

**YOGA AND ADOLESCENTS: WHAT DO WE KNOW?
THE EFFECTS OF YOGA ON ADOLESCENTS' COGNITION
AND SOCIAL-EMOTIONAL DEVELOPMENT**

by

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ABSTRACT

Yoga's presence in mainstream American culture has grown dramatically during the past 30 years, with the number of practitioners almost doubling between 1998 and 2008. Researchers have begun to evaluate the impact of yoga practice on outcomes such as stress, anxiety, and depression, as well as attention and working memory. Early findings suggest that yoga practice is related to a host of positive outcomes, but interpretation of these findings is limited by methodological weaknesses. Yoga programs are being implemented in middle and high schools across the country, yet little is known about the impact of yoga practice on school-related variables, such as attention. This dissertation presents results from one of the first randomized, controlled trials of yoga for adolescents, and examines the effects of participation in a school-based yoga program on ninth-grade students' working memory capacity, math performance, and attention problems, as well as affect, emotion regulation, and self-esteem. Results suggest that practicing yoga may be related to improvements in working memory capacity among boys. Similarly, yoga may protect boys against increases in negative affect. Although these results are promising, yoga practice was not related to changes in attention problems, and was only marginally related to emotion regulation. Counter to expectations, students in the yoga group showed decreases in positive affect over time, compared to control students. Additionally, girls in the yoga group showed larger decreases in self-esteem than girls in the control group. There is indication that yoga may have a positive effect on select outcomes, but many questions about the nature of yoga's impact on young people have yet to be answered.

CHAPTER I

INTRODUCTION

Practicing yoga has been associated with numerous benefits. Anecdotal reports speak to its transformative power, and its ability to impact mood, self-awareness and self-acceptance, mental health, and cognition. The number of Americans who report practicing yoga has almost doubled in the past 20 years (Saper et al., 2004; Yoga Journal, 2008), and with the increase in the number of practitioners there has been increasing interest among scholars in understanding yoga's effects. The number of empirical studies conducted on yoga has risen in the past 10 years, but the field of yoga research continues to advance slowly. Many of the published studies have been exploratory in nature, and have been limited by various methodological and statistical weaknesses. Additionally, although yoga is making its way into schools and extracurricular programs, there is very little research on the impact of yoga on children and adolescents, and much of this small body of work is limited by poor methodological quality (see Birdee et al., 2009 and Galantino & Quinn, 2008 for reviews).

Yoga offers the promise of positive transformation, but until the field moves beyond the exploratory phase, it will be difficult to translate the anecdotal reports into empirical evidence of yoga's effects. If yoga does effect positive change in mental health, affect, self-concept, and cognition, then it may be an ideal practice to introduce to young people. Adolescents face numerous biological, cognitive, and emotional changes, and yoga may support young people as they transition through the potentially rocky adolescent years. However, it will be essential to conduct rigorous research and to have scientific evidence that supports these claims before any universal statements are made about yoga's benefit for adolescents. This

includes evaluating the differential impact of different kinds of yoga practices (e.g., with different ratios of postures, meditative practices, and philosophy) on different outcomes and across ages and developmental stages.

This dissertation evaluates the impact of a school-based yoga program on ninth-grade students' social-emotional and cognitive outcomes. The yoga program was administered to ninth-grade students because of the unique developmental challenges associated with this time period. Ninth-grade may be a particularly difficult time for young people: high schools tend to be larger and more bureaucratic than middle schools (Eccles & Roeser, 2003), and the high school environment may be particularly alienating for minority students and students who are not doing well academically (Eccles & Roeser, 2009). The transition into middle school consists of moving from an environment that supports the individual to one that encourages social-comparison and competition (Eccles & Midgley, 1990; Eccles et al., 1991), and the transition from middle school to high school often involves shifting into an even more competitive environment. Offering ninth-grade students a practice that encourages self-awareness and self-acceptance may support students as they transition into an environment that places greater emphasis on competition and social comparison, and help protect against the declines in GPA and self-concept that have been associated with school transitions (e.g., Eccles et al., 1989; Eccles & Midgley, 1990).

The entire ninth-grade class at a large high school was group randomized, by physical education (PE) class, to either the yoga or control condition. The yoga intervention was conducted during PE in order to allow for comparison between yoga and other forms of physical activity. Physical activity and exercise have been associated with such positive outcomes as improved mood and decreased anxiety (Netz & Lidor, 2003; Strohle et al., 2007), and the current study allows for the possibility of examining yoga's unique benefit above and beyond the benefits associated with other kinds of exercise.

This dissertation is structured in a multi-manuscript format, comprised of one review paper and two empirical papers. There will be some overlap between papers, with the empirical papers borrowing some content from the review paper,

and—because both empirical papers use data from the same study—the empirical papers’ methods sections are almost identical. The review paper begins with an overview of adolescent development, and then moves on to review the current state of research on yoga. This paper also reviews meditation research, and makes connections between several bodies of literature that have not been discussed in relation to research on yoga: exercise and social-emotional learning. Findings from exercise research, and research on positive youth development programs, can contribute important knowledge about the effects of physical activity and exposure to positive messages. This knowledge can be used to develop more grounded hypotheses, which may facilitate a faster evolution of the field of yoga research and encourage a shift towards more rigorous evaluations of yoga’s effects. Finally, the review paper proposes a three-part conceptualization of yoga that will aid in the design and implementation of future studies. This three-part conceptualization will be particularly useful for studies that evaluate the mechanism(s) that underlie yoga’s effects.

The two empirical papers discuss the effects of this yoga intervention on cognitive and social-emotional outcomes. The first paper evaluates the impact of participation in the yoga program on students’ working memory capacity (WMC), math performance, and self-reported attention problems. It was expected that participants in the yoga program would show improvements in working memory capacity and math performance, and report decreases in attention problems, relative to control students. Somewhat consistent with these expectations, boys in the yoga condition showed significant increases in WMC scores from baseline to post-intervention, while WMC among boys in the control condition did not change significantly. However, because WMC scores did not differ significantly between boys in the yoga group and boys in the control condition at either time point, it is not clear that this change was the result of yoga practice. Counter to expectations, participation in the yoga group was not related to change in self-reported attention problems or math performance

The second empirical paper examines the effects of yoga on adolescents’ affect, emotion regulation, and self-esteem. It was expected that, relative to

controls, students in the yoga condition would report lower levels of negative affect and expressive suppression, and higher levels of positive affect, cognitive reappraisal, and self-esteem. Somewhat consistent with hypotheses, boys in the yoga group had lower levels of negative affect than boys in the control group during the middle of the school year, though this difference was resolved by the end of the school year. Neither group increased in positive affect, cognitive reappraisal, or self-esteem; however, counter to expectations, students in the control group maintained baseline levels of positive affect compared to significant decreases in positive affect among students in the control group. Similarly, girls in both groups had significant decreases in self-esteem, but girls in the yoga group reported significantly lower levels of self-esteem at the end of the year than girls in the control group. Yoga group students' use of expressive suppression as an emotion regulation strategy was higher than control students during the middle of the school year, but this difference was not maintained and there was no difference between groups at the end of the year. Yoga practice was not related to changes in cognitive reappraisal.

The findings from this dissertation have important implications for the future of yoga research. Although none of the hypotheses were fully supported, the findings provide important information for future research, and shed light on issues to consider when conducting research on yoga with adolescents. Possible explanations for the unsupported hypotheses and suggestions for future work are presented in the discussion sections of the two empirical papers and in the final discussion chapter.

CHAPTER II

YOGA AND ADOLESCENTS: WHAT DO WE KNOW?

Yoga's presence in mainstream American culture has grown dramatically during the past 30 years, with the number of practitioners almost doubling between 1998 and 2008 (Saper et al., 2004; Yoga Journal, 2008). Researchers have begun to evaluate the impact of yoga practice on outcomes such as stress, anxiety, and depression, as well as cognition. The majority of this work has been conducted with adults, but, with the increasing prevalence of yoga in schools, researchers are beginning to examine the impact of yoga on children and adolescents. The current paper presents a review of research on yoga and young people, as well as bodies of literature that correspond to components of yoga: meditation, exercise, and social-emotional learning. Research on meditation and exercise suggests that these components of yoga have effects on adolescents' cognition and psychological well-being. However, the majority of research studies on yoga continue to be exploratory in nature—based on little theory or previous empirical findings. The lack of large, randomized control trials makes it difficult to establish conclusive claims about yoga's benefit for adolescents. The current paper outlines a conceptualization of yoga as a three-component practice and makes suggestions about how to evaluate yoga in a way that will develop our understanding of mechanism, as well as of the dose and content of practice necessary to effect change. It is hoped that the three-component conceptualization will begin a conversation among researchers about how to design and conduct research studies of yoga in a way that will best advance the field. Additionally, this paper may serve as a source of information for practitioners who wish to implement and evaluate yoga programs for adolescents.

Adolescent Development

Adolescence is characterized by dramatic biological, cognitive, and social changes (Susman & Rogel, 2004), including changes in physical stature and appearance, improvements in cognition and executive function, increases in emotional activity and self-reflection, and changes in self-concept and identity (e.g., Buchanan, et al., 1992; Erikson, 1968; see Wigfield, et al., 2006 and Keating, 2004 for reviews). Many adolescents move through this developmental period with little to no display of the “storm and stress” that has historically been associated with the adolescent years (Arnett, 1999; Eccles et al., 1993; Susman & Rogel, 2004). However, a significant percentage may not be prepared to face so many changes in so many different domains at once (Arnett, 1999; Eccles, et al., 2008). These youth may be more likely to suffer from poor mental and physical health, to engage in high-risk behaviors, to display low academic engagement, and to struggle with school-related experiences (Eccles et al., 2008; Roeser, et al., 2000).

The adolescent years are a time of exploring new ways of thinking about one’s self and one’s interactions with surrounding environments (e.g., Eccles et al., 1993), as young people begin to question their identity, their feelings of self-worth, and their relationships with family members and peers (Eccles et al., 1989; Eccles & Midgley, 1990; Erikson, 1968; Steinberg & Morris, 2001). Some adolescents experience significant fluctuations in self-esteem (Baldwin & Hofmann, 2002) and mood (Buchanan et al., 1992), and appear more susceptible to experiencing depression (Nolen-Hoeksema & Girgus, 1994). Girls are particularly vulnerable to anxiety (Lewinsohn et al., 1998) and to developing depression during adolescence (Nolen-Hoeksema & Girgus, 1994), with European American girls reporting lower levels of self-esteem during middle-adolescence than African American girls (Gutman & Eccles, 2007). Some adolescents also experience a drop in self-competence beliefs, and academic motivation and achievement as they move from elementary- to middle-, and middle- to high-school (Eccles et al., 1989; Eccles et al. 1991; Jacobs et al., 2002).

School transitions are times of heightened risk for many early and middle adolescents, and these transitions have been associated with declines in academic

engagement, GPA, self-perceptions, and self-competence beliefs (e.g., Eccles et al., 1991; Isakson & Jarvis, 1999). Transitions between school settings (e.g., elementary to junior high) often involve moving to an environment that is less supportive of the individual than the previous school's environment (Eccles et al., 1991). For example, the shift from elementary to middle-school involves moving into a school environment that: emphasizes social comparison and competition at a time of heightened self-focus; offers fewer decision-making opportunities to young people at the time when their desire for autonomy increases; and, alters peer networks at a time when young people are particularly concerned with social relationships (Eccles et al., 1991). Similar incongruities arise when students move from middle- to high-school (Eccles & Roeser, 2009), and adolescents find themselves in an environment with even less support from teachers and fewer opportunities for meaningful engagement (Eccles & Roeser, 2003).

Biological changes associated with adolescence have been linked to changes in arousal, motivation, and emotion (Steinberg, 2005) and risky behavior (Ge et al., 1996), and pubertal changes in tandem with other stressful life events (e.g., school transitions, changes in peer relationships) may increase the risk of negative psychological outcomes (Simmons & Blyth, 1987). The influence of hormonal changes on mood and behavior is influenced by environmental factors (Susman, 1997; Buchanan, et al., 1992), and the interaction between biological changes and changes in the environment has been linked to a range of negative psychological and behavioral outcomes, including increases in negative affect (Susman et al., 1991; Susman & Rogel, 2004) and depressive symptoms (Nolen-Hoeksema & Girgus, 1994). Additionally, particularly among European American girls, changes that occur during puberty have been associated with increased dissatisfaction with physical appearance, which for some youth has been found to remain stable over time regardless of whether actual attractiveness changes (Rosenblum & Lewis, 1999). However, these effects are culturally dependent, and are more pronounced in Western cultures where there is greater value placed on thinness (Steinberg & Morris, 2001). Introducing adolescents to yoga—a practice that emphasizes self-awareness and self-acceptance—may offer protection against declines in body-

satisfaction, as early findings indicate that yoga practice leads to reductions in self-objectification and increases in satisfaction with physical appearance (Daubenmier, 2005; Impett et al., 2006).

A practice that generates a welcoming and supportive environment, which yoga intends to do, may be key to protecting adolescents from some of the negative outcomes that arise during school transitions. Additionally, the emphasis on non-judgmental self-awareness may protect adolescents from experiencing decreases in self-esteem and increases in negative mood.

Promoting positive youth development

Because behaviors and decisions made during adolescence have the potential to impact later life outcomes (Eccles et al., 2008), implementing interventions during this critical developmental stage may have positive effects throughout the life course. There is growing consensus among intervention specialists that programs that promote positive development, in addition to preventing negative outcomes, are the most successful (Catalano et al., 2004). Social and emotional learning (SEL) programs for children and adolescents aim to support the development of healthy social and emotional functioning by encouraging self-awareness, social awareness, responsible decision-making, self-management, and relationship management (Zins et al., 2004). Very few studies have begun to implement and evaluate meditation or yoga programs in schools, but substantial research has been conducted on school-based SEL interventions. Findings from this body of work provide some indication of how yoga may impact young people's social, emotional, and school-related experiences. A recent review of 213 SEL programs for students (kindergarten through high school) concluded that students participating in SEL programs had significantly improved academic achievement, attitudes and behaviors, and social and emotional skills relative to students who did not participate in these programs (see Durlak et al., 2011). This review also identified the role of implementation design and quality in study outcomes. Interventions that used strategic sequencing, included active forms of learning, gave students time to focus on skill development, and had clear learning goals led to

significant improvements in six outcomes: social emotional skills, attitudes toward self and others, positive social behaviors, and academic performance, as well as reductions in emotional distress and problem behaviors (see Durlak et al., 2011). Interventions that did not include all four elements—sequencing, active learning, skill development, learning goals—led to improvements in only three outcomes: attitudes, academic performance, and conduct problems. Additionally, interventions that reported problems during implementation led to significant effects in only two outcomes (attitudes and conduct problems), while interventions that did not report problems with implementation achieved significant effects in all six outcomes (see Durlak et al., 2011). Thus, both intervention implementation design and implementation quality moderated the effects of the intervention.

Some SEL programs include such mindfulness practices as meditation and yoga, and SEL and yoga espouse similar messages about self-awareness, self-acceptance, and pro-social behavior. Research suggests that SEL interventions that include meditation and/or yoga improve coping with school stress, increase pro-social behavior, increase academic motivation and persistence, and decrease aggression and school absences among children and adolescents (Greenberg et al., 2003; Zins et al., 2004). Additionally, SEL programs that support students' abilities to identify and regulate their emotions, to develop social, emotional and cognitive competence, and to engage in prosocial behaviors enhance academic performance and school-related behaviors (Greenberg et al., 2003; Zins et al., 2004). Because yoga contains many of the same messages about self-awareness, self-acceptance, and prosocial behavior found in SEL programs, it seems likely that yoga might have similar effects on children and adolescents' social and emotional functioning.

Yoga

Yoga is a mind-body practice that combines physical postures, breathing exercises, and meditative practices, with the goal of unifying the physical, mental, and emotional selves. In the United States, one common type of yoga is Hatha yoga. Hatha yoga descends from the eight-part practice outlined in the Yoga Sutras by Patanjali (Cope, 2006). There are numerous approaches to this eight-part practice,

each with a different focus and progression. For example, Vinyasa yoga—an increasingly popular style—places emphasis on connecting breath with movement. In Ashtanga yoga, practitioners move through a set sequence of postures, advancing to the next level only when they have achieved basic mastery of the preceding posture series. Some practices place greater emphasis on physical postures than on breathing or meditation; others focus more on the meditative and philosophical components. In Iyengar yoga, in which the main emphasis is on proper body alignment, students may work on postures and alignment for extended periods of time before beginning breathwork. In Kripalu yoga, there is greater emphasis on connecting to one’s internal state, observing emotions and sensations as they arise, and using the breath in postures to be with, and move through, the sensations as they appear. While each practice emphasizes different components of yoga, the eight branches of yoga as described in the yoga sutras form the foundation Hatha yoga, of one of the most widely practiced yoga traditions in the United States and Europe.

Why study yoga?

Yoga’s presence in mainstream American culture has grown dramatically during the past 30 years, with the number of practitioners almost doubling between 1998 and 2008. About 8 million Americans reported practicing in 1998 (Saper et al., 2004) and almost 16 million reported practicing in 2008 (Yoga Journal, 2008). The rapid increase in the number of people practicing, or expressing interest in practicing yoga, has led to an abundance of anecdotal reports about yoga’s positive impact on such outcomes as mental health and well-being, attention, and physical fitness. However, the scientific and empirical evidence that supports these claims is limited. There is a growing body of work dedicated to the scientific study of yoga, but the field is in its nascent stages and much of the work is limited by poor methodological quality (Kirkwood et al., 2005; Pilkington et al., 2005). Despite these limitations, early research suggests that yoga practice might be related to a host of positive outcomes, including: decreased negative affect (West et al., 2004; Woolery et al., 2004) and increased positive affect (Impett et al., 2006; Netz & Lidor,

2003); improved self-awareness and self-acceptance (Daubenmier, 2005; Schure et al., 2008); reduced symptoms of depression (Pilkington et al., 2005; Shapiro et al., 2007; Ubelacker et al., 2010) and anxiety (Field et al., 2010; Kirkwood et al., 2005); and, improved quality of life and overall well-being (Oken et al., 2006).

Although the majority of yoga studies suffer from methodological limitations, findings generally support the anecdotal claims about yoga's positive influence on physical and psychological outcomes. Several studies have evaluated physiological outcomes associated with practicing yoga, finding that heart rate decreased during and immediately after yoga practice (Schell et al., 1993) and that serum (Kamei et al., 2000) and salivary (Michalsen et al., 2005; West et al., 2004) cortisol levels decreased during and after yoga practice. Michalsen et al. (2005) used a waitlist-control design, but interpretation of the other results is limited by poor study design. Schell et al., (1993) did not randomly assign participants to the yoga or control conditions; Kamei et al. (2000) examined the acute affects of yoga among only seven yoga teachers; and, West et al. (2004) used a convenience sample of students who had self-selected to participate in a yoga class. There may be a significant impact of yoga on heart rate and cortisol levels, but, at this point, the weak study designs and use of convenience samples makes it difficult to form conclusive claims about yoga impact on these outcomes. Two randomized, controlled trials (RCTs) of yoga for physical ailments identified relationships between yoga practice and reductions in back pain (Williams et al., 2005), as well as improved grip strength and reduced pain among individuals with carpal tunnel (Garfinkel et al., 1998). Another RCT identified relationships between yoga practice and improved knee strength and balance (Hart & Tracy, 2008). Finally, results from two non-RCTs suggest that practicing yoga is related to reduced self-objectification, increased body awareness, and improved body satisfaction (Daubenmier, 2005; Impett et al., 2006).

The most common outcomes evaluated in relation to yoga practice have been stress, anxiety, depression, and mood. Most studies of yoga have been conducted with a single group; however, several RCTs provide evidence of yoga's benefits. A RCT of yoga for healthy seniors found that participants in a six-month yoga program

had pre-post improvements in quality of life, overall well-being, energy, and physical outcomes (e.g., balance, flexibility), relative to controls (Oken et al., 2006). Similarly, menopausal women participating in a four-month yoga program showed greater increases in self-esteem than controls (Elavsky & McAuley, 2007). Finally, a study in which professional musicians self-selected into one of two, two-month long yoga conditions or to a no-yoga control condition found that participation in either of the yoga conditions was linked to significantly larger reductions in performance anxiety and general anxiety than control group participation (Khalsa et al., 2009).

The remaining studies discussed in this section are not RCTs, and evaluate the pre-post effects of yoga on only a single group. In a study of yoga asana only (e.g., no meditation and breathwork) combined with tai chi, participants showed decreases in anxiety after only 20-minutes of practice (Field et al., 2010). Additionally, participants in this study had improved performance on a math task, suggesting that elements of yoga may have some positive impact on cognitive performance. This is consistent with research on physical exercise and cognition, which has identified relationships between physical fitness and cognition among children and adolescents (Budde et al., 2010; Hillman et al., 2005, 2009). Depressive symptoms decreased among participants in a pilot study of an eight-week Vinyasa yoga class for depression (Ubelacker et al., 2010) and in a study of a 20-class Iyengar yoga program as a complementary treatment for depression (Shapiro et al., 2007). Perceived stress and depressive symptoms decreased, and overall health improved, in a sample of medical students who received instruction in 12-week pilot study of Kripalu yoga (Simard & Henry, 2009).

Several review papers have evaluated yoga as a treatment for anxiety (Kirkwood et al., 2005) and depression (Pilkington et al., 2005) and concluded that the results are promising, but that more research is needed before results can be interpreted in any conclusive manner.

Yoga and Young People

Studies of yoga with adolescents and children have been rare, despite the increasing trend towards introducing yoga for children and adolescents in schools

and at yoga studios (White, 2009). More rigorous, controlled studies of yoga for children and adolescents are badly needed. To date, there have been few RCT studies of yoga for children and adolescents. Findings from these RCTs suggest that practicing yoga is related to: reduced symptoms of irritable bowel syndrome (IBS) and anxiety in adolescents (ages 11-18) with IBS (Kuttner et al., 2006); reduced eating disorder scores and food preoccupation among adolescents (ages 11-21) with disordered eating (Carei et al., 2010); and, improved scores on the DSM IV Hyperactivity/Impulsivity subscale, the Test of Variables of Attention, and five subscales on the Conner's Parent Rating Scale among adolescent boys (ages 8-13) with Attention Deficit and Hyperactivity Disorder (Jensen & Kenny, 2004). A study that compared an after-school program with yoga to an after school program without yoga found that fourth- and fifth-graders in the yoga program used fewer negative behaviors in response to stress at the end of the program than students in the control group (Berger et al., 2009). A non-RCT evaluation of a stress-reduction program that included yoga concluded that participation in the program was linked to pre-post reductions of aggression and feelings of helplessness among fifth-grade students (Stueck & Gloeckner, 2005). Finally, Peck et al. (2005) concluded that doing yoga with a 30-minute videotape three times per week, for three weeks, was related to improved time on task among elementary-school students, as observed by school psychologists (Peck et al., 2005). However, the studies Stueck & Gloeckner (2005) and Peck et al. (2005) are limited by their use of single-group designs.

Yoga in Schools

There has been increasing presence of yoga and meditation in school-based and after-school programs for children and adolescents, including interventions designed to improve social-emotional intelligence (Catalano et al., 2004) and programs intended to prevent behavioral problems and declines in mental health (Horowitz & Garber, 2006). Two recent RCTs of yoga in schools indicate that yoga-based interventions are feasible and well-received by students, teachers, and parents (Khalsa et al., in press; Mendelson et al., 2005). In these studies—evaluations of school-based yoga programs for 4th and 5th graders in an underserved

urban community (Mendelson et al., 2010) and 11th and 12th graders in a rural high school (Khalsa et al., in press)—students in the yoga conditions showed reductions in rumination, intrusive thoughts, and emotional arousal (Mendelson et al., 2010), and improvements in resilience, anger control, and fatigue/inertia (Khalsa et al., in press) relative to controls. In Khalsa et al. (in press), although there were only slight improvements among yoga group participants, control students showed decreases in resilience and anger control, suggesting that the yoga intervention buffered against the negative changes reported by control students.

Taken together, the findings from yoga research suggest that yoga-based techniques may be beneficial for young people as they navigate the adolescent years. However, at this point there is not enough research—and the research findings to date are not strong enough—to unequivocally support the introduction of yoga in schools. Furthermore, it is not clear how, for how long, and when the yoga should be introduced. Perhaps the greatest benefit would occur if young people received yoga in elementary school, and would thus be able to carry the practice with them through the middle- or junior high-school years, and on into high-school. Yoga may be most effective when it is an on-going practice (Vera et al., 2009; Yoshihara et al., 2011). Introducing children to yoga early on, and then continuing to offer yoga instruction in middle- and high-school, might lead to the greatest benefit. Conversely, it is possible that introduction to yoga at later stages of development would lead to greater positive effects. These questions and many others remain to be explored before drawing conclusions about the universal benefits of yoga for children and adolescents.

Meditation

Meditation is the process of training one's attention to either focus on one thing (e.g., breath, a mantra) or to notice and observe external and internal sensations without judgment—or both. Because connecting movement with breath and engaging in other forms of focused awareness are integral to the practice of yoga, the research on meditation and mindfulness practices can help inform the emergent field of yoga research.

Meditation and mindfulness practices have been the subject of more extensive scientific inquiry than yoga; consequently, studies of meditation tend to have stronger research designs and more rigorous methods and analyses than the majority of yoga studies. Research on meditation can be divided into different lines of inquiry, with the goal of some studies being the evaluation of biological and/or cognitive effects, while other studies aim to examine the effects of long-term versus short-term practice, and yet others intend to compare the effects of different kinds of meditation practices. In order to address these different goals, meditation research has begun to implement a range of converging methodologies. Yoga research may benefit forging a similar path, with researchers utilizing multiple study designs and data collection techniques.

Neuroscientists have begun to explore relationships between meditation and changes in brain activation and structure. Lazar et al. (2005) compared the cortical thickness of expert meditators with matched controls and identified significant differences in thickness in the prefrontal cortex, an area associated with executive function. Although this study did not evaluate change over time, cortical thickness and meditation experience was positively correlated, suggesting that greater meditation practice may be associated with structural changes in the brain. More recently a waitlist-control study of brain change in meditation naïve individuals before and after an 8-week MBSR course found increases in gray matter in areas of the brain involved in emotion regulation, perspective taking, self-awareness, and learning and memory, relative to individuals in the waitlist control group (Holzel et al., 2010a). Similarly, a group of individuals with high baseline levels of perceived stress participated in an 8-week MBSR course and showed decreases in amygdala gray matter density—the amygdala is associated with stress responses—and declines in perceived stress (Holzel et al., 2010b). Meditation has also been associated with activation in parts of the brain associated with attention. A study of long-term Buddhist meditation practitioners identified changes in brain wave patterns associated with attention, working memory, and learning (Lutz et al., 2004), though this was not an RCT and the uniqueness of the sample makes these findings difficult to generalize. Finally, a U-shaped curve in brain activation

emerged in one study of meditation: novice and expert meditators showed less activation in areas related to distracting thoughts and emotions and more activation in areas associated with response inhibition and attention than intermediate meditators (Brefczynski-Lewis et al., 2007). Although these results suggest that meditation is related to neural changes, because these studies are correlational (with the exception of the waitlist-control design in Holzel et al., 2010a) or single-sample designs, causal inferences cannot be drawn.

Researchers have also evaluated the effect of meditation on cognitive outcomes, such as attention and working memory. Results from a RCT of a five-day mindfulness program indicate that participation in a mind-body training program was related to improved aspects of attention, as well as decreased stress, anxiety, and depressive symptoms (Tang et al., 2007). Jha et al. (2007) also evaluated the effects of mindfulness training on attention by comparing the effects of participation in either an eight-week MBSR course or a one-month intensive mindfulness retreat with participation in a control condition. Participants in the MBSR course showed improvement on the orienting section of the ANT while the intensive retreat participants' scores improved on the alerting subcomponent (Jha et al., 2007), relative to controls. Although this study compared different groups, participants were not randomly assigned to conditions and thus generalizability is limited. A feasibility study with a single group of adults and adolescents with Attention Deficit Hyperactivity Disorder (ADHD) evaluated the effect of an eight-week mindfulness training program and concluded that participation in the mindfulness program was related to improved performance on the Stroop, subsystems of attention, and self-report ADHD-related symptoms (Zylowska et al., 2007). Though Zylowska et al. (2007) did not find any effect of mindfulness training on working memory capacity (WMC) as measured by the Digit Span, Jha et al. (2010) concluded that practicing mindfulness meditation may help maintain baseline levels of working memory capacity (measured with the Operation Span task) in the face of extreme stress. In a sample of pre-deployment military members, participants in an 8-week mindfulness training program who had high meditation practice time showed increases in WMC, while those in the mindfulness course with low practice time, and those in the

military control group, showed decreases in working memory capacity (Jha et al., 2010). These results suggest that there may be a relationship between quantity of practice and observed effects. Finally, another RCT evaluated undergraduate students' performance on a Stroop task before and after three meditation sessions and found that habitual responding on the Stroop task decreased pre-post a 20-minute meditation session, compared to controls (Wenk-Sormaz, 2005).

Quite a few studies have identified relationships between meditation and such psychological outcomes as stress, anxiety, and depressive symptoms (for review, see Kabat-Zinn et al., 2003) as well as emotion regulation. Unfortunately, because the majority of these studies evaluate the effects of meditation on only a single group and are not RCTs, causal inferences cannot be made. Results from these feasibility and exploratory studies suggest that participation in mindfulness training is related to reductions in stress, anxiety, depressive symptoms, and mood disturbance, and increases in well-being (Brown & Ryan, 2003; Carmody & Baer, 2008; Kabat-Zinn et al., 1992). There is also indication that meditation practice is linked to greater capacity for engaging in cognitive reappraisal (Gootjes et al., 2011).

Findings from the small number of RCTs that examine meditation's impact on social-emotional outcomes suggest that meditation is linked to reductions in rumination, emotional reactivity, and relapse and or/recurrence of depression (Arch & Craske, 2006; Jain et al., 2007; Teasdale et al., 2000). Students who were randomly assigned to a focused breathing condition had lower negative affect and emotional reactivity in response to negative slides than students in both the "worry" group and the control group (Arch & Craske, 2006). Participation in a mindfulness based cognitive therapy program significantly reduced risk of relapse/recurrence of depression among patients with three or more past previous episodes of depression (Teasdale et al., 2000). Finally, a RCT of loving-kindness meditation for adults found that daily experience of positive emotions and life satisfaction increased, and depressive symptoms decreased, among meditation group participants, compared to controls (Fredrickson et al., 2008).

Most behavioral and survey studies did not mention asking participants to meditate or to think about their meditation experiences immediately before data

collection, but some gave participants a meditation prime and/or asked them to meditate 10 or 20 minutes prior to data collection. Thus, it is unclear if and how giving participants a meditation prime influences results. Future studies will need to examine this issue by comparing the results from prime and no-prime conditions. Future studies should also explore possible recency effects by collecting data at follow-up intervals in addition to the immediate post-intervention data collection.

Additionally, MBSR and TM require daily practice of 30-45 minutes/day. It is possible that this level of intense and consistent practice is necessary to see the changes that have been identified in some of the studies. However, several studies have identified changes after just three or five 20-minute sessions (Tang et al., 2007; Wenk-Sormaz et al., 2005). The findings regarding dose remain equivocal and, although there is evidence to suggest that higher dose will lead to greater change (e.g., Fredrickson et al., 2008), future studies need to gather more information about dose effects.

Meditation and young people

As with research on yoga and young people, the field of research on meditation with children and adolescents is limited by methodological weaknesses (see Black et al., 2009). However, several studies point to the potential of this practice as an intervention tool in school settings. Middle-school students who were in at least two semester-long classes led by teachers trained in meditation and relaxation, and who received instruction in these techniques, had higher GPAs, work habit scores, and cooperation scores at the end of a two-year period than students with fewer than two semesters (Benson et al., 2004). African American adolescents (ages 15-18) who participated in a four-month TM program had significant decreases in absenteeism, school rule infractions, and suspension days compared to increases in all three outcomes among students in the health education control group (Barnes et al., 2003). Adolescents (ages 14-18) suffering from PTSD in post-war Kosovo experienced reductions in PTSD symptoms after participating in a 12-week mind-body skills meditation program, compared to participants in the waitlist control group (Gordon et al. 2008). A 24-week mindfulness training program led to

decreases in test-anxiety and increases in selective attention test scores among elementary school students in the meditation condition compared to students in the quiet activities (e.g. reading) control group (Napoli et al., 2005). Ten students in an exploratory, qualitative study of a TM program for middle-school students described their meditation experience as improving emotional intelligence and improving academic performance (Rosaen & Benn, 2006). Another qualitative study reported that middle-school students in a Tai Chi and mindfulness program attributed increased calmness, self-awareness, and well-being to participation in the program (Wall, 2005).

Similar to the research on yoga with children and adolescents, many questions remain about the benefit of meditation for young people. Thus far the field has primarily focused on feasibility studies, and in order to further our understanding of the effects of yoga and meditation on young people, researchers will need to implement larger studies with more rigorous designs and methodologies. At this point, there is indication that meditation has beneficial effects for young people, particularly on school-related behaviors, but much more research is needed. The age of young people in these studies ranged from early elementary school students to early high-school, and there is indication that benefit was observed when the meditation was introduced as early as 2nd and 3rd grade and as late as 9th and 10th grade. However, it is not clear how much meditation is necessary to observe changes, and when the optimal introduction time may be. Future studies will need to determine the optimal developmental period to introduce young people to meditative practices and yoga.

Exercise and Physical Activity

Exercise and physical activity have been associated with positive changes in cognition and psychological well-being (Berger & Owen, 1992; Hillman et al., 2008; Strohle et al., 2007). Yoga is comprised of both physical and meditative components, and combining these two elements may produce an additive effect and enhance the positive outcomes associated with meditation. There is substantial research on the effects of physical activity on adults and aging (for review, see

Colcombe & Kramer, 2003), but the current review will focus on research that has evaluated effects of exercise on children and adolescents.

Many studies of children and adolescents have identified relationships between physical activity and cognition (see Tomporowski et al., 2008 for review). A correlational study comparing high-fit and low-fit children (mean age = 9.4 years) found that high-fit children exhibited greater cognitive control, better allocation of attentional resources, and performed better on flanker tasks than low-fit children (Hillman et al., 2009). Other correlational studies suggest that there is a positive relationship between fitness level and attention and working memory among children (mean age = 9.6 years) (Hillman et al., 2005), and that physical fitness is positively related to academic achievement among third- and fifth-graders (Castelli et al., 2007). A randomized control trial of ninth-grade students compared the effects of different levels of exercise intensity on working memory for high- and low-performing students and found that low-performing students at baseline significantly improved their scores on a test of working memory capacity after a 12-minute bout of low-intensity running (Budde et al., 2010). The study did not gather follow-up data, so it is unknown whether this change persisted after an acute bout of exercise.

These findings lend some support to the belief that low- to moderate-intensity exercise has greater effects than high-intensity physical activity (Cotman et al., 2007; Tomporowski et al., 2003). This speaks to the potential of yoga to improve cognitive outcomes, as it is generally a low- to moderate-intensity form of physical activity. Low-intensity exercise has been related to positive mood change, compared with no pre-post mood improvements after high-intensity exercise (Septoe & Cox, 1988).

There is also indication that both aerobic exercise and yoga are associated with improvements in psychological well-being. Two studies compared the effects of yoga with other forms of exercise and concluded that yoga has similar positive effect on such outcomes as mood and well-being as aerobic forms of exercise (Berger & Owen, 1992; Netz & Lidor, 2003). A study comparing different types of exercise to yoga found that participants in the yoga group reported similar mood

improvements as the participants in the swimming and Feldenkrais groups—and greater improvements than the aerobic dance and computer control groups—after just one yoga session (Netz & Lidor, 2003). However, this was not a controlled trial and participants were not randomly assigned to conditions. A similar, non-randomized, controlled study compared the effects of participating in a yoga or swimming class to a lecture control group (Berger & Owen, 1992). Participants completed measures of mood pre-post three classes, and results suggest that swimming and yoga were related to similar pre-post decreases in tension, anger, and depression relative to controls. However, in both these studies students self-selected into the yoga classes, and it is possible that the results reflect sample characteristics and not yoga's effects.

A review article by Byrne & Byrne (1993) concluded that exercise has a positive effect on mood states, depressive symptoms, and anxiety, and that non-aerobic (weight training) exercise has similar positive effect on depressive symptoms as aerobic exercise. Yoga combines balance, strength training, and aerobic activity, thus yoga may have positive effects on outcomes such as depressive symptoms. Additionally, a comparison between physically active adolescents and less-physically active adolescents found that physically active adolescents reported lower levels of anxiety (Strohle et al., 2007), although this was not a randomized control trial and causal inferences cannot be made. Another review article identified relationships between exercise and reduced depressive symptoms, improved mood, self-perceptions, and self-esteem (Fox, 1999). This lends some support to the theory proposed by Sonstroem & Morgan (1988) that exercise enhances self-esteem.

In sum, physical activity and exercise have been associated with positive changes in cognitive and psychological outcomes. Moreover, two studies identified similar positive effects of yoga and aerobic activity. It is possible that yoga, which combines physical activity and meditation, will lead to greater changes in cognition and psychological well-being than exercise or meditation alone.

Yoga as a 3-part Practice

Yoga is a multi-component process, and is described in The Yoga Sutras by Patanjali as consisting of eight components (Cope, 2006). In order to effectively conceptualize the impact of yoga practice on psychological outcomes, it will be beneficial to distill these eight components of yoga into a smaller number. The components of yoga, as outlined by Patanjali, are as follows: *yamas*, *niyamas*, *asana*, *pranayama*, *pratayahara*, *dharana*, *dhyana*, *samadhi*.

The *yamas* and *niyamas* refer to behavior and beliefs that support healthy functioning and living fully. They include the cultivation of self-awareness, self-discipline, nonviolence, contentment, and honesty. The *yamas* and *niyamas* will be grouped together under the heading, “philosophical teachings.” “Philosophical teachings” refers to the content of the lessons and the messages that accompany the physical and meditative practices. An example of philosophical teachings during a yoga class may be, “notice the sensations that arise as you hold this posture and allow them to be, without judgment,” and, “staying present and focusing on your breath while holding a difficult pose helps build the ability to stay calm during difficult situations.” “Philosophical teachings” is included as one of the three components of yoga because the content of teachings that accompany the physical postures and meditative practices may vary widely across teachers and styles of yoga. Some yoga traditions include very little discussion of yoga philosophy, while others place great emphasis on this component of the practice. In many ways, the philosophy component of yoga is similar to teachings in SEL programs and youth development interventions that emphasize self-awareness, self-acceptance, and compassion. Thus, part of understanding the differential impact of different styles of yoga will require evaluation of the philosophical teachings included in the instruction.

The next component, *asana*, refers to the physical practice of yoga postures, and will be called, “postures.” The next four components—*pranayama*, *pratayahara*, *dharana*, and *dhyana*—refer to meditative and breathing practices, and to the refinement of one’s attention and focus. These four elements will be grouped together as “meditation and breath work.” There is some debate about whether breathing practices are distinct from meditation. This paper combines breathing

exercises and meditation into one category, as breath work is often a component of meditative practice in yoga. For example, instructors may guide their students to focus on the rise and fall of the abdomen as they breathe, or to link movement to breath. More advanced breathing practices are also generally taught in the context of meditation, with students moving through several rounds of a breathing exercise at the beginning of a seated meditation. The final component, *samadhi*, is the most esoteric of the eight components, and refers to the peace one feels after mastering all the others. *Samadhi* an outcome of practice and will be conceptualized as the outcomes of interest in a given study (e.g., improved mood, decreased stress and anxiety, and enhanced attentional capacities would be domain-specific examples of *Samadhi*). For the purposes of scientific inquiry, yoga can be divided into three distinct components: postures, meditation and breath work, and philosophy. The goal of most research on yoga may to evaluate the unique and additive effects of these components on the outcomes of interest, or *samadhi*.

There may be an ideal ratio of philosophy, meditation, and postures for specific populations, and in order to further our understanding of yoga's influence on mental health and cognitive functioning, we will need to conduct studies that evaluate the impact of each component of yoga alone, as well as different combinations of the three dimensions. Given the findings from research in the bodies of literature addressed in this paper—SEL interventions, meditation, and exercise—and the existence of each of these components in yoga (e.g., yoga philosophy is similar SEL program messages), it is expected that each dimension of yoga will have a unique effect on outcomes. It is also expected that there will be an additive effect when two or three of the components are practiced together, and that specific ratios of the three components may be most appropriate for specific populations.

Based on findings from research on exercise and physical activity (Budde et al., 2010; Byrne & Byrne, 1993; Cotman et al., 2007; Dunn et al., 2005), it is expected that there may be direct links between practicing yoga postures and improvement on outcomes such as stress, anxiety, depression, mood and affect, and cognition. Relationships between posture practice and these psychological variables may be a product of changes in underlying neural mechanisms and processes, similar to the

changes in brain structure and function observed in the exercise literature (see Tomporowski et al., 2008). Thus, methods employed in neuroscience research (e.g., fMRI, EEG) may be useful in studies that attempt to explain the neural underpinnings of physical postures' effects on behavior and psychological functioning.

Findings from research on meditation suggest that links exist between meditation practices and improved mental health, mood and affect, and cognition (Arias et al., 2006; Brefczynski-Lewis et al., 2007; Brown & Ryan, 2003; Kabat-Zinn et al., 1992; Lazar et al., 2000). In the context of yoga, meditation and breathwork may appear as a seated meditation at the beginning or end of a session, as the practice of connecting breath with movement (e.g., inhale, lift arms; exhale, fold forward), or as a continual focus on breath. The effects of meditation have been evaluated with physiological, neurological, behavioral, and survey/interview methodologies, and each methodology has been useful for elucidating some of the ways in which meditation impacts psychological functioning. Future studies that combine methods—drawing on those used in neuroscience as well as surveys, interviews, and behavioral tasks—will provide the most complete information about mechanism and the behavioral outcomes. Studies of meditation that have used fMRI or MRI have provided exciting data regarding the neurological underpinnings of psychological change, and these studies will continue to be crucial to our understanding of mechanism and the pathways between meditation practice and changes in cognition and psychological well-being.

Finally, results from intervention research and evaluations of positive youth development programs (e.g., SEL interventions), which are often based on messages and teachings similar to those found in yoga philosophy (e.g., promotion of self-awareness, compassion), have documented the positive effects of participating in these programs on children and adolescents' emotion regulation, coping strategies, academic performance, and school-related behaviors (Greenberg et al., 2003; Zins et al., 2004). Given the nature of this component of yoga, survey, interview, behavioral, and observational methods may best suited for research that evaluates the influence of exposure to philosophical teachings on psychological and behavioral outcomes.

In order to adequately evaluate the impact of yoga, and to build an understanding of the mechanism, research will need to include measures of brain change, behavioral change, and self-reported change. Yoga consists of three distinct components—postures, meditation and breath work, and philosophical teachings—and future research will benefit from using converging methodologies to evaluate the unique and additive effects of these components.

Summary

Findings from research on yoga with adults and young people indicate that practicing yoga is associated with numerous positive outcomes, including improvements in cognition and mental health. However, as several reviews have already highlighted, most studies have been exploratory in nature and many suffer from methodological flaws (Kirkwood et al., 2005; Pilkington et al., 2005). There is a great deal of promise in the findings thus far, but in order to report with certainty that practicing yoga improves adolescents' psychological functioning, several steps need to be taken. First, researchers need to conduct larger randomized control studies. Without control groups, and without larger, more representative samples, the generalizability of the findings, and the ability to attribute change to practicing yoga, is limited. Second, yoga practitioners and researchers need to work together to develop standardized yoga programs—similar to MBSR (a well-established, standardized curriculum)—that can be replicated with different populations. Currently, there is too much variation in the yoga taught, in the amount and frequency at which it is taught, and in the characteristics of the populations to which it is taught, to make any conclusive statements about yoga's impact and the dose and content necessary to elicit change. Third, researchers need to evaluate the effects of yoga at different ages and developmental stages. It may be that certain kinds of yoga, with specific ratios of postures, meditation, and philosophical teachings, are more appropriate at some developmental stages than others. For example, a program that teaches gentle postures with a heavy emphasis on meditation and philosophical teachings may be more appropriate for adults than for early adolescents. There is currently little to no empirical evidence to inform decision

making about developmentally appropriate yoga programs. Several yoga programs for children and adolescents already exist (e.g., YogaEd), but these have yet to be scientifically evaluated. The prevalence of yoga programs in schools around the country is increasing, but it is unclear whether these programs are developmentally appropriate and, if they're not, what kind of effects they may be having. While unlikely, it is possible that some of the philosophical teachings and meditative components of yoga could have negative impact if adolescents begin to reflect on issues without having a venue in which process the changes (e.g., supportive family, therapist). Yoga can have a positive impact on behavior and psychological functioning, but anecdotal reports suggest that it is not uncommon for this practice to bring up difficult thoughts and emotions on the path to improvement (Cope, 2000). If young people are asked to access uncomfortable thoughts and feelings in an environment that does not feel supportive, they may resist the practice entirely and either show no change or show an increase in negative outcomes. Thus, it is essential that teachers of the yoga interventions create a supportive and welcoming environment for students to explore emotions and ideas that arise during practice.

Adolescence is a time when many young people experience declines in academic motivation and performance (Eccles et al., 1989; Eccles & Midgley, 1990) and increases in stress, anxiety, and depressive symptoms (Lewinsohn et al., 1998; Nolen-Hoeksema & Girgus, 1994). Introducing adolescents to yoga—a practice that has been linked to improvements in school-related behaviors, cognition, and psychological well-being—may protect young people from some of these declines. However, in order to ensure that practicing yoga is beneficial, significant work needs to be done to evaluate what kind of yoga is most appropriate given the unique developmental changes that occur during adolescence.

CHAPTER III

THE EFFECTS OF YOGA ON ADOLESCENTS' WORKING MEMORY CAPACITY AND ATTENTION PROBLEMS

Abstract

Yoga's presence in mainstream American culture has grown dramatically during the past 30 years, with the number of practitioners almost doubling between 1998 and 2008. Researchers have begun to evaluate the impact of yoga practice on outcomes such as stress, anxiety, and depression, as well as attention and working memory. Early findings suggest that yoga practice is related to a host of positive outcomes, but interpretation of these findings is limited by methodological weaknesses and inadequate reporting. Yoga programs are being implemented in middle and high schools across the country, yet little is known about the impact of yoga practice on school-related variables, such as attention. The current study evaluates the effects of a school-based yoga program on adolescents' working memory capacity and self-reported attention problems. The present study utilizes a Kripalu yoga curriculum, which emphasizes the development of nonjudgmental self-awareness through the teaching of physical postures, breathing exercises, and meditation practices. Hierarchical Linear Model analyses indicate that working memory capacity significantly improved among boys in the yoga group, but that there was a non-significant decrease among boys in the control group. Working memory capacity improved among girls in both conditions, but this improvement was statistically significant only for girls in the control group. Counter to expectations, no differences between conditions emerged in math performance or attention problems. The results suggest that participation in a school-based yoga may be related to increases in working memory capacity scores among boys, and

that impact of yoga on working memory capacity differed for boys and girls. Future directions are discussed, and explanations for the differential impact of yoga on boys and girls and the lack of impact on attention problems and math performance, are explored.

Development in Adolescence

Adolescence is a time of dramatic biological, cognitive, and social changes, including changes in physical stature and appearance, improvements in cognition and executive function, increases in emotional activity and self-reflection, and changes in self-concept and identity (e.g., Buchanan, et al., 1992; Erickson, 1968; see Wigfield, et al., 2006 and Keating, 2004 for reviews). Many adolescents move through this developmental period with little to no display of the “storm and stress” that has historically been associated with the adolescent years (Arnett, 1999; Eccles et al., 1993; Susman & Rogel, 2004). However, a significant percentage may not be prepared to face so many changes in so many different domains at once (Eccles, et al., 2008). These youth may be more likely to suffer from poor mental and physical health, to engage in high-risk behaviors, to display low academic engagement, and to struggle with school-related experiences (Eccles et al., 2008; Roeser, et al., 2000). Additionally, transitions between school settings (e.g., elementary to junior high) are times of heightened risk for many early and middle adolescents, and these transitions have been associated with declines in academic engagement, GPA, self-perceptions, and self-competence beliefs (e.g., Eccles et al., 1991; Isakson & Jarvis, 1999).

The origins of these declines are hotly contested, but these findings all support the conclusion that, for many young people, adolescence is a time of increased risk for declines in mental health and academic engagement. Research on the effects of yoga suggests that practicing yoga may protect against some of these declines in psychological well-being (e.g., Field et al., 2010; Ubelacker et al., 2010) and academic outcomes (Peck et al., 2005), and thus may be an ideal practice to introduce to children and adolescents.

Yoga

Yoga is mind-body practice that combines physical postures, breathing exercises, and meditative practices, with the goal of balancing the physical, mental, and emotional selves. Postures consist of balancing and strengthening poses, as well as stretching and twisting; meditation and breathing exercises may include focusing on the breath, and noticing—but not engaging with—one’s thoughts and feelings as they arise; philosophy refers to the central tenets of yoga, which include non-judgmental self-awareness, honesty, contentment, and nonviolence. There are numerous styles of yoga, with some traditions placing greater emphasis on posture alignment, others focusing more on the meditative and breath work components, and yet others focus more on creating an aerobic experience by vigorously flowing through posture sequences. Because of this diversity in practices it is fundamental that researchers thoroughly document the yoga program used and describe what is unique about the particular style of yoga taught in the intervention. Despite a wide range of yoga traditions, all practices share the fundamental goal of unifying mind and body and generating a greater sense of well-being and fulfillment in one’s life.

Yoga’s presence in mainstream American culture has grown dramatically during the past 20 years, with the number of practitioners almost doubling between 1998 and 2008. Fewer than 8 million Americans reported practicing in 1998 (Saper et al., 2004) and almost 16 million reported practicing in 2008 (Yoga Journal, 2008). The rapid increase in the number of people practicing yoga has led to an abundance of anecdotal reports about yoga’s positive impact on outcomes such as mental health and well-being, attention, and physical fitness. However, the scientific and empirical evidence that support these claims is limited. There is a growing body of work dedicated to the scientific study of yoga, but the field is in its nascent stages and much of the work has been limited by poor methodological quality (Kirkwood et al., 2005; Pilkington et al., 2005). Despite these limitations, early research indicates that yoga practice is related to a host of positive outcomes, including: decreased negative affect (West et al., 2004; Woolery et al., 2004) and increased positive affect (Impett et al., 2006; Netz & Lidor, 2003); improved self-awareness and self-acceptance (Daubenmier, 2005; Schure et al., 2008); reduced symptoms of

depression (Pilkington et al., 2005; Shapiro et al., 2007; Ubelacker et al., 2010), stress (Michalsen et al., 2005), and anxiety (Field et al., 2010; Kirkwood et al., 2005); and, improved quality of life and overall well-being (Oken et al., 2006).

While the findings generally support claims about yoga's positive influence on mood, stress, anxiety, and depressive symptoms, there is little research on the relationship between yoga practice and cognitive processes for adults or children. A recent study of yoga and tai chi identified relationships between practicing yoga/tai chi for 20 minutes and improved math performance among adults (Field et al., 2010), and a study of yoga and perceived cognitive change among breast cancer survivors, Galantino et al., (2008) identified improvements in self-reported cognition after an 8-week yoga course. However, as this was a case study (N = 3) and there was no control group, these results can only be interpreted as exploratory. The relationship between yoga and cognition has also been explored in a sample of older adults. In the only randomized, controlled trial (RCT) of the effects of yoga on adult cognition, Oken et al. (2006) reported improvements in participants' physical strength and flexibility, as well as quality-of-life measures, after a yoga intervention, but they did not find any effects of yoga on older adults' (aged 65-85) performance on the Stroop Color and Word Test.

Several studies have looked at relationships between yoga and cognitive performance among children by focusing on the effects of yoga on Attention Deficit Hyperactivity Disorder (ADHD) related symptoms. A RCT of yoga for boys with ADHD (ages 8-13) found that those assigned to the yoga condition who also practiced yoga at home showed improved reaction time on the Test of Variables of Attention relative to boys in the control group and to boys in the yoga condition who did not practice at home (Jensen & Kenny, 2004). This suggests that greater levels of yoga practice may be necessary to produce changes in attention among a sample of boys diagnosed with ADHD. However, the dose effects for non-clinical samples have yet to be tested. An uncontrolled study of the effects of yoga on attention among elementary-school children with attention problems found that students who participated in a three-week yoga class showed improvements in classroom behavior and time on task (Peck et al., 2005). Finally studies conducted in India

suggest that yoga may have a positive impact on spatial memory and planning and execution time among adolescents (ages 11-16 and 10-13) (Manjunath & Telles, 2001; Manjunath & Telles, 2004).

The inconsistency of results across this handful of studies, the limitations in study design, and the lack of specificity regarding the yoga interventions all affirm the need for more research to determine what impact, if any, yoga has on cognitive functioning. Given the attentional components of yoga, and the preliminary findings that yoga may improve aspects of attention, this line of research merits further study.

Meditation

Meditation is the process of training one's attention to either focus on one thing (e.g., breath, a mantra) or to notice and observe external and internal sensations without judgment--or both. Because connecting movement with breath and engaging in other forms of focused awareness are integral to the practice of yoga, the research on meditation and mindfulness practices can help inform the emergent field of yoga research.

Meditation and mindfulness practices have been the subject of more extensive scientific inquiry than yoga; consequently, studies of meditation tend to have stronger research designs and more rigorous methods and analyses than the majority of yoga studies. Work conducted by neuroscientist has begun to explore relationships between meditation and changes in areas of the brain related to cognition. Results suggest that meditation is related to structural and functional changes in areas of the brain related to executive function (Lazar et al., 2005); emotion regulation, self-awareness, and learning and memory (Holzel et al., 2010); attention and working memory (Lutz et al., 2004). Explorations of meditation and cognition have identified relationships between meditation practice and improved attention and working memory (Jha et al., 2007; Jha et al., 2010; Tang et al., 2007); self-report ADHD-related symptoms (Zylowska et al., 2007); and performance on the Stroop task (Wenk-Sormaz et al., 2005).

Exercise and physical activity

Exercise and physical activity have been associated with positive changes in cognition and psychological well-being (Hillman et al., 2009; Fox, 1999; Strohle et al., 2007). Yoga is comprised of both physical and meditative components, thus combining these two elements may produce an additive effect and enhance the positive outcomes associated with meditation. Exercise and physical activity have been associated with positive changes in cognition and psychological well-being (Berger & Owen, 1992; Hillman et al., 2008; Strohle et al., 2007). Yoga is comprised of both physical and meditative components, and combining these two elements may produce an additive effect and enhance the positive outcomes associated with meditation.

Many studies of children and adolescents have identified relationships between physical activity and cognition (for review, see Tomporowski et al., 2008). A correlational study comparing high-fit and low-fit children (mean age = 9.4 years) found that high-fit children exhibited greater cognitive control, better allocation of attentional resources, and performed better on flanker tasks than low-fit children (Hillman et al., 2009). Other correlational studies suggest that there is a positive relationship between fitness level and attention and working memory among children (mean age = 9.6 years) (Hillman et al., 2005); that physical fitness is positively related to academic achievement among third- and fifth-graders (Castellie et al., 2007); . A randomized control trial of ninth-grade students compared the effects of different levels of exercise intensity on working memory for high- and low-performing students and found that low-performing students at baseline significantly improved their scores on a test of working memory capacity after a 12-minute bout of low-intensity running (Budde et al., 2010). The study did not gather follow-up data, so it is unknown whether change persisted after this acute bout of exercise. These findings lend some support to the belief that low- to moderate-intensity exercise has greater effects than high-intensity physical activity (Cotman et al., 2007; Tomporowski et al., 2003), and speak to the potential of yoga to improve cognitive outcomes, as it is generally a low- to moderate-intensity form of physical activity.

In sum, physical activity and exercise have been associated with positive changes in cognitive outcomes, including working memory. It is possible that yoga, which combines physical activity and meditation, will lead to greater changes in cognition than exercise or meditation alone.

Yoga in Schools

There has been increasing presence of yoga and mediation in school-based and after-school programs for children and adolescents, including interventions designed to improve social-emotional intelligence (Catalano et al., 2004) and programs intended to prevent mental health and behavioral (Horowitz & Garber, 2006). Two recent RCTs of yoga in schools indicate that yoga-based interventions are feasible and well-received by students, teachers, and parents (Khalsa et al., in press; Mendelson et al., 2005). These studies—evaluations of school-based yoga programs for 4th and 5th graders in an underserved urban community (Mendelson et al., 2010) and 11th and 12th graders in a rural high school (Khalsa et al., in press)—show that there were reductions in rumination, intrusive thoughts, and emotional arousal (Mendelson et al., 2010) and improvements in resilience, anger control, and fatigue/inertia (Khalsa et al., in press) among yoga students, relative to controls. Khalsa et al. (in press) also noted that, while there were only slight improvements among yoga group participants, control students showed decreases in resilience and anger control, suggesting that the yoga intervention buffered against the negative changes reported by control students.

Study Goals

The current study is, to our knowledge, the first study to evaluate the effects of yoga on working memory capacity and attention problems. It is also one of the first randomized, controlled trials of yoga for adolescents. Results from the current study will generate knowledge about the impact of participation in a school-based yoga program on adolescents' cognitive performance during the course of a school year. The goal of the current study is to identify relationships between yoga practice, working memory capacity, and attention problems, and to begin to

elucidate the nature of these relationships. Given the relationships between working memory capacity and academic performance (e.g., Engle et al., 1999; Gathercole et al., 2004), the results of the current study may also shed light on relationships between yoga and academic performance.

It is expected that students in the yoga group will show greater pre-post improvement in working memory capacity and improvement on the math component of the Operation Span task than students in the control group. It is also expected that students in the yoga group will report decreases in attention problems during the course of the year, relative to controls.

Methods

School selection

Boston-area high schools were identified based on how similar their demographic profiles were to the state and national averages. Introductory letters were sent to four public high schools in the Boston area that met some or all of the school selection criteria. These letters included a brief description of the study, an inquiry into the school's interest in participation, and an invitation to contact the principal investigator if interested in learning more about the study.

The final school selection was made by accounting for the Physical Education (PE) class schedule and the length of classes at the school. Longer class sessions and a consistent number of PE classes per week were preferred. The selected school's demographic statistics for the 2007-2008 academic year were as follows: enrollment of over 1400 students; a racial-ethnic composition of 12% African American, 25% Latino or Hispanic, 6% Asian, and 56% White; and, 33% of the student body qualifies as low income. The graduation rate at this high school was 84% for the 2007-2008 school year, with a 6% dropout rate and an average daily attendance rate of 91%. The high school is located in a suburb of Boston, just outside the Boston city limits.

Participant recruitment

All students (N = 344) enrolled in the ninth grade class during the 2010-2011 academic year were invited to participate in the study. The recruitment and consent procedures were different for the survey and Operation Span (Ospan) components of the study. A passive opt-out consent procedure for participation in the yoga intervention and completion of the surveys, and active informed consent was gathered from parents whose children completed the Ospan task. Information packets were sent to the parents and/or guardians of all the ninth grade students. These information packets included a letter describing the nature of the survey study, an academic records release form, and a parent survey. If parents did not consent to allow their child to participate in the yoga intervention or the survey portion of the study they contacted the school, the principal investigator of the survey study, or the study coordinator. A detailed informed consent form for the Ospan portion of the study was also included in this parent mailing. The letter described the nature of the Ospan task and explained that students' participation was completely voluntary. If parents agreed to allow their child to complete the Ospan they either signed and returned a self-addressed, stamped postcard, called and gave verbal consent, or sent an email with written electronic consent. Follow-up phone calls were made to parents who did not return the consent form, call, or email, and verbal consent was obtained through these phone calls.

Intervention

All ninth-grade PE classes were randomly assigned to either the yoga condition or control condition, with nine classes assigned to the yoga condition and eight to the control condition. Random assignment was done by class, using section time and instructor as constraints. Only one PE class per class session was assigned to the yoga condition (three class sessions had multiple ninth-grade PE classes). PE teachers generally taught two ninth-grade PE classes (they taught other grade levels when not teaching ninth-grade), and random assignment was such that most PE teachers taught one class that had been assigned to the yoga condition and one class that had been assigned to the control condition. Three of seven PE teachers taught three PE classes total, in which case two teachers taught two yoga-condition classes

and one control-condition class and the third teacher taught two control-condition classes and one yoga-condition class.

Yoga was interspersed throughout the academic year, such that students received a maximum of 32 yoga classes over the course of four yoga modules, ranging in length from 3- to 5-weeks. The first yoga module began on October 12, 2010 and concluded on November 19, the second yoga module began on January 3 and ended on January 28, the third yoga module began on March 14 and ended on April 8, and the fourth module began on April 25 and ended on May 13.

PE classes at this high school meet twice a week, every week, for the entire year (excluding holidays and service days). Class sessions are 60-minutes, though with changing time students generally receive 45-50 minutes of PE instruction. The PE content consists of different modules, ranging in length from 2- to 5-weeks. These modules are: basketball, CPR, fitness, floor hockey, health, pickleball, recreation games, soccer, softball, and volleyball.

The control condition classes received education in most of the modules, in different combinations. All control classes had the health and fitness modules; six classes had CPR, floor hockey, pickleball, volleyball, and/or softball; five classes had recreation games and/or basketball; two classes had soccer. The yoga condition received instruction in most modules as well, but each class in the yoga condition received instruction in only four modules in addition to yoga. Nine classes had fitness and eight had health; eight classes had softball; three had pickleball and/or soccer; two had floor hockey; and, four classes had one of the following: basketball, CPR, rec games, and volleyball. Two yoga condition classes had softball twice during the year, meaning they had health, fitness, and softball only, in addition to yoga.

The comparison between participation in a physical education class with a yoga component and a physical education class without yoga will allow us to differentiate the unique impact of yoga on self-concept and cognition from the psychological benefits associated with physical exercise (Mendelson et al., 2010).

The yoga classes were based on a Kripalu Yoga curriculum that has been modified by senior Kripalu Yoga teachers for use in a secondary school setting. Kripalu Yoga was chosen because of its strong emphasis on building non-judgmental

self-awareness. Adolescence is a time of heightened self-consciousness, and Kripalu Yoga's emphasis on self-awareness and self-acceptance may help reduce some of the self-judgment and criticism that emerges during the adolescent years. The high school curriculum includes yoga postures, breathing exercises, and relaxation. The goal of the yoga classes is to teach students how to use the breath and the body to focus on the present moment, thus developing emotion regulation and attention skills that are grounded in the body and the breath. The 45-minute yoga sessions began with 5-minutes of relaxation and focused breathing to help students transition from the activities they were engaged in before arriving at the yoga class. After the initial centering, students were guided through a 25 to 30-minute sequence of, on average, 20 physical postures. Yoga classes concluded with a 5-minute period of closing relaxation. Each lesson has a theme that guided the practice, to which the teacher refers throughout the class. Themes included: information about yoga practice (e.g., descriptions of postures and breathing exercises), stress management, contentment, decision-making, and self-awareness. These discussions were connected to the postures or breathing exercises being taught during the class and were not presented in lecture format.

The yoga classes were taught by three female, certified Kripalu yoga instructors¹ who had completed at least 200-hours Kripalu yoga teacher training. One female teaching assistant, whose primary responsibility was to take notes, was present during each class.

Due to snow days during the yoga modules and some schedule changes during the school year, the maximum number of classes students may have attended ranged from 29 to 32. All students in the yoga condition attended at least 13 yoga classes. Attendance will be entered as a covariate in all analyses.

Measures

Adult ADHD Self-Report Scale (ASRS). The ASRS (Kessler et al., 2005) was developed in conjunction with the World Health Organization Composite

¹ Teachers were selected after an interview process that included teaching a practice yoga class.

International Diagnostic Interview in order to create a valid and reliable self-report measure of ADHD-related symptoms. The scale consists of two nine-item subscales (Inattention and Hyperactivity) that evaluate the frequency of ADHD-related symptoms. Sample items include "How often were you distracted by activity or noise around you?" and "How often did you have difficulty keeping your attention while you were doing boring or repetitive work?" to which individuals respond using a scale of 1 (never) to 5 (multiple times a day). The scale has been widely used and shows high internal and test-retest reliability (e.g., Adler et al., 2006; Kessler et al., 2005; Gau et al., 2007). The current study uses the Inattention scale only ($\alpha = .83$), in which wording of select items have been changed to be developmentally appropriate (e.g., "at work" changed to "at school"). Given the average age of the participants ($M=14.5$) it is believed that this scale is appropriate for use with the current sample.

Operation Span Task (Ospan). The automated Ospan (Unsworth et al., 2005) is a computerized measure of working memory capacity. During this 25-minute task participants are instructed to solve basic math problems while simultaneously storing letters that appear after each equation. At the end of each series of equations and letters participants are asked to recall the letters in the correct order by selecting them from a screen that contains all the letters used in the experiment (F, H, J, K, L, N, P, Q, R, S, T, and Y). Participants are given three practice rounds—one for letter memorization, one for equation completion, and one for both—before the main task. During the math practice, the computer calculates participants' average completion time. The program then uses this time, plus 2.5 standard deviations, as a time limit for each equation during the math portion of the task. This controls for individual differences in time required to solve the math problems. The Ospan-WMC (WMC) score refers to the sum of all correctly recalled letters in their correct position. The number of letter-equation pairs varies from sets of three to sets seven, with three pairs of each size in each set (e.g., a participant will encounter a string of five letter-equation pairs three times during the task). Overall scores could range from 0 to 70.

This task is widely used and has been shown to be appropriate for use with children and adolescents (Gradisar et al., 2008; Kaufman et al., 2009). The absolute score is reported for students who scored 80% or higher on the math portion of the task. This is to eliminate the possibility that Ospan scores reflect participants' ability to replay the letters in their head without putting effort into the math problems, in which case their score may not reflect working memory capacity. The current study also evaluates performance on the math portion of the Ospan (Math).

Home-practice. In order to control for the possibility that control students practice yoga, all students were asked how often they practice yoga at home, using a scale ranging from 1 (*4-7 days/week*) to 6 (*never*). The home practice scores were reverse-coded, such that higher scores equal more home practice.

Data collection procedure

Students completed baseline survey questionnaires one week before the first yoga module began and post-intervention surveys the week immediately after the completion of the last yoga module. At the beginning of each survey administration session participants were reminded that they have the option to withdraw from the study at any time and did not have to answer any question(s) they may be uncomfortable answering. Baseline and post-intervention survey administrations occurred during both PE classes during a single week, and were conducted by several trained members of the research team.

In addition to the pre- and post-intervention survey administrations, participants completed a short questionnaire that included the ASRS during PE class at the end of each yoga module. The data collected from these mini-questionnaires will allow for preliminary exploration of dose effects and will further our understanding of the potential additive effects of yoga practice on attention.

Baseline Ospan administered occurred the week prior to the baseline survey data collection. Two students completed the task at the same time, on two laptops that were set up in an office adjoining the gymnasium. The final Ospan administration took place the week after the post-intervention survey administration.

Results

Participant information and demographics

All ninth-grade students (N = 344) were invited to participate in the survey portion of the study, of which 326 students participated. A randomly selected subsample (N = 100) was selected to participate in the Ospan component of the study. Informed parent consent was gathered from 79 parents, but only 70 students completed the Ospan at baseline. Two students did not want to participate in the Ospan portion of the study and seven were unable to participate or complete the task due to absences (N = 2) and a half-day of school (N = 5) during the baseline Ospan administration week. A total of 323 students completed the baseline survey; 311 students completed the first module questionnaire; 298 students completed the second module questionnaire; and, 301 students completed the third module questionnaire. Three hundred and two students completed the post-intervention survey, and 64 students completed the Ospan. In the Ospan subsample, one student had a concussion during the Ospan administration week and was unable to participate, one student had left school, and four students were absent. The attrition rate for the baseline to post-intervention data collection was 6% and the attrition rate for the Ospan completion was 8%. A total of 251 students completed all five surveys, and 56 students completed all five surveys and both Ospan administrations. The final data analyses were conducted on the students who completed all five waves of data collection. The final Ospan analyses were completed on the 64 students who participated at baseline and post-intervention.

Table 3.1 presents demographic information and baseline scores for students who completed the survey at each individual time point, students who completed all five surveys, and the Ospan subsample. The students who completed all five surveys (N = 251) were evenly distributed across conditions, with 53% (N=132) in the control group and 47% (N=119) in the yoga group. The final sample was 48% female (N=120), 53% White/non-Hispanic (N=135), 23% Hispanic/Latino (N=58), 9% Asian (N=22), and 8% Black/African American. One student was 13 years old at baseline and nine students were 16, with the average age at baseline being 14.58

(SD=.57). At baseline 83 students (34%) qualified for free/reduced lunch. Students who completed all five surveys did not differ from students who complete 4 or fewer surveys on any demographic variable.

The Ospan subsample was also evenly divided across conditions, with 53% (N = 33) in the control condition and 47% (N = 31) in the yoga condition. The gender ratio in Ospan subsample was similar to the final sample, with 33 girls (53%) and 31 boys (47%). However, the subsample differed from the overall sample in racial/ethnic composition, and in the percentage who qualified for free/reduced lunch. Seventy percent (N = 45) of the students who completed the Ospan were White, and only 22% (N = 14) of these students qualified for free/reduced lunch. Therefore, this subsample is not representative of the larger sample or the student body at this high school.

Chi-square analyses indicate that the ratio of boys and girls in the yoga group was similar to the ratio of boys and girls in the control group (chi-square = .46). Groups were also similar in the percentage of students who qualified for free/reduced lunch (chi-square = .97). Analyses indicate that yoga and control groups differed in their racial composition, with fewer (N=10) Latino/Hispanic students in the yoga group and fewer (N=10) Asian students in the control group (chi-square = .04).

Descriptive Statistics

Means and standard deviations for the yoga and control groups' ASRS, Ospan-WMC, and Ospan-Math are presented in Table 3.2. Scores on ASRS and both Ospan measures were compared at each time point with respect to condition, gender, race/ethnicity, and free/reduced lunch using analysis of variance (ANOVA). No baseline differences were found across any of these variables.

Hierarchical Linear Modeling

Preliminary exploration of the data indicated that estimating a single linear model would not be the best fit. Therefore, the data were analyzed using random intercept, fixed slope HLM models with students nested within classrooms and time

as a fixed factor². All the models included random effects for intercept, which represented each participant's baseline score, nested within class. Condition, time, and gender, as well as condition by time or full factorial interactions, were entered as predictors. In order to account for the number of yoga classes attended and for the possibility that students in the control condition practiced yoga at home, attendance and home yoga practice were entered as covariates.³ All models were first run with an additional random effect of class, which accounted for the impact of class-level variance. However, in all models, this random effect did not account for any unique variance beyond the level of variance already accounted for by student nested within class. Therefore, the random intercept for class was removed for simplification of the model.

Due to the exploratory nature of this study, all results that are significant at the $\alpha = .1$ level will be reported. The reference categories for all tables displaying estimates, standard errors, and significance levels are as follows: the reference category for gender is boys, the reference category for condition is the control condition, and the reference time point is baseline.

Attention Problems

The random effect of students nested within class was significant (intercept variance = .47, SE = .01, $p < .001$), indicating that students within a class differed significantly in their baseline levels of attention problems. A significant gender by time interaction was found ($F(4,667.04)=2.79$, $p = .03$). Boys' and girls' levels of attention problems decreased significantly between baseline and the end of the first yoga module (boys: $p < .001$; girls: $p < .01$) but only girls' level of attention problems increased later in the year. Girls showed a gradual increase in attention problems, such that the difference between the end of the first yoga module and post-intervention data collection was significant ($p < .01$). Girls reported higher levels of

² If time were included as a random effect the model would be estimating a single slope, as opposed to allowing for different slopes between time points.

³ Few students in either condition reported practicing yoga at home, but a greater proportion of control students reported practicing yoga outside of school than students in the yoga condition.

attention problems than boys at the end of the third ($p = .05$) and fourth ($p = .004$) yoga modules. There was no effect of condition. Table 3.3 presents the estimated means and standard errors, and Table 3.4 shows the coefficients, standard errors, and significance levels for the model. Figure 3.1 presents a graph of the estimated means for the boys and girls over time.

Math

The random effect of students nested within class was significant (intercept variance = .005, SE = .002, $p = .002$), indicating that students within a class differed in their math performance on the Ospan task. There was evidence of an interaction between time and gender ($F(1,34)=6.04$, $p = .02$). Boys' math scores significantly improved from baseline to post-intervention ($p = .04$), while girls' math scores decreased. However, the change in girls' math scores was not statistically significant. There was no effect of yoga on students' math scores. Table 3.5 presents the estimated means and standard errors, and Table 3.6 presents the coefficients, standard errors, and significance levels for the model. Figure 3.2 illustrates the change over time for boys and girls.

WMC

Unsworth et al. (2005) recommend that subjects who score less than 85% on the math component of the Ospan be excluded from analyses on the absolute (WMC) score. This is done to ensure that participants' absolute scores reflect working memory capacity and not a short-term memory strategy, such as rehearsal. Sixteen participants scored less than 85% on the math task, but 10 of these scored above 80%. Based on observations of students taking the Ospan, it was obvious that 5 or 6 students were choosing responses at random and not putting effort into completing the task. Therefore, these students—who, in most cases scored below 75%—were excluded from the analyses, and the 10 students who scored above 80% will be included. The final set of analyses reflects changes in working memory capacity for the 58 students who scored 80% or higher on the math task.

Consistent with the other two outcomes, the random intercept was significant (intercept variance = 173.38, SE = 68.14, $p = .01$), indicating that students within a class differed significantly in their baseline working memory capacity scores. Results gave evidence of a three-way interaction between condition, time, and gender ($F(1, 28.31) = 4.28, p = .05$). Working memory capacity improved from baseline to post-intervention among girls in both conditions, but this difference was significant only for girls in the control group ($p = .08$). Conversely, working memory capacity among boys in the yoga group improved from baseline to post-intervention ($p = .04$), but decreased among boys in the control group. The decrease in working memory capacity for boys in the control group was not statistically significant ($p = .42$), but the opposite pattern of change between boys in the yoga and control groups is what is driving the significant interaction effect. Table 3.5 presents the estimated means and standard errors, and Figure 3.3 illustrates the interaction of gender and condition over time. The difference in working memory capacity between boys in the yoga and control groups, and girls in the yoga and control groups, was not significant at either time point. It appears that participation in the yoga program may be related to significant improvements in working memory capacity for boys, but more information is necessary before any final conclusions can be made. Table 3.5 presents the estimates, standard errors, and significance levels.

Discussion

The present study evaluated the effects of participation in a school-based yoga program on ninth-grade students' self-reported attention problems and performance on the Ospan task. It was expected that students in the yoga condition would report fewer attention problems and show improvement in their WMC and Math scores, relative to controls. Somewhat consistent with these expectations, boys in the yoga condition showed significant increases in WMC scores from baseline to post-intervention, while WMC among boys in the control condition decreases (though not significantly). However, WMC scores did not differ significantly between boys in the yoga group and boys in the control condition at

either time point, so it is not clear that the observed change was the result of yoga practice. Additionally, a different trend emerged among girls. WMC capacity scores among girls in both groups increased, though the increase was statistically significant only for girls in the control group. Similar to the outcome for boys, WMC scores did not differ significantly between girls in the control and yoga conditions at either time point. Counter to expectations, participation in the yoga group was not related to change in self-reported attention problems. Instead, a gender difference emerged, with girls reporting higher levels of attention problems than boys towards the end of the school year. There was also no effect of participation in the yoga program on Math score, but boys' Math scores increased significantly from baseline to post-intervention and girls' scores did not change significantly. These findings raise several questions about the differential impact of yoga on girls and boys, and about emergence of gender differences in self-reported attention problems.

Although the existence of gender differences in performance on the Math task is not surprising, given the past documentation of gender differences in high school math performance (Hyde et al., 1990), a recent study shows that among a nationally representative sample of high school students there are no longer gender differences in math performance (Hyde et al., 2008; Lindberg et al., 2010). Perhaps the scores on the Math task represent something other than math ability. Research has established the presence of declines among adolescent girls in self-concept of math ability and subjective value placed on math (eg., Eccles et al., 1983; Eccles et al., 1989). As adolescents develop more gender stereotypic views of their abilities, boys begin to develop higher confidence in math and girls develop higher competence beliefs for reading, even when controlling for actual skill (Eccles et al., 1989; Wigfield et al., 1991). It is possible that gender differences in competence beliefs and task values may explain the gender difference in Math task performance. If girls place more value on reading and believe themselves to be competent at this task, and boys place more value on math and believe themselves to be competent at this task, perhaps the differential performance reflects differences in focus and effort-allocation while completing the Ospan. Girls may place more effort on the memorization of the letters—a reading related task—, and boys may place more

value, and thus more effort, on the math component. Additionally, the goal of the Ospan is to recall the letters in the order in which they were observed, not to generate a high math score. So, perhaps girls were—intentionally—lowering their math scores in order to do better on the overall test of working memory capacity.

A more curious finding is the gender difference in self-reported attention problems. Girls reported more attention problems at the end of the school year than boys, regardless of condition. This is an intriguing finding, and may be explained by the fact that girls are more likely than boys to engage in self-blaming causal attributions (Perry & Pauletti, 2011). Girls may be more likely to attribute difficulties with attention to internal factors (e.g., “I have a hard time focusing”), whereas boys may be more likely to attribute these difficulties to external factors (e.g., “my friends were distracting me”). It is also possible that girls are more aware of their thoughts and when their mind wanders than boys, and that this difference in self-reported attention problems is more reflective of a difference in awareness of attention problems than attention problems themselves.

Limitations and Future Directions

Although the results suggest that participation in a school-based yoga program may be related to increases in boys’ working memory capacity, most hypotheses were not met. Several limitations of the current study may help explain the unsupported hypotheses.

First, during the third yoga module it came to my attention that one of the yoga teachers was behaving in a way that conveyed a lack of patience and frustration to the students. Several students wrote on their final evaluation questionnaire that some of the teachers were “mean” or “unfriendly.” This presents a serious problem, both for the quality of the students’ experience and for the quality of the data. Research on the effectiveness of SEL interventions indicates that the presence of problems during intervention implementation moderates the effectiveness of the intervention (see Durlak et al., 2011), and this teacher’s behavior could be considered a problem with implementation. It is possible that

this implementation problem played a large role in the results, and in the existence of unmet hypotheses.

Additionally, only one of the yoga teachers had significant experience working with adolescents and several of the teachers were not selected until a month before the intervention began, which may have provided teachers with inadequate time to prepare. Unfortunately the yoga classes were not tape-recorded, so I am only able to infer how teachers behaved from descriptions of several in-class observations and students' program evaluation forms. Future studies will need to record or videotape classes in order to evaluate teaching style and curriculum fidelity. The teachers in the current study kept detailed logs about which postures were covered in class and which postures were cut from lesson plans, but questions still remain about how a particular posture was taught, and how teachers interacted with students. In order to ensure similar class content across teachers, the field of yoga research would benefit from the creation of several standardized yoga curricula; perhaps one for each of the primary yoga traditions (e.g., Iyengar, Ashtanga, Kripalu). The current study utilized a Kripalu yoga curriculum, modified for use with adolescents, but it was not a standardized curriculum and was open to changes made by the yoga instructors. Future studies should develop a more standardized protocol that includes content, teaching instructions, and guidelines for cutting material or altering class content and structure.

Second, the current study exposed students to a maximum of 32 45-minute yoga classes spread over the course of an academic year, which may not be enough to effect change in all outcomes and for all students. More time spent practicing yoga may be necessary to effect change in self-reported attention problems. It is also possible that boys and girls require different doses, or different kinds of yoga, to elicit the same response. Certain populations and certain outcomes may be less sensitive to yoga, and a different amount or frequency of practice may be necessary to elicit changes for those groups and on those outcomes.

Research on MBSR, an intensive 8-week course that consists of 45-minutes of practice each day, consistently identifies pre-/post-changes in psychological

outcomes. However, several meditation studies have identified changes after just 20-minutes or 5-days of practice (Tang et al., 2007 Wenk-Sormaz et al., 2005). Though there is evidence to suggest that more meditation practice leads to greater change (e.g., Fredrickson et al., 2008), there has been no research on the relationships between the amount of yoga necessary to elicit changes in outcomes. The current attempted to examine dose-response effects by evaluating attention problems after each month-long yoga module. However, participation in yoga did not affect students' self-reported attention problems. Research on dose effects will be critical to furthering our understanding of yoga's effects. One option may be to conduct a study with three conditions: high dose, low dose, and control, and to measure outcomes at regular intervals (e.g., every week) for the duration of the study. This would provide crucial information about the dynamic (or perhaps static) nature of change over time depending on how much yoga individuals receive, as well as the differences between different levels of exposure. Patterns of change could range from individuals showing initial resistance to the practice such that they change in directions that are opposite of the hypothesized paths, to participants showing large change early on and little change as exposure progresses. Many interesting questions regarding dose remain to be explored. In order to fully understand the effects of yoga on psychological outcomes future research will need to identify the minimum dose necessary to begin to elicit change, and to track the nature of the change over time.

Third, yoga may have unique acute and sustained effects. By collecting data anywhere from 2-10 days after the last yoga class, the current reduced the possibility that observed change was the product of acute effects of that last yoga class, but the current study was unable to evaluate the nature of yoga's acute vs. sustained impact. Future studies would benefit from gathering data immediately after a yoga practice, as well as several days or a week after that yoga session. Long-term follow-up will also be critical to include in future studies, as there may be a period of incubation before effects are seen.

The current study is one of the first to evaluate the effect of yoga on adolescents, and it is one of the first randomized, controlled trials of yoga for young

people. Therefore, it is exploratory in nature and many questions about the effects of yoga remain. The current study has generated substantial knowledge about possible effects of yoga, but it has also raised questions about the applicability of yoga for certain populations and at certain developmental stages. In order to determine what kinds of yoga interventions would be most beneficial for specific populations we will need to begin exploring the differential impact of each yoga component. Kripalu yoga tends to be less aerobic than other traditions, with more time spent focusing on the breath and integrating philosophical teachings into posture instruction. In order to deepen our understanding of yoga's effects, future research will need to evaluate how different styles of yoga—with different combinations of postures, meditation practices, and philosophical teachings—differentially affect specific populations and impact specific outcomes.

CHAPTER IV

YOGA AND ADOLESCENTS' SOCIAL-EMOTIONAL FUNCTIONING: THE EFFECTS OF YOGA ON ADOLESCENTS' AFFECT, EMOTION REGULATION, AND SELF-ESTEEM

Abstract

Over 15 million people in the United States reported practicing yoga in 2008, yet research on the effects of yoga on psychological outcomes remains limited. The majority of research on yoga has been conducted with adults, and these studies have been primarily exploratory in nature. Increasing presence of yoga programs in schools raises questions about the impact of yoga on children and adolescents. Early findings suggest that yoga may help protect adolescents against some of the declines in mental health and academic engagement that arise during this developmental stage, but interpretation of these findings remains limited due to methodological weaknesses. The current study is one of the first randomized, controlled trials of yoga for adolescents, and evaluates the impact of a school-based yoga program on adolescents' affect, emotion regulation, and self-esteem. The present study utilizes a Kripalu yoga curriculum, which emphasizes the development of nonjudgmental self-awareness through the teaching of physical postures, breathing exercises, and meditative practices. Hierarchical Linear Modeling analyses indicate that hypotheses about the positive effects of yoga were not entirely met. Consistent with expectations, boys in the control group reported higher levels of negative affect than yoga students during the middle of year, though the difference between groups was resolved by the end of the year. Conversely, students in the control group maintained baseline levels of positive affect, while yoga students' positive affect decreased over the course of the year. Girls in both

groups experienced decreases in self-esteem, but girls in the yoga group reported significantly lower levels of self-esteem at the end of the year than girls in the control group. Yoga group students' use of expressive suppression as an emotion regulation strategy was higher than control students during the middle of the school year, but this difference was not maintained and there was no difference between groups at the end of the year. Yoga practice was not related to changes in cognitive reappraisal. The results suggest that yoga practice may have protected boys from increases in negative affect, but most of the hypotheses were not met. Explanations for unmet hypotheses, and suggestions for future work, will be discussed.

Social and Emotional Development During Adolescence

Adolescence is a time of exploring new ways of thinking about one's self and one's interactions with surrounding environments (see Wigfield et al., 2006 for review). It is a critical social and emotional developmental stage, during which young people begin to question their identity, their feelings of self-worth, and their relationships with family members and peers (Eccles et al., 1989; Erikson, 1968; see Steinberg & Morris, 2001). During the adolescent years, young people may experience significant increases in negative affect (Susman et al., 1991), anxiety (Lewinsohn et al., 1998), and depressive symptoms (see Nolen-Hoeksema & Girgus, 1994). The origins of these declines are hotly contested, but these findings all support the conclusion that, for many young people, adolescence is a time of increased risk for declines in mental health and well-being. Many adolescents also experience a drop in self-competence beliefs, and academic motivation and achievement as they move from elementary- to middle-, and middle- to high-school (Eccles et al., 1989; Eccles et al. 1991; Jacobs et al., 2002).

School transitions are times of heightened risk for many early and middle adolescents, and these transitions have been associated with declines in academic engagement, GPA, self-perceptions, and self-competence beliefs (e.g., Eccles et al., 1991; Isakson & Jarvis, 1999). Transitions between school settings (e.g., elementary to junior high) often involve moving to an environment that is less supportive of the individual than the previous school's environment (Eccles et al., 1991). For

example, the shift from elementary to middle-school involves moving into a school environment that emphasizes social comparison and competition at a time of heightened self-focus, that offers fewer decision-making opportunities to young people at the time when their desire for autonomy increases, and alters peer networks at a time when young people are particularly concerned with social relationships (Eccles et al., 1991). Similar incongruities arise when students move from middle- to high-school (Eccles & Roeser, 2009), and adolescents find themselves in an environment with even less support from teachers and fewer opportunities for meaningful engagement (Eccles & Roeser, 2003).

Early research on the effects of yoga suggests that practicing yoga may protect against some of these declines in mental health (e.g., Field et al., 2010; Pilkington et al., 2005) and academic outcomes (Peck et al., 2005), and thus may be an ideal practice to introduce to children and adolescents.

Yoga

Yoga is mind-body practice that combines physical postures, breathing exercises, and meditative practices, with the goal of balancing the physical, mental, and emotional selves. Postures consist of balancing and strengthening poses, as well as stretching and twisting; meditation and breathing exercises may include focusing on the breath, and noticing—but not engaging with—one’s thoughts and feelings as they arise; philosophy refers to the central tenets of yoga, which include non-judgmental self-awareness, honesty, contentment, and nonviolence. There are numerous styles of yoga, with some traditions placing greater emphasis on posture alignment, others focusing more on the meditative and breath work components, and yet others focus more on creating an aerobic experience by vigorously flowing through posture sequences. Because of this diversity in practices it is fundamental that researchers thoroughly document the yoga program used and describe what is unique about the particular style of yoga taught in the intervention. The current study introduces adolescents to a yoga intervention that emphasizes development of non-judgmental self-awareness, and uses the teaching of physical postures and breathing as tools for developing this self-awareness. Although there is a wide

range of yoga styles, all practices share the fundamental goal of unifying mind and body and generating a greater sense of well-being and fulfillment in one's life.

Yoga's presence in mainstream American culture has grown dramatically during the past 20 years, with the number of practitioners almost doubling between 1998 and 2008. Fewer than 8 million Americans reported practicing in 1998 (Saper et al., 2004) and almost 16 million reported practicing in 2008 (Yoga Journal, 2008). The rapid increase in the number of people practicing yoga has led to an abundance of anecdotal reports about yoga's positive impact on outcomes such as mental health and well-being, attention, and physical fitness. However, the scientific and empirical evidence that support these claims is limited. There is a growing body of work dedicated to the scientific study of yoga, but the field is in its nascent stages, and much of the work has been limited by poor methodological quality (see Kirkwood et al., 2005 and Pilkington et al., 2005 for reviews). Despite these limitations, early research indicates that yoga practice is related to a host of positive outcomes, including: decreases in negative affect and increases in positive affect (Impett et al., 2006; West et al., 2004; Woolery et al., 2004); improved self-awareness and self-acceptance (Daubenmier, 2005; Schure et al., 2008); reduced symptoms of depression (Shapiro et al., 2007; Ubelacker et al., 2010), stress (Michalsen et al., 2005), and anxiety (Field et al., 2010); and, improved quality of life and overall well-being (Oken et al., 2006).

Most studies of yoga have been conducted with a single group. However, several randomized, controlled trials (RCTs) have provided evidence of yoga's benefits. A RCT of yoga for healthy seniors found that participants in a yoga group reported improvements in quality of life, overall well-being, and energy, and had observable improvements in physical outcomes (e.g., balance, flexibility) (Oken et al., 2006). Another RCT found that, among menopausal women, participants reported increases in physical self-esteem (Elavsky & McAuley, 2007). Finally, a study in which professional musicians self-selected into one of two, two-month long yoga conditions or to a no-yoga control condition found that participation in either of the yoga conditions was linked to significantly larger reductions in performance anxiety and general anxiety than control group participation (Khalsa et al., 2009).

The remaining studies discussed in this section are not RCTs, and evaluate the effects on yoga on only a single group. A study of yoga postures only (e.g., no meditation and breathwork) combined with tai chi found decreases in anxiety after only 20-minutes of practice (Field et al., 2010). An evaluation of a two-month yoga immersion program found relationships between higher levels of practice and increases in positive affect and decreases in negative affect, as well as decreases in body objectification (Impett et al., 2006). Improvements in depressive symptoms were reported in a study of Vinyasa yoga for depression (Ubelacker et al., 2010) and in a study of Iyengar yoga as a complementary treatment for depression (Shapiro et al., 2007). Medical students who received instruction in Kripalu yoga reported decreases in perceived stress and depressive symptoms, as well as improvements in overall health (Simard & Henry, 2009). A study comparing different types of exercise to yoga found that participants in the yoga group reported mood improvements after just one yoga session (Netz & Lidor, 2003), though this was not a controlled trial and participants were not randomly assigned to conditions.

Several review papers have evaluated yoga as a treatment for anxiety (Kirkwood et al., 2005) and depression (Pilkington et al., 2005) and concluded that the results are promising, but that more research is needed before results can be interpreted in any conclusive manner.

Yoga and Young People

Studies of yoga with adolescents and children have been rare, but the trend towards introducing yoga for children and adolescents in schools and at yoga studios (White, 2009) points to the need for more rigorous, controlled studies of yoga for children and adolescents. To date, there have been few RCT studies of yoga for children and adolescents. However, the findings from this small number of RCTs suggest that yoga practice is related to: reduced symptoms of irritable bowel syndrome (IBS) and anxiety in adolescents (ages 11-18) with IBS (Kuttner et al., 2006); reduced eating disorder scores and food preoccupation among adolescents (ages 11-21) with disordered eating (Carei et al., 2010); and, improved scores on the DSM IV Hyperactivity/Impulsivity subscale, the Test of Variables of Attention, and

five subscales on the Conner's Parent Rating Scale among boys (ages 8-13) with Attention Deficit and Hyperactivity Disorder (Jensen & Kenny, 2004). Findings from non-RCTs of yoga and adolescents suggest that yoga practice is associated with reduction in negative behaviors among fourth- and fifth-grade inner-city students (Berger et al., 2009); reduced feelings of helplessness and aggression among fifth-grade students (Stueck & Gloeckner, 2005); and, improved time on task among elementary school children with attention problems, as observed by school psychologists (Peck et al., 2005).

Yoga in Schools

There has been increasing presence of yoga and meditation in school-based and after-school programs for children and adolescents, including interventions designed to improve social-emotional intelligence (Catalano et al., 2004) and programs intended to prevent declines in mental health and emergence behavioral problems (Horowitz & Garber, 2006). Two recent RCTs of yoga in schools indicate that yoga-based interventions are feasible and well-received by students, teachers, and parents (Khalsa et al., in press; Mendelson et al., 2005). These studies—evaluations of school-based yoga programs for 4th and 5th graders in an underserved urban community (Mendelson et al., 2010) and 11th and 12th graders in a rural high school (Khalsa et al., in press)—show that students in the yoga condition had reductions in rumination, intrusive thoughts, and emotional arousal (Mendelson et al., 2010) and improvements in resilience, anger control, and fatigue/inertia (Khalsa et al., in press) relative to controls. Khalsa et al. (in press) also noted that, while there were only slight improvements among yoga group participants, control students showed decreases in resilience and anger control, suggesting that the yoga intervention buffered against the negative changes reported by control students.

Positive Youth Development

Because behaviors and decisions made during adolescence have the potential to impact later life outcomes (Eccles et al., 2008), implementing interventions during this critical developmental stage may have positive effects throughout the

life course. There is growing consensus among intervention specialists that programs that promote positive development, in addition to preventing negative outcomes, are the most successful (Catalano et al., 2004). Social and emotional learning (SEL) programs aim to support the development of healthy social and emotional functioning by encouraging self-awareness, social awareness, responsible decision-making, self-management, and relationship management (Zins et al., 2004). SEL interventions provide some indication of how yoga may impact young people's social, emotional, and school-related experiences. SEL programs have frequently been influenced by mindfulness practices, such as meditation and yoga, and SEL and yoga espouse similar messages about self-awareness, self-acceptance, and pro-social behavior. Research suggests that SEL interventions influenced by meditation and/or yoga improve coping with school stress, increase pro-social behavior, increase academic motivation and persistence, and decrease aggression and school absences among children and adolescents (Greenberg et al., 2003; Zins et al., 2004). Additionally, SEL programs that support students' abilities to identify and regulate their emotions, to develop social, emotional and cognitive competence, and to engage in prosocial behaviors have been found to enhance academic performance and school-related behaviors (Greenberg et al., 2003; Zins et al., 2004). Findings from this body of literature suggest that yoga, which contains the same messages about self-awareness, self-acceptance, and prosocial behavior that are found in SEL programs, may have similar effects on adolescents' social and emotional functioning.

Meditation

Meditation is the process of training one's attention to either focus on one thing (e.g., breath, a mantra) or to notice and observe external and internal sensations without judgment. Advanced meditation practices may incorporate both approaches. Because connecting breath with movement and engaging in other forms of focused awareness are integral to the practice of yoga, the research on meditation and mindfulness practices can help inform the emergent field of yoga research.

Meditation and mindfulness practices have been the subject of more extensive scientific inquiry; consequently, studies of meditation tend to have stronger research designs and more rigorous methods and analyses than the majority of yoga studies. A number of research studies have examined relationships between meditation and psychological outcomes such as stress, anxiety, and depressive symptoms (for review, see Kabat-Zinn et al., 2003) as well as emotion regulation. Findings suggest that meditation practice is associated with decreased stress (Brown & Ryan, 2003; Carmody & Baer, 2008), increased positive mood (Jain et al., 2007), and reduced relapse and/or recurrence of depression (Teasdale et al., 2009). Two studies of meditation and emotion regulation found that participants in the meditation groups were more capable of cognitive reappraisal (Gootjes et al., 2011) and more likely to have a positive reaction to neutral stimuli and lower levels of emotional reactivity to aversive stimuli (Arch & Craske, 2006). Finally, in a RCT evaluating loving-kindness meditation for adults, meditation group participants reported increases in daily experience of positive emotions, increased life satisfaction, and decreased depressive symptoms (Fredrickson et al., 2008). In sum, findings indicate that meditation is linked to improvements in emotion regulation and mental health. Yoga, which includes meditative practices, may effect similar improvements.

Meditation and young people

As with research on yoga and young people, the field of research on meditation with children and adolescents is limited by methodological weaknesses (Black et al., 2009). However, several studies point to the promise of this practice as an intervention tool in elementary- and middle-school settings. Middle-school students who were in at least two semester-long classes led by teachers trained in meditation and relaxation, and who received instruction in these techniques, had higher GPAs, work habit scores, and cooperation scores at the end of a two-year period than students with fewer than two semesters (Benson et al., 2004). African American adolescents who participated in a four-month Transcendental Meditation (TM) program had significant decreases in absenteeism, school rule infractions, and

suspension days compared to increases in all three outcomes among students in the control group (Barnes et al., 2003). Adolescents suffering from PTSD in post-war Kosovo experienced reductions in PTSD symptoms after participating in a 12-week mind-body skills meditation program (Gordon et al. 2008). A 24-week mindfulness training program led to decreases in test-anxiety and increases in selective attention test scores among elementary school students (Napoli et al., 2005) and 10 participants in a middle-school TM program described their experience as improving emotional intelligence and improving academic performance (Rosaen & Benn, 2006). Another qualitative study reported that middle-school students in a Tai Chi and mindfulness program stated that participation in the program increased calmness, self-awareness, and well-being (Wall, 2005).

Although these findings are promising, none of the studies reviewed here were RCTs and the results need to be interpreted with some hesitation. Future studies will need to engage RCT study designs, and to compare intervention and control group participants' scores on the outcomes of interest.

Physical activity and exercise

Exercise and physical activity have been associated with positive changes in cognition and psychological well-being (Berger & Owen, 1992; Hillman et al., 2008; Strohle et al., 2007). Yoga is comprised of both physical and meditative components, and combining these two elements may produce an additive effect and enhance the positive outcomes associated with meditation.

There is already indication that both aerobic exercise and yoga are associated with improvements in psychological well-being. Two studies have compared the effects of yoga with other forms of exercise and concluded that yoga has similar positive effect on outcomes such as mood and well-being as aerobic forms of exercise (Berger & Owen, 1992; Netz & Lidor, 2005). A study comparing different types of exercise to yoga found that participants in the yoga group reported similar mood improvements as the swimming and Feldenkrais groups—and greater improvements than the aerobic dance and computer control groups—after just one yoga session (Netz & Lidor, 2003), though this was not a controlled trial and

participants were not randomly assigned to conditions. A similar, non-randomized, controlled study compared the effects of participating in a yoga or swimming class to a lecture control group (Berger & Owen, 1992). Participants completed measures of mood pre-post three classes, and results suggest that swimming and yoga were related to similar pre-post decreases in tension, anger, and depression relative to controls. However, in both these studies students self-selected into the yoga classes, and it is possible that the results reflect sample characteristics and not yoga's effects.

A review article by Byrne & Byrne (1993) concluded that exercise has a positive effect on mood states, depressive symptoms, and anxiety, and that non-aerobic (weight training) exercise has similar positive effect on depressive symptoms as aerobic exercise. Yoga combines balance, strength training, and aerobic activity, thus yoga may have positive effects on outcomes such as depressive symptoms. Moreover, low-intensity exercise has been related to positive mood change, compared with no pre-post mood improvements after high-intensity exercise (Septoe & Cox, 1988). This speaks to the potential of yoga to improve psychological outcomes, as it is generally a low- to moderate-intensity form of physical activity. Similarly, a correlational study found that physically active adolescents reported lower levels of anxiety than less physically active adolescents (Strohle et al., 2007). Another review article identified relationships between exercise and reduced depressive symptoms, improved mood, self-perceptions, and self-esteem (Fox, 1999), which gives some support to the theory proposed by Sonstroem & Morgan (1988) that exercise enhances self-esteem.

In sum, physical activity and exercise have been associated with positive changes in psychological outcomes, such as depressive symptoms and mood. It is possible that yoga, which combines physical activity and meditation, will lead to greater changes in psychological outcomes than exercise or meditation alone.

Study Goals

The current study evaluates whether a yoga intervention can help adolescents deal with the unique stressors of this developmental period. Results

from this study will provide knowledge about the impact of participation in a school-based yoga program on adolescents' positive and negative affect, emotion regulation, and self-esteem during the course of a school year. The goal of the current study is to identify relationships between yoga practice, affect, emotion regulation, and self-esteem, and to begin to elucidate the nature of these relationships. It is expected that students in the yoga group will report greater pre-post intervention improvement in affect, emotion regulation, and self-esteem relative to control students.

Methods

School selection

Boston-area high schools were identified based on how similar their demographic profiles were to the state and national averages. Introductory letters were sent to four public high schools in the Boston area that met some or all of the school selection criteria. These letters included a brief description of the study, an inquiry into the school's interest in participation, and an invitation to contact the principal investigator if interested in learning more about the study.

The final decision was made by accounting for the Physical Education (PE) class schedule and the length of classes at the school. Longer class sessions and a consistent number of PE classes per week preferred. The selected school's demographic statistics for the 2007-2008 academic year were as follows: enrollment of over 1400 students; a racial-ethnic composition of 12% African American, 25% Latino or Hispanic, 6% Asian, and 56% White; and, 33% of the student body qualifies as low income. The graduation rate at this high school was 84% for the 2007-2008 school year, with a 6% dropout rate and an average daily attendance rate of 91%. The high school is located in a suburb of Boston, just outside the Boston city limits.

Participant recruitment

All students (N = 344) enrolled in the ninth grade class during the 2010-2011 academic year were invited to participate in the study. Information packets were

sent to the parents and/or guardians of all the ninth grade students. These information packets included a letter describing the nature of the survey study, an academic records release form, and a parent survey. If parents did not consent to allow their child to participate in the survey portion of the study they contacted the school, the principal investigator of the survey study, or the study coordinator.

Intervention

All ninth-grade PE classes were randomly assigned to either the yoga condition or control condition, with nine classes assigned to the yoga condition and eight to the control condition. Random assignment was done by class, using section time and instructor as constraints. Only one PE class per class session was assigned to the yoga condition (three class sessions had multiple ninth-grade PE classes). PE teachers generally taught two ninth-grade PE classes (they taught other grade levels when not teaching ninth-grade), and random assignment was such that most PE teachers taught one class that had been assigned to the yoga condition and one class that had been assigned to the control condition. Three of seven PE teachers taught three PE classes total, in which case two teachers taught two yoga-condition classes and one control-condition class and the third teacher taught two control-condition classes and one yoga-condition class.

Yoga was interspersed throughout the academic year, such that students received a maximum of 32 yoga classes over the course of four yoga modules, ranging in length from 3- to 5-weeks. The first yoga module began on October 12, 2010 and concluded on November 19, the second yoga module began on January 3 and ended on January 28, the third yoga module began on March 14 and ended on April 8, and the fourth module began on April 25 and ended on May 13.

PE classes at this high school met twice a week, every week, for the entire year (excluding holidays and service days). Class sessions were 60-minutes, though with changing time students generally receive 45-50 minutes of PE instruction. The PE content consisted of different modules, ranging in length from 2- to 5-weeks. These modules were: basketball, CPR, fitness, floor hockey, health, pickleball, recreation games, soccer, softball, and volleyball.

The control condition classes received education in most of the modules, in different combinations. All control classes had the health and fitness modules; six classes had CPR, floor hockey, pickleball, volleyball, and/or softball; five classes had recreation games and/or basketball; two classes had soccer. The yoga condition received instruction in most modules as well, but each class in the yoga condition received instruction in only four modules in addition to yoga. Nine classes had fitness and eight had health; eight classes had softball; three had pickleball and/or soccer; two had floor hockey; and, four classes had one of the following: basketball, CPR, rec games, and volleyball. Two yoga condition classes had softball twice during the year, meaning they had health, fitness, and softball only, in addition to yoga.

The comparison between participation in a physical education class with a yoga component and a physical education class without yoga will allow us to differentiate the unique impact of yoga on self-concept and cognition from the psychological benefits associated with physical exercise (Mendelson et al., 2010).

The yoga classes were based on a Kripalu Yoga curriculum that had been modified by senior Kripalu Yoga teachers for use in a secondary school setting. Kripalu Yoga was chosen because of its strong emphasis on building non-judgmental self-awareness. Adolescence is a time of heightened self-consciousness, and Kripalu Yoga's emphasis on self-awareness and self-acceptance may help reduce some of the self-judgment and criticism that emerges during the adolescent years. The high school curriculum includes yoga postures, breathing exercises, and relaxation. The goal of the yoga classes is to teach students how to use the breath and the body to focus on the present moment, thus developing emotion regulation and attention skills that are grounded in the body and the breath. The 45-minute yoga sessions began with 5-minutes of relaxation and focused breathing to help students transition from the activities they were engaged in before arriving at the yoga class. After the initial centering, students were guided through a 25 to 30-minute sequence of, on average, 20 physical postures. Yoga classes concluded with a 5-minute period of closing relaxation. Each lesson has a theme that guided the practice, to which the teacher referred throughout the class. Themes included:

information about yoga practice (e.g., descriptions of postures and breathing exercises), stress management, contentment, decision-making, and self-awareness.

The yoga classes were taught by three female, certified Kripalu yoga instructors⁴ who had completed at least 200-hours Kripalu yoga teacher training. One female teaching assistant, whose primary responsibility was to take notes, was present during each class.

Due to snow days during the yoga modules and some schedule changes during the school year, the maximum number of classes students may have attended ranged from 29 to 32. All students in the yoga condition attended at least 13 yoga classes. Attendance will be entered as a covariate in all analyses.

Measures

Positive Affect Negative Affect Scale for Children (PANAS-C). The PANAS-C (Laurent et al., 1999) is a 30-items scale, adapted from the adult PANAS (Watson, Clark, & Tellegen, 1988) for use with children, which is comprised of two 15-item subscales designed to evaluate negative (alpha = .87) and positive affect (alpha = .89). Participants respond to each item by selecting the degree to which they felt a certain way during the past few weeks, using a scale of 1 (*very slightly or not at all*) to 5 (*extremely*). Sample items for positive affect include “happy,” “calm,” and “joyful.” Sample negative affect items include “nervous,” “afraid,” and “miserable.”

Emotion Regulation Questionnaire (ERQ). The Emotion Regulation Questionnaire (ERQ; Gross & John, 2003) is a 10-item scale that evaluates individual’s use of cognitive reappraisal (6 items; alpha = .74) and expressive suppression (4 items; alpha = .71) strategies. Cognitive reappraisal is an antecedent-focused emotion regulation strategy that refers to reevaluating a situation in a way that changes its emotional impact. Items from the cognitive reappraisal subscale include: “When I want to experience more positive emotion (such as joy or amusement), I change what I’m thinking about,” and, “I control my emotions by changing the way I’m thinking about the situation.” Expressive

⁴ Teachers were selected after an interview process that included teaching a practice yoga class.

suppression is response-focused emotion regulation strategy that refers to inhibition of emotion-related expression. Sample items from the expressive suppression subscale are: “I keep my emotions to myself,” and “I control my emotions by not expressing them.” Participants respond using a scale that ranges from 1 (*strongly disagree*) to 7 (*strongly agree*).

Rosenberg Self Esteem Scale (RSE). The RSE (Rosenberg, 1979) is a 10-item scale ($\alpha = .87$) designed to measure individuals’ general levels of self-acceptance. Participants respond to items using a four-point response scale that indicates the degree to which they agree with the items (*1=strongly agree; 4=strongly disagree*). Sample items include: “On the whole, I am satisfied with myself,” and “I feel I do not have much to be proud of.” Negatively worded items are reverse coded, such that higher scores indicate higher levels of self-esteem.

Home-practice. In order to control for the possibility that control students practice yoga, all students were asked how often they practice yoga at home, using a scale ranging from 1 (*4-7 days/week*) to 6 (*never*). The home practice scores were reverse-coded, such that higher scores equal more home practice.

Data collection procedure

Students completed a baseline survey questionnaire one week before the first yoga module began and a post-intervention survey the week immediately after the completion of the last yoga module. At the beginning of each survey administration session participants were reminded that they had the option to withdraw from the study at any time and did not have to answer any question(s) they may be uncomfortable answering. Baseline and post-intervention survey administrations occurred during all PE classes in a single week, and were conducted by several trained members of the research team. In addition to the pre- and post-intervention survey administrations, participants completed a mini-questionnaire, including the PANAS-C and ERQ, during PE class at the end of each yoga module.

Results

Participant information and demographics

All ninth-grade students (N = 344) were invited to participate in the study, of which 326 students participated. A total of 325 students completed the baseline survey; 311 students completed the first module questionnaire; 298 students completed the second module questionnaire; and, 301 students completed the third module questionnaire. Three hundred and two students completed the post-intervention survey. A total of 251 students completed all five surveys. The final data analyses will be conducted on the students who completed all five waves of data collection.

Table 4.1 presents demographic information and baseline scores for students who completed the survey at each individual time point, and students who completed all five surveys. The students who completed all five surveys (N =251) were evenly distributed across conditions, with 53% (N=132) in the control group and 47% (N=119) in the yoga group. The final sample was 48% female (N=120), 53% White/non-Hispanic (N=135), 23% Hispanic/Latino (N=58), 9% Asian (N=22), and 8% Black/African American. One student was 13 years old at baseline and nine students were 16, with the average age at baseline being 14.58 (SD=.57). At baseline 83 students (34%) qualified for free/reduced lunch. Students who completed all five surveys did not differ from students who complete 4 or fewer surveys on any demographic variable.

Chi-square analyses indicate that the ratio of boys and girls in the yoga group was similar to the ratio of boys and girls in the control group (chi-square = .46). Groups were also similar in the percentage of students who qualified for free/reduced lunch (chi-square = .97). Analyses indicate that yoga and control groups differed slightly in their racial composition, with fewer Latino/Hispanic students (N=10) in the yoga group and fewer Asian students (N=10) in the control group (chi-square = .04).

Descriptive statistics

Means and standard deviations for the yoga and control groups' affect, emotion regulation, and self-esteem scores are presented in Table 4.2. Scores on all baseline outcomes were compared with respect to condition, gender, race/ethnicity,

and free/reduced lunch, using analysis of variance (ANOVA). No differences between condition, race/ethnicity, or free/reduced lunch emerged. Girls reported significantly higher levels of negative affect ($p=.009$) and lower levels of self-esteem than boys ($p=.000$) at baseline; therefore, gender will be added as a predictor to subsequent analyses.

Hierarchical Linear Modeling

Preliminary exploration of the data revealed non-linear trends in the data; therefore, the data were analyzed using random intercept, fixed slope HLM models⁵. The models included random effects for intercept, which represents each participant's baseline score, nested within class. Condition, time, and gender, as well as condition by time or full factorial interactions, were entered as predictors. Attendance and home yoga practice were entered as covariates, in order to account for the number of yoga classes attended and for the possibility that students in the control condition practiced yoga at home.⁶ All models were first run with an additional random intercept for class, which evaluated the impact of class-level variance. However, in all models, this random effect did not account for any unique variance beyond the level of variance already accounted for by student nested within class. Therefore, the random intercept for class was removed for simplification of the model.

Due to the exploratory nature of this study, all results that are significant at the $\alpha = .1$ level will be reported. The reference categories for all tables displaying estimates, standard errors, and significance levels are as follows: the reference category for gender is boys, the reference category for condition is the control condition, and the reference time point is baseline.

Positive Affect

⁵ Including time as a random effect makes the assumption that the data fit a linear model, as opposed to allowing for different slopes between time points.

⁶ Few students in either condition reported practicing yoga at home, but a greater proportion of control students reported practicing yoga outside of school than students in the yoga condition.

Students within a class differed significantly in their baseline levels of positive affect (intercept variance = .35, SE = .05, $p < .001$). There was evidence of a significant interaction between condition and time ($F(4, 668) = 2.60$, $p = .035$), with positive affect decreasing significantly between baseline and the end of the first yoga module ($p = .03$) among students in the control group. Students in the control group maintained baseline levels of positive affect throughout the year, and had higher levels of positive affect than yoga students after the second ($p = .08$), third ($p = .06$), and fourth ($p = .06$) months of yoga class. Table 4.3 presents the estimated means and standard errors for the yoga and control groups, and Figure 4.1 illustrates the change in these means over time. Table 4.4 presents the coefficients, standard errors, and significance levels for this model.

Negative Affect

The random effect of students nested within class was also significant for negative affect (intercept variance = .23, SE = .03, $p < .001$), indicating that students within a class differed significantly in their baseline levels of negative affect. Test statistics give evidence of a three-way interaction between time, condition, and gender ($F(4, 660) = 2.74$, $p = .03$). Boys in the control group reported having higher levels of negative affect than boys in the yoga group after the second ($p = .09$) and third ($p = .05$) months of yoga class. However, there was no significant change in negative affect between any of the time points for boys in the control or yoga conditions. Therefore, it is not possible attribute to lower level of negative affect among boys in the yoga group to their participation in the yoga intervention. Table 4.5 shows the estimated means and standard errors for boys and girls, and Figure 4.2 the change in these means over time. Table 4.6 presents the coefficients, standard errors, and significance levels for this model.

Emotion Regulation

Students within classes differed significantly in their baseline reports of expressive suppression (intercept variance = .11, SE = .05, $p < .05$), and there was evidence of a significant interaction between condition and time ($F(4, 668) = 2.82$, p

= .024). Students in both conditions significantly increased their use of expressive suppression strategies between baseline and the end of the first yoga module (yoga: $p < .01$; control: $p < .001$), and students in the yoga group reported using more expressive suppression strategies at the end of the second ($p = .04$) and third ($p = .09$) yoga modules than control students. However, because the change between the first and second, and second and third, modules was not significant for either group it is not possible to attribute this difference solely to condition. Table 4.3 shows the estimated means and standard errors for the yoga and control groups, and Figure 4.3 illustrates the change in these means over time. Table 4.7 presents the coefficients, standard errors, and significance levels for the expressive suppression model.

Analyses indicated that there was significant variance within classes between students' baseline levels of cognitive reappraisal (intercept variance = .09, SE = .04, $p < .05$), but there was no significant effect of condition over time. Table 4.8 shows the coefficients, standard errors, and significant levels for this model.

Self-Esteem

Consistent with the other outcomes explored in this study, students within a class differed significantly in their baseline reports of self-esteem (intercept variance = .16, SE = .02, $p < .001$). Test statistics indicated that there was a significant three-way interaction of time, condition, and gender ($F(1, 165) = 3.26$, $p = .07$). Self-esteem significantly decreased from baseline to post-intervention among girls in both conditions (yoga: $p = .07$; control: $p < .01$), but girls in the control condition reported significantly higher levels of self-esteem than girls in the yoga condition at the end of the school year ($p = .06$). Self-esteem did not differ by condition for boys at either time point, but self-esteem decreased significantly for boys in the control condition between baseline and post-intervention ($p = .07$). Table 4.5 presents the estimated means and standard errors for boys and girls in both conditions, and Figure 4.4 displays the interaction of gender and condition over time. Table 4.9 presents the estimates, standard errors, and significance levels for the self-esteem model.

Discussion

The present study evaluated the effects of participation in a school-based yoga program on ninth-grade students' affect, emotion regulation, and self-esteem. It was expected that students in the yoga condition would report improved affect, emotion regulation, and self-esteem relative to controls. Somewhat consistent with hypotheses, boys in the yoga condition had lower levels of negative affect than boys in the control condition. Although there was no significant change between any of the time points for boys in either group, and this difference cannot be attributed to participation in the yoga or control group, it is possible that boys in the yoga group had a qualitatively different experience than boys in the control group and that this difference helps explain their lower levels of negative affect. The impact of yoga on emotion regulation was also examined. No relationship between yoga practice and cognitive reappraisal emerged, but students in the yoga condition reported higher levels of expressive suppression than students in the control condition after the second and third months of yoga. Finally, the current study evaluated pre- and post-intervention change in students' reports of global self-esteem. The results show that girls had significantly lower levels of self-esteem than boys, which is consistent with the literature (e.g., Gutman & Eccles, 2007; Kling et al., 1999; Wigfield et al., 1991), and that self-esteem for girls in both conditions decreased from the beginning to the end of the year. However, girls in the yoga group reported significantly lower self-esteem than girls in the control group at the end of the year. In light of past research, these results are puzzling. Most of the results from the current study are counter to the expected results, and possible explanations for these unexpected results are explored.

Limitations and Future Directions

The results suggest that participation in a school-based yoga program may offer some benefit to adolescents, and the lack of support for the majority of the hypotheses may be explained by several limitations of the current study.

First, during the third yoga module it came to my attention that one of the yoga teachers was behaving in a way that conveyed a lack of patience and frustration to the students. Several students wrote on their final evaluation questionnaire that some of the teachers were “mean” or “unfriendly.” This presents a serious problem, both for the quality of the students’ experience and for the quality of the data. Research on the effectiveness of SEL interventions indicates that the presence of problems during intervention implementation moderates the effectiveness of the intervention (see Durlak et al., 2011), and this teacher’s behavior could be considered a problem with implementation. It is possible that this implementation problem played a large role in the results, and in the existence of unmet hypotheses.

Additionally, the nature of student-teacher relationships and feelings of classroom belonging are related to students’ social-emotional well-being; more supportive classroom climates are associated with higher levels of well-being (Eccles & Roeser, 2011; Wigfield et al., 2006). If students felt uncomfortable or unwelcome in class, it is possible that this may have precipitated the decreases in positive affect among students in the yoga group. Unfortunately the yoga classes were not tape-recorded, so I am only able to infer how this particular teacher behaved from descriptions of several in-class observations and students’ program evaluation forms. Future studies will need to record or videotape classes in order to evaluate teaching style and ensure program fidelity. Teachers should receive regular feedback and guidance from the researchers, in order to guarantee that participants are receiving the intended instruction. Finally, only one of the yoga teachers had significant experience working with adolescents and several of the teachers were not selected until a month before the intervention began, which may have provided teachers with inadequate time to prepare.

The teachers in the current study kept detailed logs about which postures were covered in class and which postures were cut from lesson plans, but questions still remain about how a particular posture was taught, and how teachers interacted with students. In order to ensure similar class content across teachers, the field of yoga research would benefit from the creation of several standardized yoga

curricula—perhaps one for each of the primary yoga traditions (e.g., Iyengar, Ashtanga, Kripalu). The current study utilized a Kripalu yoga curriculum that was modified for use with adolescents, but it was not standardized and was open to changes made by the yoga instructors. Future studies will need to develop and implement more standardized protocols that include content, teaching instructions, and guidelines for cutting material or altering class content and structure. Research on mindfulness and meditation has been so successful in part because of MBSR’s standardized curriculum. The existence of a standardized curriculum has allowed researchers to evaluate the effects of MBSR on a range of outcomes and with a range of populations. In order to replicate yoga studies, and to compare the effects of yoga on different outcomes and with different populations, we will need to develop standardized yoga intervention protocols.

Second, it is possible that the current study did not have a high enough dose to effect change in all the outcomes, and for all the participants. MBSR and TM require daily practice of 30-45 minutes/day, and it may be that this high level of consistent practice is necessary to observe the changes that have been identified in some of the meditation studies. However, several meditation studies have identified changes after just 20-minutes or 5-days of practice (Tang et al., 2007 Wenk-Sormaz et al., 2005). Although there is evidence to suggest that higher dose of meditation will lead to greater change (e.g., Fredrickson et al., 2008), there is no information about the relationship between amount of yoga and change in outcomes. The current study attempted to examine dose effects by evaluating affect and emotion regulation after each month-long yoga module. In some cases differences between students in the yoga and control conditions emerged after the first month of yoga instruction, while for other outcomes differences did not emerge until the end of the third month. This suggests that some outcomes may be more sensitive to a yoga intervention than others, but it remains unclear how the amount of yoga affects changes in outcomes. Research on dose effects will be critical to furthering our understanding of yoga’s effects.

One option may be to conduct a study with three conditions: high dose, low dose, and control, and to measure outcomes at regular intervals (e.g., every week)

for the duration of the study. This would provide crucial information about the dynamic (or perhaps static) nature of change over time depending on how much yoga individuals receive, as well as the differences between different levels of exposure. Patterns of change could range from individuals showing initial resistance to the practice, such that they may change in directions that are opposite of the hypothesized paths; or, to participants showing large change early on and little change as exposure progresses. And, the patterns of change may be different depending on how much yoga participants receive. In order to fully understand the effects of yoga on psychological outcomes future research will need to identify the minimum dose necessary to begin to elicit change, and to track the nature of the change over time.

Third, yoga may have unique acute and sustained effects. By collecting data anywhere from 2-10 days after the last yoga class the current reduced the possibility that observed change was the product of acute effects of that last yoga class, but the current study was unable to evaluate acute vs. sustained impact. Future studies would benefit from gathering data immediately after a yoga practice, as well as several days or a week after that yoga session. Long-term follow-up will also be critical to include in future studies, as there may be a period of incubation before effects are seen.

The current study is one of the first to evaluate the effect of yoga on adolescents, and it is one of the first randomized, controlled trials of yoga for young people. Therefore, it is exploratory in nature and many questions about the effects of yoga remain. The current study has generated substantial knowledge about possible effects of yoga, but it has also raised questions about the applicability of yoga for certain populations and at certain developmental stages. In order to determine what kinds of yoga interventions would be most beneficial for specific populations we will need to begin exploring the differential impact of each yoga component. Kripalu yoga tends to be less aerobic than other traditions, with more time spent focusing on the breath and integrating philosophical discussions into posture instruction. It is possible that, given the developmental changes occurring in mid-adolescence, a more vigorous form of physical activity would be a better fit

for ninth-grade students. In order to deepen our understanding of yoga's effects, future research will need to evaluate how different styles of yoga—with different combinations of postures, meditation practices, and philosophy—differentially affect specific populations and impact specific outcomes.

Conclusion

In sum, the results from the current study are inconclusive. There is some indication that practicing yoga was related to lower levels of negative affect among boys, but in general the results are counter to expectations. Students in the yoga group had lower levels of positive affect, and higher levels of expressive suppression, than students in the control group. Additionally, girls in the yoga group showed larger decreases in self-esteem than girls in the control group. These results are puzzling and suggest that, though there may be some benefit for young people, much more work needs to be done to understand the effects of yoga on adolescents.

CHAPTER V

GENERAL DISCUSSION

Summary of Dissertation and Results

The goal of this dissertation was to evaluate the effects of participation in a school-based yoga program on ninth-grade students' social-emotional and cognitive functioning. The dissertation began with a review article that touched on adolescent development, and described the current state of the research literature on yoga and meditation. The review paper also included brief discussions of research on social-emotional learning programs and exercise, and their effects on children and adolescents. Yoga is comprised of multiple components, some of which correspond with exercise and physical activity and positive development programs, and research findings from these two bodies of literature may help inform future studies of yoga.

Both empirical papers hypothesized that students in the yoga group would report increases in "positive" outcomes and decreases in "negative" outcomes, relative to control students. However, this general hypothesis was not entirely met. Boys in the yoga group did seem to experience some protection from increases in negative affect, but the difference in negative affect between boys in the control group and boys in the yoga group was short-lived and cannot be entirely attributed to condition. Surprisingly, students in the yoga group were not protected from the declines in positive affect that emerge during adolescence (Buchanan et al., 1992), but instead showed decreases in positive affect compared to no significant change among students in the control group. Girls in the yoga group had significantly lower levels of self-esteem than girls in the control group at the end of the school year, but self-esteem decreased significantly between baseline and post-

intervention for girls in both conditions. There was no difference between conditions in use of cognitive reappraisal emotion regulation strategies, but yoga students reported higher levels of expressive suppression than control students during the middle of the school year. There was also no effect of condition on Math performance or self-reported attention problems. Instead, gender effects emerged for both these outcomes, with girls reporting more attention problems at the end of the year than boys, and boys showing a significant increase in Math scores from baseline to post-intervention. Finally, WMC increased from baseline to post-intervention among boys in the yoga group, compared to no significant change in WMC among boys in the control group. WMC improved among girls in both conditions, but this difference was significant only for girls in the control condition. Because WMC did not differ between the groups for either gender at either time point, it is not possible to attribute the change to yoga. However, there is indication that participation in this yoga program was related to a significant improvement in WMC among boys.

In sum, none of the hypotheses were fully supported. The following sections review the limitations and future directions and explore additional explanations for why the hypotheses were not fully supported.

Limitation and Future Directions

Both empirical papers outlined the limitations of the current study and provided suggestions for future directions, and thus will not be discussed in detail here. In sum, the critical issues for yoga research with adolescents concern developmental fit, development of standardized curricula, exploration of dose and acute vs. long-term effects, the use of more objective measures.

First, because yoga is comprised of multiple components—postures, meditation and breathing, and philosophical teachings— and because different styles of yoga include different combinations of these three components, we would benefit from evaluating the impact of different ratios of postures, meditation and breathing, and philosophy. It is possible that particular styles of yoga are more appropriate for one developmental stage, while other styles may be more

appropriate for a different developmental stage. For example, children and adolescents may receive the most benefit from a highly physical practice with fewer meditative and philosophical components, while older adults may benefit from a practice that places less emphasis on physical movement and more emphasis on internal states and awareness. At this point there is little data to support this speculation, but developmental changes in executive function, emotion, and cognition, as well as changes in physical abilities, indicate that benefits of yoga may depend on the developmental fit of the practice.

One of the strengths of yoga is that it can be tailored to fit an individual's needs, and thus can be designed to be developmentally appropriate for any population. However, the wide range of styles and levels make it difficult to conduct yoga research that is replicable and that produces generalizable knowledge. In order to determine which styles of yoga are most appropriate for specific populations, we will need to create standardized curricula that can be used in replication studies with different populations and with different outcomes. In some ways, standardizing a yoga curriculum is counter to the nature of yoga; yoga is a practice that evolves to fit an individual's needs in the current moment. However, even this tenet is not inherent in all traditions; some yoga styles have a more rigid curriculum, with less room for individual modification. One of the main weaknesses of yoga research is that there are so many different styles, and that there has been no consistency among researchers in the kinds of yoga they evaluate. Research studies of yoga range from evaluations of Iyengar (alignment based, with less emphasis on meditation and philosophical teachings) to Kundalini (mediation and breath focused, with less emphasis on physical alignment) to Vinyasa/flow (aerobic, flowing classes, with more emphasis on breath and movement and less emphasis on alignment in postures). There has been no consensus among researchers about which kind of yoga to evaluate, and this has limited the potential of yoga research. Overcoming this limitation will require developing and evaluating several standardized curricula, and providing more detailed descriptions of the yoga interventions being studied.

Once there is more consistency in the kinds of yoga interventions being evaluated, researchers will be able to examine issues of dose and recency. There is some indication that changes in psychological outcomes may be observed after as little as 20 minutes of yoga (Field et al., 2010), but given the significant differences between the yoga intervention in this study (physical postures only, combined with tai chi) and most other styles of yoga, it is difficult to make any claims about dose. There is also little information about the sustained and long-term effects of yoga.

Additional Explanations

Expectancies and Values about Yoga

Perceptions and attitudes about yoga that existed before the intervention began may have influenced the value students placed on participating in yoga and their expected outcome (Eccles, 1983). Students' expectations for "success" (e.g., doing the yoga posture) and the value they place on achieving that "success" are shaped by their past experiences of yoga, and their past ideas and attitudes about it. The expectancy-value theory of achievement (Eccles, 1983) may help future researchers conceptualize the complex nature of attitudes and beliefs about yoga, and how these expectancies and values influence individuals' experiences of doing yoga. Stereotypes and negative perceptions of yoga may have influenced the value students placed on yoga, which may have influenced the outcome of participating in the program. Future research will benefit from gathering information about participants' pre-intervention attitudes and beliefs about yoga.

Similarly, an awareness of the study hypotheses may have introduced the possibility of demand characteristics. Though most of the results did not support the study hypotheses, it is possible that students were responding to the surveys in ways that were either consistent or inconsistent with what they thought the expected results should be. Surveys were administered in gym class, and students were aware of the fact that the study was being conducted to compare the yoga and control groups. Future studies would benefit from gathering data in a setting where the difference between groups, and the purpose of the survey, was not obvious.

Future studies may also want to consider blinding the survey administrator to students' conditions, to reduce the likelihood of experimenter bias.

Expectancies and Values about PE Class

On a similar note, students generally have a set of expectations for PE class. They may think of PE class as time to be active and social, a time to release excess energy, or a time where they have fewer restrictions over their behavior. The yoga intervention evaluated in this dissertation did not fit most of these speculated expectations. Students in the yoga group did physical postures, but the practice was moderate in intensity. Additionally, students were not allowed to be as social as they are in standard PE classes, and the nature of the yoga class was such that students may not have had much freedom to do something other than what the teacher was leading. Students in the yoga group may have expected one thing from PE class and gotten something completely different, and this discrepancy could have led to disappointment and lack of engagement in the yoga program.

Several students told me that PE was their favorite class. Requiring all students to participate in yoga, particularly during a favorite class, may not elicit the hypothesized positive changes in social-emotional and cognitive outcomes. Students may respond differently to a yoga program that meets during a study hour, or after school. It is also highly likely that students would react differently to yoga class if it met during their least favorite subject. Teachers and administrators will need to think carefully about the best way to introduce a school-based yoga program.

Schools and Stage-Environment Fit

As young people mature they develop needs for greater autonomy and decision-making opportunities (Eccles et al., 1989). The current study did not gather active consent, and did not directly ask students if they would like to participate in the yoga intervention. This lack of choice is counter to adolescents' desires for autonomy and control and, in combination with possible unmet expectations for PE class, may have influenced students' attitudes about yoga, which

in turn may influenced their engagement in the program and the overall results. Additionally, the timing of the intervention may have influenced the results. The transition from middle school to high school can be challenging for many adolescents, and it is possible that environmental factors related to this change were profound enough to limit the effectiveness of the yoga intervention.

Beginning with the transition between elementary school and middle school, students move from an environment that provides substantial support environments with significantly less support. The transition from elementary to middle school moves children into a school setting that encourages competition and self-comparison, reduces the opportunity to develop meaningful student-teacher relationship, and decreases individuals' opportunities for decision-making and choice (Eccles et al., 1991). The transition into this environment coincides with a developmental shift towards heightened self-focus and self-awareness, and increased need for autonomy and decision-making (Eccles et al., 1991). The mismatch between the environmental setting and the needs of young people at this developmental stage have been linked to declines in self-concept and achievement-related motive, beliefs, values, and behaviors (Eccles & Midgley, 1989; Eccles et al., 1993). This incongruence between adolescents' needs and their environmental surroundings continues as they transition into high school. High schools tend to be larger and more bureaucratic than middle schools, and offer students even less individual support and fewer opportunities for meaningful engagement and decision-making (Eccles & Roeser, 2003). Many students who began the decline towards academic disengagement in middle-school may experience heightened alienation in high school (Eccles & Roeser, 2009).

It is possible that some of the outcomes were not responsive to participation in the yoga program because of the difficult nature of transitioning to high school. Future research would benefit from exploring the impact of yoga interventions in different school environments. For example, exposing students to a yoga intervention in eighth grade could result in greater change in outcomes, and also give young people tools they can draw upon during the transition to high school.

Final Thoughts

Yoga has the potential to create positive change in individuals' lives, and millions of yoga practitioners have provided anecdotal reports of improvements in physical health and psychological well-being. However, the state of research on yoga is such that we are unable to fully support these anecdotes with empirical results. The current study attempted to resolve some of the limitations that plague yoga research by implementing a randomized, controlled trial of a well-documented yoga intervention for adolescents. Although the results presented in this dissertation did not fully support the hypotheses, we should not conclude that yoga is ineffective at promoting positive change. Conversely, yoga practice was marginally related to improvements in working memory capacity and reduced negative affect among boys. The studies in this dissertation shed light on issues that will be important to consider in future research studies of yoga, including questions of developmental fit and the appropriate ratio of postures, meditation, and philosophy for different populations. There are many different kinds of yoga and many different outcomes of practicing. One yoga does not fit all, and until we understand the unique effects of different styles of yoga we will be limited in our ability to design successful yoga interventions for all populations at all developmental stages. The results presented in this dissertation present important information about the effects of a Kripalu yoga intervention for ninth-grade students, and illustrate the need for continued exploration of yoga's effects on different populations and at different ages. Future research can use this information to design studies that will deepen our understanding of yoga's potential for positive transformation.