking

Yoga practice is associated with improved cognitive functioning, with effects that are distinctly different from those found with acute aerobic exercise.^{26,27} Those findings are consistent with work from the perspective of embodied cognition which notes the influence of physiological systems in shaping experience and related thoughts.³⁷ Research from that perspective indicates that musculoskeletal actions influence thinking in several ways, including the amount of thinking taking place at a given time and biasing the thinking that does take place.²⁵

Those findings, which represent a concept referred to as embodied cognition, suggest one mechanism through which yoga reduces stress. Given the role of cognition in reactivity (e.g. ^{12,38}), applying findings related to embodied cognition to the appraisal component of stress suggests yoga may influence stress by impacting the way the individual thinks about and, therefore, responds to stressors (see Table 2, for a

Table 1
Summary of findings related to potentially stressful events or conditions.

Embodiment and Stress Exposure	Yoga and Stress Exposure
Musculoskeletal actions influence amount of thinking and bias thinking ²⁵ enacting body positions associated with a particular emotion invokes that emotion ^{28–30}	Yoga practice is associated with improved cognitive functioning ^{26,27} 8-week yoga intervention resulted in decreases in negative mood and increases in positive mood ³¹
Body position influences observer's perceptions of an actor's emotions ^{32,33} posture while preparing for a potentially stressful event influences observers' evaluations of an actor during the event ³⁵ sitting is associated with higher levels of negative affect ³⁶	Practitioners report yoga positively influences social interactions ³⁴

summary of findings related to interpretation of potentially stressful event or condition). This integration also helps explain how yoga interventions that vary substantially in length and content all help reduce stress.

Investigations of the effects of yoga range in duration, with interventions as short as 20 min influencing anxiety and mood.⁴⁶ From one perspective, these findings may be attributed to placebo effects – particularly given the popular belief that yoga reduces stress.⁵¹ The validity of the findings is supported; however, by findings that a 30-minute, video-based yoga practice was associated with lowered reactivity to a subsequent stressor and faster recovery from that reaction.⁴⁹

Considering the common components of a yoga practice in the context of embodied cognition suggests additional mechanisms for stress reduction. For example, yoga often involves students lying on their backs while instructors provide cues emphasizing natural variation in abilities or relaxation. Research suggests that individuals lying on their backs are more likely to be persuaded by messages than they would be when standing, suggesting the combination of position and message can uniquely contribute to reduction in stress-related thinking.³⁹

The influence of body position on thoughts and feelings appears to be outside of conscious awareness. In one experimental study, participants who were instructed to sit in an “upright” position experienced higher levels of pride when they received successful feedback compared to individuals who were unobtrusively placed in a “slumped” position.⁴¹ That influence may be reflected in findings that yoga practitioners are more positive about their bodies and more compassionate toward themselves.^{42–44} These patterns may subsequently contribute to lower levels of stress by reducing the threat appraisals when the individual encounters related stressors. The impact may expand to include a range of stressors given findings that yoga increases general self-efficacy.⁵⁰

Embodied cognition suggests that the influence of yoga on self-efficacy may also be the result of the way the poses influence thoughts. Many yoga poses include extending the arms, the legs, or both arms and legs. Instructors also frequently use cues that encourage expansiveness by encouraging actions that retract the scapula and expand the chest, allowing for a stretch of the pectoralis major and minor. These

Table 2
Summary of findings related to interpretation of a potentially stressful event or condition.

Embodiment and Reactivity	Yoga and Reactivity
Individuals are more likely to be persuaded by messages when lying on their backs than they when standing ³⁹	A six-week yoga resulted in more confidence in stressful situations ⁴⁰
Individuals sitting in an “upright” position experienced higher levels of pride when they received successful feedback ⁴¹	Yoga practitioners are more positive about their bodies and more compassionate toward themselves ^{42–44}
Confident body positions strengthen the relationship between thoughts and self-evaluation ⁴⁵	A 20-minute yoga intervention influenced anxiety and mood ⁴⁶
Expansive positions cause feelings of power and powerful behavior, independent of role ^{47,48}	A 30-minute, video-based yoga intervention lowered reactivity to a subsequent stressor and was associated with faster recovery from that reaction ⁴⁹
Individuals in expansive positions report higher levels of self-esteem and demonstrate greater levels of task persistence when faced with a potentially stressful task ¹¹	Yoga increases general self-efficacy ⁵⁰

Findings in Table 1 also relate to reactivity.

expansive actions are also used in operationalizing “confident,” “expansive,” and “powerful” positions in research regarding embodied cognition. Findings that confident body positions can strengthen the relationship between thoughts and self-evaluation – both positively and negatively – suggest that the combination of messages and movement in yoga may influence self-efficacy.⁴⁵

The influence of musculoskeletal activity during yoga takes on added meaning given findings that expansive positions cause feelings of power and corresponding behavior, even when an individual is not in a powerful role.^{47,48} Implications for stress are highlighted in findings that posture while preparing for a potentially stressful event influences others' evaluations of an individual during that event, even when their self-reported feelings are not strongly influenced.³⁵ Individuals in expansive positions also report higher levels of self-esteem and demonstrate greater levels of task persistence when faced with a potentially stressful task.¹¹ This line of thinking parallels findings that participants in a six-week yoga intervention were more confident in stressful situations when compared to a control group.⁴⁰ Findings that dominant body position was not related to differences in hormonal responses to stress suggest that the influence of the musculoskeletal body is also independent of other systems.⁵²

5. Body position and emotion

Expansiveness of movement also varies with emotional state.⁵³ For example, the upper body is described as “collapsed” when an individual is experiencing shame, sadness, and boredom.⁵⁴ This may explain, in part, findings that sitting is associated with higher levels of negative affect.³⁶ In addition, emotional experiences are accompanied by muscle activation independent of the response that accompanies perceptual processing.⁵⁵ Collectively, these patterns support the assertion that the musculoskeletal body plays a significant role in the stress process given that stress and emotion are intricately connected.^{10,15,18}

That suggests additional implications for findings regarding yoga and emotion. One 8-week intervention with participants who did not practice yoga before the study resulted in decreases in negative mood and increases in positive mood.³¹ A systematic review by Pascoe and Bauer⁵⁶ indicates those findings are consistent with those from other studies. While some studies include both mood and stress variables

Table 3
Musculoskeletal effects of yoga and gaps in knowledge.

Previous Findings	Gaps in Knowledge
Yoga can strengthen excessively extended and excessively contracted muscles while also assisting in re-education of postural development and maintenance ⁶⁹	Studies of musculoskeletal effects of yoga do not include psychological variables
The Sun Salutation sequence improves muscular strength and endurance for healthy individuals ⁷¹	A limited number of muscles have been tested in research
Shoulder flexibility improves with yoga practice ⁷⁴	Agonist-antagonist pairs have not been included in musculoskeletal studies
Patients with chronic neck pain report improvements following yoga interventions ⁶⁵	Musculoskeletal benefits frequently operationalized in terms of symptom relief rather than effects on specific muscles or muscle groups
Patients with chronic low back pain report improvements following yoga interventions ^{66,67}	Research on musculoskeletal effects includes a limited number of poses and sequences
Yoga is as effective for knee strengthening as a traditional physical therapy program ⁶⁸	
During high speed practices greater muscle activity occurs during transitions compared to holding yoga poses ⁷⁰	
Plank pose improves rectus abdominis endurance ⁷²	
A number of studies report effects on low back and hamstring flexibility based on the sit-and-reach task (i.e. ^{31,64,73})	

(i.e. ⁵⁷); however, analysis of the mediating effects has not been reported.

Those patterns also have a number of implications in the relationship between yoga and stress given findings that enacting body positions associated with a particular emotion invokes that emotion.^{28,29} Shafir et al³⁰ emphasize that potential in saying “. . . feelings might be altered not only by active execution of certain movements, but also by stopping and/or avoiding other movements,” (p. 225).

Research regarding the interpretation of others' emotions raises the question of whether yoga also influences stress by influencing social interactions. While facial expression plays a role in the interpretation of expressions of some emotions, others can be interpreted based only on body language – in some cases, such as anger, requiring only a glimpse of a portion of the body or a less than clear view.^{32,33} This interpretation is processed in multiple regions of the brain and does not require conscious attention or awareness^{32,58}. Yoga may affect the musculoskeletal body in a way that influences others' perceptions of the practitioner's emotions, though interpretation of those musculoskeletal indicators of emotion is not always accurate.⁵⁹ Given that, yoga may also reduce stress by reducing negative effects of inaccurate interpretations by influencing the way practitioners relate to others.³⁴

6. Yoga and embodied stress

There is ample evidence that stress is associated with activity throughout the nervous system.⁶⁰ While that activity is frequently viewed as an effect of stress, an embodied perspective suggests that activity may be part of the cause. The embodied perspective also highlights the role of the musculoskeletal system, whereas previous work focused on the neuroendocrine and cardiovascular systems. This leads to the question of whether yoga influences stress by directly influencing the musculoskeletal system, indirectly by influencing awareness of that system, or through a combination of the two (see Fig. 1).

6.1. Musculoskeletal effects of yoga

There is evidence that yoga can benefit individuals with a range of physical and orthopedic conditions affecting the musculoskeletal system.^{61,62} For example, yoga interventions result in significant improvements in discomfort for computer users.^{63,64} Patients with chronic neck pain report improvements following yoga interventions⁶⁵ as do those with chronic low back pain.^{66,67} Individuals with knee injuries may also benefit from yoga-based therapy given findings that yoga is as effective as a traditional knee strengthening program.⁶⁸

These therapeutic effects are consistent with findings regarding yoga and muscular activity. Research suggests on-going practice can

strengthen excessively extended and excessively contracted muscles while also assisting in re-education of postural development and maintenance.⁶⁹ During high speed practices, such as with Power Vinyasa yoga, greater muscle activity occurs during transitions versus during the yoga poses.⁷⁰ The Sun Salutation sequence included in various styles of yoga also improves muscular strength and endurance for healthy individuals.⁷¹ The poses themselves require isometric contractions of specific muscles. Plank pose is frequently included in yoga class and has been found to improve rectus abdominis (RA) endurance when evaluated using an EMG.⁷² Findings that other poses did not result in significant RA activity underscores the differential effects of the poses.

In addition to strengthening muscles, yoga practice is associated with increases in flexibility. A number of studies report effects on low back and hamstring flexibility based on the sit-and-reach task (i.e. ^{31,64,73}). Shoulder flexibility has also been shown to improve with yoga, specifically Bikram Yoga training.⁷⁴

When considered in conjunction with findings regarding embodied emotion and cognition, analysis of the musculoskeletal effects of yoga suggests different styles of practice may have different effects on stress. Although the variations in activities that are included under the umbrella of yoga create limitations for some research paradigms, they may serve as a source of knowledge regarding embodiment effects. Similarly, embodiment allows for additional insights from studies that do not support the relationship between stress and yoga.

Current knowledge of the musculoskeletal effects of yoga is; however, limited in a number of ways. Studies regarding chronic lower back pain and other conditions typically use reports of symptoms rather than assessing specific muscles. Studies of musculoskeletal variables are relatively limited in number and scope. Many of those studies measure agonistic and synergistic contractions of anterior musculature, or the results of those actions, without corresponding measurement of the antagonistic musculature of these actions.

Those limitations are of greater consequence when considered in the context of embodiment. Current findings would indicate practice encourages a slumped body position by lengthening of the posterior musculature, which in turn cause a contracture of the anterior musculature leading to a kyphotic posture.^{64,71,72,74} That conclusion, however, may not be supported by studies taking a more comprehensive approach to the musculoskeletal effects of yoga (see Table 3, for musculoskeletal effects of yoga and gaps in knowledge).

6.2. Body awareness

Findings regarding body awareness provide another perspective on the mechanisms through which musculoskeletal activity during yoga

reduces stress. Awareness of bodily experiences and sensations is positively associated with a number of variables that are negatively associated with stress.⁷⁵ Awareness of physical movement and the way the body feels during that movement is also associated with lower levels of self-objectification.⁴² This may be, in part, because increased body awareness may influence the unconscious connection between body and emotion.⁷⁶

Body awareness is also associated with increased understanding of unconscious cardiovascular responses to emotional stimuli.⁷⁷ That parallels findings from experimental manipulations of appraisal during which participants are educated about the potential for physiological arousal to be helpful, a process which presumably also increases awareness of that arousal.^{17,78,79} Participants in those studies demonstrated lower levels of cardiovascular activity to the stress response and scored higher on exams.

This suggests yoga may influence cognitive processes during the reactivity stage of the stress process given that yoga practice is associated with awareness of bodily experiences and sensations.^{75,80,81} Yoga practitioners are also more likely to be aware of the mind-body connection.⁴⁴ Smith⁸² emphasizes that awareness in asserting that yoga can provide “a radical form of engagement with the body,” (p. 37). Variations in body awareness from person-to-person may also help explain discrepant findings about the impact of yoga on stress.⁸³

7. Conclusion

The increasing popularity of yoga creates an opportunity for synergy between practitioners and scholars in multiple disciplines. Whether it is called “the mind-body connection” or “embodiment,” yoga may facilitate a unique interaction between psychological and physiological processes – an interaction that suggests a new perspective on the variables mediating the relationship between yoga and stress. Existing research provides a theoretical basis for investigating that relationship and highlights the importance of expanding the physiological variables associated with the stress process. Tables 1–3 summarize the findings discussed in the previous sections.

8. Future directions

The analysis in the previous sections presents a number of suggestions for investigations of psychological processes, body position, musculoskeletal activity during yoga, and the interactions between those variables. Expanded consideration of variables related to the musculoskeletal system will be essential in understanding the physiological effects of yoga practice, both related to stress and in other contexts. Testing the related hypotheses will also allow researchers to address weaknesses represented by previous studies by facilitating robust research design.

Emphasizing musculoskeletal measures, alone and in conjunction with psychological measures, has the potential to address a number of critiques of previous research. For example, the range of activities represented by the term “yoga” presents a number of challenges for researchers and practitioners.^{8,84} Musculoskeletal analysis will require specification of poses and allow for consistency in both research and practice. Identifying appropriate comparison groups for yoga interventions can also be challenging for yoga researchers.⁸⁵ Knowledge from kinesiology and biomechanical analysis of the musculoskeletal system may overcome this issue when considering variables related to muscle activity. Similarly, previous research regarding muscle activity facilitates the process of determining appropriate sample size, addressing another concern in previous research about the effects of yoga.⁸

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