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ORIGINAL PAPER

Enhancing Preschoolers' Self-Regulation Via Mindful Yoga

Rachel A. Razza · Dessa Bergen-Cico · Kimberly Raymond

Abstract This study evaluated the effectiveness of a mindfulness-based yoga intervention in promoting self-regulation among preschool children (3–5 years old). Twenty-nine children (16 intervention and 13 control) participated in the yearlong study that used a quasi experimental pretest/posttest treatment and control design. The mindful yoga intervention was implemented regularly by the classroom teacher for the treatment group. Treatment and control participants completed evaluations that assessed multiple indices of children's self-regulation (i.e., attention, delay of gratification and inhibitory control) using a combination of parent report and direct assessments. Results from the direct assessments indicated significant effects of the intervention across all three indices of self-regulation. There was also some evidence that the children who were most at risk of self-regulation dysfunction benefited the most from the intervention. Implications of this study for current practice in early childhood education are discussed along with possibilities for future research in this area.

Keywords Mindfulness · Yoga · Self-regulation · Executive function · Effortful control

R. A. Razza (✉) · K. Raymond
Department of Child and Family Studies, Syracuse University, 426 Ostrom Avenue, Syracuse, NY 13244, USA
e-mail: rrazza@syr.edu

D. Bergen-Cico
Department of Public Health, Syracuse University, 426 Ostrom Avenue, Syracuse, NY 13244, USA

Introduction

Self-regulation is considered a critical component of school readiness (Blair 2002; Raver 2004), as these skills facilitate peer acceptance and social success, as well as academic performance in early elementary school (Blair and Razza 2007; Ladd et al. 1999; McClelland et al. 2000). There is also substantial evidence that early self-regulatory skills are predictive of children's successful adjustment in the longer term, as higher levels of regulation have been linked with positive developmental outcomes including greater self-esteem, professional attainment, and better health in later childhood and adolescence (Moffitt et al. 2011; Shoda et al. 1990). Conversely, poor self-regulation has been associated with a host of negative outcomes including attention deficit hyperactivity disorder (ADHD), school failure, addiction/substance abuse, and anxiety and depression (Diamond 2005; Hester and Garavan 2004; Ivanov et al. 2008; Kyte et al. 2005; Moffitt et al. 2011). Thus, there has been increasing interest in intervention and prevention strategies targeting self-regulation during early childhood when children are acquiring these foundational skills (Blair 2002; Higgins and Spiegel 2004).

Two key components of self-regulation that undergo substantial growth during the preschool years are effortful control (EC) and executive function (EF; Best et al. 2009; Kochanska et al. 2001; Li-Grinning 2007). A developmental model of self-regulation highlights the reciprocal association between these two constructs during early childhood (Blair and Dennis 2010) and underscores the value of interventions that target processes common to both facets, such as attention and inhibition. One such approach is mindfulness-based practice, including meditation and yoga, as these activities share a common goal of promoting

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focused attention, as well as other facets of EC and EF (Tang et al. 2012; Zelazo and Lyons 2012).

Mindfulness-based interventions have been demonstrated to be effective in promoting self-regulatory skills and mental health among adults and are thought to be feasible among children and adolescents (Greenberg and Harris 2012). Although this approach has been increasingly adapted for children and adolescents, literature reviews of programs targeting youth illustrate the poor evaluative quality of existing studies, such as the lack of randomized control trials, and highlight the need for replication in Western societies (Birdee et al. 2009; Black et al. 2008; Burke 2009; Galantino et al. 2008). Results from more recent, rigorously evaluated school-based interventions suggest that mindfulness-based practice can be effective in enhancing self-regulation among children (Flook et al. 2010; Schonert-Reichl and Stewart Lawlor 2010). However, these programs and studies target older elementary-aged children and included a restricted set of outcome measures. Thus, the goal of the proposed study was to pilot a mindfulness-based intervention for use with children ages 3–5 years and evaluate its effectiveness using a combination of parent report and direct child assessments tapping attention and related facets of EC and EF. Such research can help elucidate the mechanisms underlying the link between mindfulness and self-regulation and provide a better understanding of how contemplative practices work in young children.

Self-regulation refers to the process of modulating systems of emotion, attention and behavior in response to a given contextual situation, stimulus or demand (Posner and Rothbart 2000; Calkins and Fox 2002). It is understood as an umbrella term that encompasses a wide range of subskills, many of which are necessary for handling socially relevant tasks and goal-directed activity. One key facet of self-regulation that emerged from temperament research is effortful control (EC), which is defined as the ability to withhold a dominant response in order to carry out a subdominant or less salient response (Rothbart and Bates 2006). For example, a child exhibits EC when she suppresses her urge to immediately peek at a surprise gift (the dominant response) and waits for the reward until an adult grants permission to do so (the subdominant response). Put simply, EC is the self-regulatory aspect of early childhood temperament that allows children to control reactivity or emotionality (Rothbart and Bates 2006); it is considered a key facet or correlate of children's emotion regulation (Eisenberg et al. 2004; Raver 2004). Studies further show that EC in early childhood has significant implications for later moral development (Kochanska et al. 1996, 1997), personality development (Rothbart and Ahadi 1994; Rothbart and Bates 2006), and academic competence (Blair and Razza 2007; Fabes et al. 2003).

Another prominent aspect of self-regulation that emerged from the neural systems approach is executive function (EF). EF refers to the interrelated higher-order cognitive processes, including working memory, inhibitory control, and attention flexibility, that underlie goal-directed activity (Garon et al. 2008; Welsh et al. 1991). Collectively, these processes allow individuals to intentionally hold information in mind and resolve conflict between stimulus representations and response options (Blair and Ursache 2011; Diamond 2013). Thus, similar to EC, EF enables children to inhibit natural response tendencies in order to comply with the demands of the environment. For example, in the popular "peg tapping" game, a child exhibits EF when he is asked to tap a wooden dowel one time after an adult taps it twice and to tap it twice after an adult taps is once. Given that the ability to monitor and control thought and action are inherent to adaptive behavior, it is not surprising that substantial research supports EF as a predictor of both academic achievement (Best et al. 2011; Blair and Razza 2007; McClelland et al. 2007) and socioemotional competence (Best et al. 2009; Calkins and Marcovitch 2010; Riggs et al. 2006b) across childhood.

EC and EF are conceptualized as related, yet distinct, constructs in recent integrated models of self-regulation (Blair and Dennis 2010; Blair and Ursache 2011; Calkins and Marcovitch 2010). On the one hand, both processes are involved in most problem-solving situations and are thought to share a common component (i.e., inhibition) and a common process (i.e., attention; Zhou et al. 2012). However, while EC is thought to draw on quick emotional processing and reflexive reactions to emotion-laden stimuli (i.e., bottom-up processing that reflects an emotional, *hot* system of self-regulation), EF focuses primarily on volitional control of cognitive processes in response to emotionally neutral stimuli (i.e., top-down processing that reflects a cognitive, *cool* system; see Zhou et al. 2012). This theoretical distinction between EC and EF is supported by neuroscience research, which indicates that these processes are functionally related to different areas of the brain that coordinate emotional and cognitive processing, respectively (Bush et al. 2000). There is also growing evidence that EC and EF have unique behavioral corollaries, as these facets of self-regulation are differentially associated with both socioemotional (Hongwanishkul et al. 2005) and academic outcomes (Blair and Razza 2007; Brock et al. 2009). Thus, it may be best to view EC and EF as independent, yet complimentary, approaches to promoting children's self-regulation.

Given the great importance of self-regulation for children's school readiness and success (Blair 2002; Eisenberg et al. 2004; Raver 2012), these skills have become an increasingly popular target for early intervention (see Diamond 2012; Diamond and Lee 2011). For example,

some studies focus on promoting a specific aspect of EF or EC, such as working memory (Bergman Nutley et al. 2011) or attention (Rueda et al. 2005), via direct skills training. Although successful, one limitation of these programs is that they are computer-based and thus are not likely to be replicable outside the lab or self-sustained. It is also unclear whether the benefits of these trainings are transferable, as some interventions are good at increasing the specific EF skill they target (i.e., inhibition), but the benefits do not generalize to other unpracticed EFs (i.e., attention; Thorell et al. 2009).

In contrast, approaches that address self-regulation more globally, such as school curricula, are associated with wider transfer effects. For example, *Tools of the Mind* (Bodrova and Leong 2007), a packaged curriculum that targets self-regulation via teacher-directed exercises designed to support children's social pretend play, has been shown to increase inhibitory control and attention flexibility among at-risk preschoolers (Diamond et al. 2007). Likewise, add-on interventions that coach teachers on behavior management strategies; such as the Chicago School Readiness Project (CSRP; Raver et al. 2011) or focus on social-emotional learning as with the Head Start REDI project (Bierman et al. 2008) and PATHS; (Riggs et al. 2006a) within Head Start preschools and elementary schools, have been successful in promoting attention, inhibitory control, and mental flexibility. Given that these are classroom-based curricula, however, a concern is whether the benefits will be sustainable once children enter elementary schools where these supports may not exist (Raver et al. 2011). Thus, the field is in need of novel intervention strategies that equip young children with self-regulatory practices that they can integrate into their daily life. One area that proves fruitful for future efforts is mindfulness training, including meditation and yoga exercises (see Diamond 2013; Zelazo and Lyons 2012).

Mindfulness is defined as "the awareness that emerges through paying attention on purpose, in the present moment, and non-judgmentally to the unfolding of experience" (Kabat-Zinn 2003, p. 145). There are many forms of mindfulness-based practice, but common approaches include static (sitting) meditative practices and mindful movement (yoga), both of which aim to combat stress by strengthening attention and emotion-regulation skills (Greenberg and Harris 2012). Given the effectiveness of mindfulness-based interventions in promoting psychological health and well-being among adults (Greeson 2009; Baer 2003), these programs are increasingly being adapted for at-risk children and adolescents. The results of existing programs using mindfulness and meditation (Black et al. 2008; Burke 2009; Harnett and Dawe 2012) and yoga (Birdee et al. 2009; Galantino et al. 2008) with younger populations have been summarized in recent reviews. Although various programs report success in enhancing children's attention and behavioral competence (Biegel et al. 2009; Napoli et al. 2005; Semple et al. 2009), the reviews highlight the limited quality of existing evidence (e.g., small samples, few randomized control trials) and conclude that while such programs are feasible, large, well-designed studies are necessary to further the field. It should also be noted that yoga-based interventions were predominantly conducted in India where the practice is more normative and thus require replication in Western cultures (Greenberg and Harris 2012).

Albeit few in number, the results of recent, more rigorously evaluated school-based mindfulness interventions (with yoga components) in the United States are promising. For example, a 12-week program significantly reduced the negative effect of stress on urban youth (4th and 5th grade) by enhancing their self-regulatory skills (Mendelson et al. 2010) and an 8-week program increased EF skills among 2nd and 3rd graders (Flook et al. 2010). Moreover, pilot data from the Mindful Schools program suggests that a 5-week program promoted executive attention and social skills among 2nd and 3rd graders (Biegel and Brown 2012). Thus, it is clear that mindfulness-based practices can enhance children's self-regulation. What is less clear, however, is whether such practices can be adapted for younger children (e.g., 3–5 years). Self-regulatory skills demonstrate considerable growth during the preschool years (Blair 2002; Diamond 2013), and thus efforts to support their development during this stage are critical for promoting school readiness. Results from the one known preschool intervention are promising, as teachers reported higher EF skills among participants at post-test (Flook et al. 2008), however, replication is needed. Thus, the present study builds on this limited research to examine the effectiveness of a classroom-based mindful yoga intervention among preschoolers.

The purpose of this study was to determine the feasibility and evaluate the effectiveness of a mindfulness-based yoga intervention among preschool-age children. The quasi-experiment was designed to document the extent to which structured yoga activities, integrated into existing academic curriculum, could improve self-regulation among 3-to 5-year-old children. In particular, we were interested in documenting the specific facets of self-regulation that would be influenced by the intervention. Although previous mindfulness-based programs have been successful in promoting attention, EC, and EF across independent studies (Biegel and Brown 2012; Flook et al. 2010; Napoli et al. 2005), this is the first study to examine all three outcomes simultaneously. Given that the potential for growth within each of these self-regulatory skills is high between ages 3 and 5 years, we hypothesized that the intervention would significantly impact all three facets within the preschool population.

We were also interested in determining whether the intervention differentially influenced children based on their initial level of self-regulation. Extant literature suggests that the children who were most at risk for self-regulatory problems (i.e., those with the lowest baseline scores) also were the ones who benefitted the most from the intervention (Bierman et al. 2008; Tominey and McClelland 2011). Although less researched, it appears that this trend extends to mindfulness-based programs as well (Biegel and Brown 2012; Flook et al. 2010). Thus, we examined initial self-regulation as a moderator of the effectiveness of the intervention, with the expectation that children with poor self-regulation would benefit the most from participating in the mindfulness-based intervention.

Method

Participants

The baseline sample consisted of 34 children (18 intervention and 16 control) from two preschool classrooms within the same urban public elementary school in Syracuse, NY. Both classrooms were full-day universal prekindergarten programs, which were free to local residents and filled using a lottery system. Due to space constraints within the building, the two classes shared a room, which was divided in half using a wall of tall bookcases. The investigators invited the families of all children in both classrooms to participate in the study. The preschool teachers reviewed the recruitment packet, which included the parental consent form and parent survey, with the parents during the orientation meeting at the beginning of the school year. The response rate was 97 %, with only one refusal (control group child).

Design and Procedures

This quasi-experiment utilized a pretest–posttest design with a non-equivalent group. Specifically, children were not randomly assigned to intervention and control conditions, but rather one teacher and her children served as the intervention classroom while the other teacher and her children served as the comparable control classroom. The mindful yoga program was a modified version of the standardized YogaKids (Wenig 2003) curriculum that was implemented daily by the intervention preschool teacher, who had completed a 200-h certification training through YogaKids. The control teacher did not have a background in mindfulness or yoga and did not incorporate these practices into her daily routine. The intervention teacher kept a daily log of her mindful yoga activities, which included descriptions of the activity, the time of day they occurred, and the length of time. In total, the children in the intervention classroom received approximately 40 h of mindful yoga across 25 weeks. The average length of time increased gradually across the school year, from 10 min per day in the fall to 30 min per day in the spring. The daily practice included breathing and sun salutations during morning circle, yoga postures linked to literacy activities in the afternoon, and breathing exercises during transition periods. Thus, the practice was incorporated into the curriculum and used across the school day in the intervention classroom. Example breathing activities included "Take-5," in which the child inhales for the count of 5 as he/she raises each finger and then exhales for 5 as each finger is closed and "Peace Breath" in which children breath in and whisper the word "peace" on the exhale. Animal poses (e.g., cat, cow, downward dog) and nature poses (e.g., mountain, tree, moon) were the most common types of asanas, as they are relatively simple and are enjoyed by young children.

Measures

The evaluation component utilized a pretest/posttest design in which parents and children completed matched participant outcome assessments both at the beginning of the school year (late September) and again at the end of school year (late May). Parents rated children's self-regulatory behavior using a questionnaire that was sent home from school with the child and was returned to the classroom teacher. Children's self-regulation was directly assessed via a battery of tasks tapping EC (2 tasks), EF (2 tasks), and attention (1 task). The assessments were conducted individually in a coatroom connected to the control classroom. The pretest assessments were collected by both of the study co-investigators. In an effort to minimize experimenter bias, however, all posttest assessments were administered by a trained graduate research assistant. Tasks were administered in a fixed order to maximize interest and minimize bias related to variation in task administration, as is common in individual difference designs (Carlson et al. 2004; Clark et al. 2013). The self-regulation battery took approximately 20 min to complete and children received stickers after each session. In addition, families received a small gift after the posttest session in appreciation of their continued participation. The measures are described in more detail below and summarized in Table 1.

Children's Behavior Questionnaire

Parents reported on children's self-regulation via the short form of the Children's Behavior Questionnaire (CBQ; Putnam and Rothbart 2006). Specifically, parents rated how true or not a particular behavior was of their child on a

Table 1 List of constructs, measures, scores, and method

Construct	Measure and description	Score	Method
Effortful control	CBQ measure of attentional focus and inhibitory control	Subscale averages (1–7)	Parent report
	Toy wrap measure of delay of gratification	Latency to first peek (0–60)	Direct assessment
	Toy wait measure of delay of gratification	Latency to first touch (0–60)	Direct assessment
Executive function	Pencil-tapping measure of inhibitory control	Proportion of correct responses (0–1)	Direct assessment
	HSKT measure of behavioral regulation	Summary across 8 practice and 20 test trials (0–52)	Direct assessment
Attention	Leiter drawing task of sustained attention	Scaled total correct and total error scores ($M = 10$, SD = 3)	Direct assessment

CBQ Children's Behavior Questionnaire, *HSKT* head shoulder knees and toes. All measures were assessed at pretest and posttest with the exception of HSKT, which was only collected at posttest

7-point Likert scale ranging from extremely untrue (1) to extremely true (7). The following two subscales were used: Attentional Focusing (6 items; e.g., "when practicing an activity, has a hard time keeping her/his mind on it," and Inhibitory Control (6 items; e.g., "can wait before entering into new activities if s/he is asked to." Items were averaged to create summary scores with higher values representing more adaptive functioning.

Toy Wrap

For the toy wrap task (Murray and Kochanska 2002), the interviewer informed the child that he/she had a surprise for him/her, but needed to wrap it first. The child was positioned so that he/she was facing away from the interviewer (the chair was at a 90° angle facing away from the table), and was asked not to peek while the interviewer noisily pretended to wrap the surprise (i.e., crinkled and shook paper). After 60 s, the child was presented with a previously wrapped toy to play with. The interviewer recorded the latency to peek (the number of seconds that elapsed before peeking; 0–60 s).

Toy Wait

For the toy wait task (Murray and Kochanska 2002), the interviewer presented the child with the wrapped toy from the Toy Wrap task and the child was directed to wait without touching it while the interviewer pretended to be busy with something else (e.g., cleaning up the wrapping paper, completing paperwork). The interviewer recorded the latency to touch the wrapped toy (the number of seconds that elapsed before touching; 0–60 s).

Pencil-Tapping Task

The pencil-tapping task (Diamond and Taylor 1996) requires children to inhibit a natural response, which is to imitate the interviewer's tapping pattern, and thus is a measure of inhibitory control. For this task, children were presented with a wooden pencil and instructed to tap twice on the table when the interviewer tapped once (Rule 1), and to tap once when the interviewer tapped twice (Rule 2). After a series of practice trials (up to four), children who were able to get both rules correct were administered a series of 16 trials presented in a fixed pseudorandom order (8 one-tap and 8 two-tap trials). A proportion score reflecting the number of correct responses divided by the total number of trials was used in analyses.

Head Shoulders Knees and Toes (HSKT)

The HSKT task (Ponitz et al. 2009) assesses children's behavioral regulation using a structured observation in which children are required to perform the opposite of a dominant response (i.e., touch their heads when the interviewer said "touch your toes") to four different oral commands corresponding to four parts of the body (i.e., head, shoulders, knees, and toes). Although this measure taps working memory and flexible shifting, it is primarily considered an assessment of inhibitory control. There were two phases of this task, each with 4 practice trails and 10 test trials. For each trial, the child received a score of 0 (incorrect), 1 (self-correct), or 2 (correct). Scores were summed across practice and test trials (range 0–52). This task was only administered at posttest.

Drawing Task

Children's sustained attention was assessed using the Attention Sustained task from the Leiter International Performance Scale-Revised (Roid and Miller 1997). Children were shown a picture of a variety of objects scattered throughout the page. There was a target object at the top of the page and children were asked to put a line through as many of the objects matching the target as possible without

accidentally crossing out any other objects. Children's performance across four timed trials was averaged to yield two attention scores. The number of correct responses (cross-outs of objects matching the target) reflected the child's *focused attention*, while the number of incorrect responses (cross-outs of objects not matching the target) was reverse coded to represent the child's *lack of attentional impulsivity*. Both scores were standardized against a national norming sample ($M = 10$, SD = 3). The task has high internal reliability ($\alpha = 0.83$) for young children and good test–retest reliability (r = 0.85).

Results

Descriptive Statistics of the Analytic Sample

Of the 34 families recruited, 32 completed the child assessment at pre-test (fall); one intervention child refused to participate and the one control child entered the classroom after the baseline assessment. An additional three children (1 intervention and 2 control) moved out of the area by post-test (spring) and thus were lost due to attrition. The final analytic sample consisted of 29 children (16 intervention and 13 control). The sample was ethnically diverse (52 % Caucasian, 34 % African American, 7 % Hispanic, and 7 % other) and included 11 girls and 18 boys. The average age at the beginning of the study was 51.1 months (SD = 3.8; range 46–57 months). The majority of parent respondents were mothers (69 %), but fathers (24 %) and other female relatives (7 %) also participated. Parents were well educated (60 % had a Masters or professional degree) and the majority of families were married (66 %) or cohabiting (7 %) with an average child:adult ratio of 1.6 (SD = 1.1; range 0.3–6.0). The means and standard deviations for demographic and outcome variables for both the full sample and by treatment group are presented in Table 2. Differences between the intervention and control group with respect to child and family characteristics were explored using independent sample *t* tests. Although there was variation between groups, these differences were not significant; the exception was some college education ($t = -2.10$, $p = .05$), which was higher among intervention families.

Missing Data

Preliminary analyses of the measures revealed limited missing data due to incomplete administration on the HSKT and drawing tasks (e.g., the child refused to complete the task, the child did not follow the directions, or the session was interrupted). Specifically, three children were missing the drawing task at pretest, one was missing the drawing task at posttest, and two were missing the HSKT at posttest. In addition, two parents did not return the Child Behavior Questionnaire at posttest. These cases were excluded from the focal analyses only for the problematic measure and thus the sample size differed slightly across outcomes (see Table 2). In addition, factor analysis supported composite scores for EC and EF tasks at pretest (results not shown), but ceiling effects (i.e., toy wait) precluded the use of composites at posttest. Based on the nature of the complete pre and posttest data set, outcomes measures were examined independently in the focal analyses. Zero-order correlations across the measures for the full sample are reported in Table 3.

Intervention Effect

There were few differences between the intervention and control groups on children's fall pretest scores for the self-regulation measures (Table 2). The exception was focused attention ($t = -2.94$, $p < .01$), which was higher among intervention children. Significant advantages favoring the intervention children were evident at posttest for pencil-tapping ($t = -2.55$, $p < .05$), HSKT ($t = -2.62$, $p < .05$), and lack of attentional impulsivity ($t = -2.19$, $p < .05$). There was also a trend for the gift wait task ($t = -1.95$, $p < .10$), as all of the intervention children were able to delay touching the present for the full 60 s.

The direct effect of the intervention on each of the outcome measures was examined using multiple regression analyses. First, we examined change in self-regulation for children based on group assignment via models that included the intervention status variable and the pretest score (a covariate) for the respective outcome. Given that the HSKT task was only collected at posttest, children's pretest pencil-tapping score served as the covariate for this outcome. Next, we added the interaction between theses two variables to determine whether children's initial score moderated the effect of the intervention. The final models, displayed in Table 4, only include the interaction term if it was significant. Partial eta-squared (η^2) represents the proportion of the variance in the dependent variable that is accounted for by the independent variable after the variance associated with other covariates is partialled out. Thus, we included it as an estimate of the effect size, as is common practice in educational research (Richardson 2011). Results did not differ when parental education, the only demographic variable the differed significantly between the two groups at pretest, was included as a covariate and therefore it was omitted from final models. Thus, the effects of the intervention did not appear to be related to differences in parental education between the groups.

The results from our first series of regression models, which examined the main effects of the intervention on the outcomes, indicated a significant effect of the intervention

Table 2 Descriptive statistics for the full samples and by intervention and control groups

	Full sample ($n = 29$)	Intervention group ($n = 16$)	Control group ($n = 13$)	t test
Posttest self-regulation in spring				
CBQ attentional focusing	5.23 (0.99)	5.31 (1.08)	5.13 (0.92)	
CBQ inhibitory control	4.86 (0.99)	4.99 (0.96)	4.73 (1.04)	
Toy wrap	48.69 (15.47)	46.44 (15.22)	51.46 (15.93)	
Toy wait	55.83 (13.40)	60.00 (0.00)	50.69 (19.15)	-1.95^{+}
Pencil-tap	0.73 (0.29)	0.85 (0.20)	0.59 (0.34)	−2.55*
HSKT	32.63 (13.85)	38.71 (11.90)	26.08 (13.14)	−2.62*
Focused attention	11.66 (2.57)	12.19 (2.81)	11.00 (2.16)	
Lack of attentional impulsivity	10.04 (1.93)	10.73 (2.28)	9.23 (1.01)	−2.19*
Pretest self-regulation in fall				
CBQ attentional focusing	3.43 (0.93)	3.65 (0.90)	3.17 (0.93)	
CBQ inhibitory control	4.90 (0.91)	4.91 (0.97)	4.89 (0.87)	
Toy wrap	49.22 (19.67)	44.96 (24.64)	54.46 (9.49)	
Toy wait	53.85 (15.48)	54.86 (15.09)	52.62 (16.48)	
Pencil-tap	0.52 (0.36)	0.57 (0.33)	0.45 (0.39)	
Focused attention	10.33 (3.00)	11.67 (2.38)	8.67 (2.93)	−2.94**
Lack of attentional impulsivity	10.37 (2.19)	10.67 (2.44)	10.00 (1.86)	
Family Characteristics				
Child age in months (fall)	51.21 (3.29)	51.56 (2.97)	50.77 (3.72)	
Girl	0.41 (0.50)	0.44 (0.51)	0.38 (0.51)	
Child race/ethnicity (white)	0.52 (0.51)	0.63 (0.50)	0.38 (0.51)	
Child race/ethnicity (black)	0.38 (0.49)	0.25 (0.45)	0.54 (0.52)	
Child race/ethnicity (other)	0.10 (0.31)	0.13 (0.34)	0.08 (0.28)	
Single-parent families	0.31 (0.47)	0.25 (0.45)	0.38 (0.51)	
Child:adult ratio	1.58 (1.08)	1.50 (0.66)	1.67 (1.47)	
Parent some college education	0.72 (0.46)	0.88 (0.34)	0.54 (0.52)	−2.10*

Values are means with standard deviations in parentheses. *CBQ* Children's Behavior Questionnaire, *HSKT* head shoulders knees and toes. All measures were assessed at pretest and posttest with the exception of HSKT, which was only collected at posttest

$^{+}$ $p < .10$, * $p < .05$, ** $p < .01$

Table 3 Zero-order correlations across measures of self-regulation for the full sample

Measures	CBQ-AF	CBQ-IC	Toy wrap	Toy wait	Pencil-tap	HSKT	FA	LAI
CBQ-AF	**0.59**	**0.49**	0.25	0.28	0.21	–	0.19	0.06
CBQ-IC	**0.62**	**0.68**	**0.43**	0.18	0.09	–	0.03	0.06
Toy wrap	0.01	0.18	0.13	**0.40**	0.16	–	0.07	0.00
Toy wait	−0.27	0.03	0.06	−0.07	0.20	–	0.08	0.13
Pencil-tap	**0.55**	**0.53**	0.16	0.29	**0.77**	–	0.33	−0.05
HSKT	**0.41**	0.37	0.10	0.15	**0.71**	–	–	–
FA	**0.63**	0.23	−0.11	−0.08	**0.51**	0.30	0.35	−0.11
LAI	0.03	−0.08	0.13	0.11	0.21	0.20	−0.01	**0.46**
n	27	27	29	29	28	27	27	27

Values above the diagonal reflect correlations at pretest. Values below the diagonal reflect correlations at posttest. Values on the diagonal reflect the correlation between the pretest and posttest scores for a given assessment. Bold values are significant at the $p < .05$ level. *CBQ* Children's Behavior Questionnaire, *HSKT* head shoulders knees and toes, *FA* focused attention (drawing task), *LAI* lack of attentional impulsivity (drawing task)

on the pencil-tapping task ($\beta = 0.28$, $t = 2.39$, partial $\eta^2 = 0.19$, $p < .05$) and lack of attentional impulsivity drawing subtask ($\beta = 0.48$, $t = 2.56$, partial $\eta^2 = 0.22$, $p < .05$). Specifically, children in the intervention demonstrated significant improvements in inhibitory control over time and maintained average levels of focused attention compared to control children who demonstrated declines in attention over time. The partial eta squared terms indicate that treatment group status accounted for 19 and 22 % of the variance in these measures of inhibitory

Table 4 Mindful yoga intervention effects on children's self-regulation

	Main effect of intervention				Interaction term			
	β	B	SE	Partial η^2	β	B	SE	Partial η^2
Effortful control								
Attentional focusing (CBQ)	−0.03	−0.06	0.31	0.00				
Inhibitory control (CBQ)	0.18	0.34	0.27	0.06				
Toy wrap	2.10*[a]	64.08	24.07	0.22	−2.37**	−1.26	0.45	0.25
Toy wait	0.36$^+$	9.50	4.85	0.13				
Executive function								
Pencil-tap	0.63*[a]	0.36	0.11	0.32	−0.52*	−0.39	0.17	0.18
HSKT	0.33$^+$	6.44	3.44	0.14				
Attention								
Focused attention	0.18	0.88	1.08	0.03				
Lack of attentional impulsivity	0.48*	1.83	0.71	0.22				

Values are means with standard deviations in parentheses. *CBQ* Children's Behavior Questionnaire, *HSKT* head shoulders knees and toes

$^+$ $p < .10$, * $p < .05$, ** $p < .01$

[a] These values correspond to the final models including the interaction term

control and attention, respectively. Trends were also supported for the toy wait task ($\beta = 0.36$, $t = 1.96$, partial $\eta^2 = 0.13$, $p = .06$), and HSKT ($\beta = 0.33$, $t = 1.87$, partial $\eta^2 = 0.14$, $p = .07$), indicating superior performance in the intervention group over time. Similarly, the partial eta squared terms indicate that treatment group status accounted for 13 and 14 % of the variance in these measures of delay of gratification and EF, respectively. The models did not support significant main effects across the other tasks (all p's $> .10$), suggesting that there were no overall differences between the two groups as a result of the intervention for the parent-reported measures of EC or direct assessments including the toy wrap and focused attention drawing (Leiter) subtask.

The next series of regressions, which tested children's initial score as a moderator of the treatment effect, indicated significant interactions for the toy wrap and pencil-tapping. In both cases, the interaction term was significant and had the opposite sign as the main effect of the intervention (see Table 4). This pattern indicates that the intervention was most effective in promoting self-regulation for children with lower levels of initial competence on these tasks. Specifically, for children with poor delay of gratification (toy wrap task; $F(3, 25) = 3.63$, $p < .05$, $\Delta R^2 = 0.22$) and inhibitory control (pencil-tapping task; $F(3, 24) = 21.53$, $p < .01$, $\Delta R^2 = 0.05$) in the fall, participation in the intervention significantly predicted gains in these skills over the school year. The partial eta squared for the interaction terms indicate that treatment group status accounted for 25 and 18 % of the variance in these measures of delay of gratification and inhibitory control, respectively. Children's posttest scores on these measures are displayed as a function of their pretest scores in Figs. 1 and 2. Interaction terms were not significant for the other tasks (results not shown), suggesting that the intervention did not differentially impact other facets of EC and EF based on children's initial scores on these skills.

Discussion

The present study examined the feasibility and effectiveness of a mindful yoga intervention in enhancing preschooler's self-regulation. These practices were integrated into the class routine at the beginning of the day (e.g., after children arrive and sit in circle time) and during transition points (e.g., before or after lunch or recess), as these are noted as opportune times for practice (Hooker and Fodor 2008). The evaluation assessed attention and related facets of EC and EF using a combination of parent report and direct child assessments. This comprehensive battery allowed us to document the extent to which mindfulness impacted particular aspects of self-regulation, which was our primary research question. Results indicated that the intervention was successful in promoting EC, EF, and attention across all children in the treatment group. In particular, children in the intervention group demonstrated significant advantages in terms of their abilities to delay gratification and inhibit both behavior and attention. These effects, however, were limited to direct assessments of these skills and did not generalize to parent-reported behavior. There was also partial support for initial self-regulation as a moderator of the effectiveness of the intervention, which was a secondary aim of the study. Specifically, children with low levels of EC and EF were markedly positively influenced by the intervention program, as indicated by their performance on the toy wrap and pencil-tapping tasks.

Overall, our results suggest that mindful yoga can be used to enhance self-regulation among preschoolers.

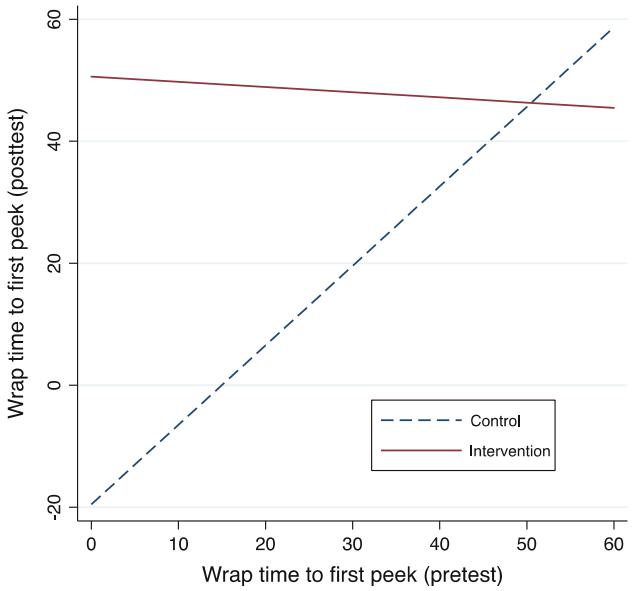

Fig. 1 Children's initial performance on the toy wrap task moderates the intervention effect on delay of gratification at posttest

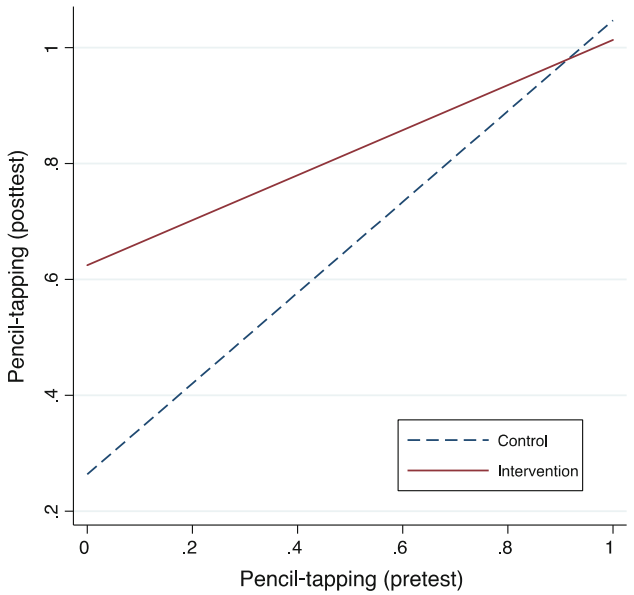

Fig. 2 Children's initial performance on the pencil-tapping task moderates the intervention effect on inhibitory control at posttest

Specifically, we found that children in the intervention classroom demonstrated greater EF skills across both measures (i.e., pencil-tapping and HSKT) at posttest compared to their peers in the control classroom. Thus, it appears that mindfulness can be used to effectively target EF in young children, as it has been shown to do with older children (Flook et al. 2010; Schonert-Reichl and Hyme 2007). Moreover, our study highlights inhibitory control as a potential mechanism underlying this link. In particular, it is possible that mindful yoga facilitated preschoolers' self-regulation by allowing the children to inhibit or control their impulses. This was true for both behavioral impulses, which were assessed via the two above mentioned tasks, as well as attentional impulsivity, which was measured using the Leiter drawing task. Indeed, mindfulness and inhibitory control are thought to be interrelated, as research suggests that they share common neuroendocrine functions related to stress (i.e., cortisol response; Blair 2010; Tang et al. 2007). There is also evidence that mindfulness is associated with greater inhibitory control among older elementary-school children (Oberle et al. 2012). While our findings suggest that these processes are interrelated in young children as well, additional research is needed to document such associations at the neurobiological level. Indeed, the specificity in the link between mindfulness and EF has been attributed to different brain-based mechanisms in work with older populations (see Tang et al. 2012 for review).

We were particularly satisfied by the effects of the program on children's delay of gratification, an index of EC, as there is some evidence that this outcome has not been successfully targeted by other classroom-based intervention strategies. For example, the Chicago School Readiness Project (CSRP) intervention, which coached teachers on behavioral management strategies in an effort to target self-regulation skills among at-risk preschoolers, improved children's EF and attention, but not their delay of gratification (Raver et al. 2011). One explanation for these findings offered by the study authors was that the CSRP intervention primarily supported those self-regulatory skills that are implicated in learning. A proposed alternative was that the systems that underlie EC (i.e., limbic and neuro-endocrine) develop early and are more substantially shaped by cumulative experiences in the school and home and thus require more comprehensive strategies that include emotion regulation across multiple contexts (Raver et al. 2011). Although the current study cannot tease apart these possibilities, our results suggest that mindfulness-based practice, when implemented daily, has the potential to support self-regulation across a broader context than more academically-focused preschool curricula. Moreover, our findings are consistent with the notion that mindfulness-based practice can impact both the top-down (e.g., EF) and bottom-up (e.g., EC) processes (Zelazo and Lyons 2012) underling self-regulation.

In contrast to our expectations and previous research with older children (Napoli et al. 2005; Semple et al. 2005), we did not see improvements in children's focused attention as a result of their participation in the intervention. It should be noted, however, that the current program was an add-on to the existing school-based

social-emotional curriculum for children, *Second Step*, which targets early self-regulation skills including listening, focusing attention, self-talk, and being assertive (Committee for Children 2002). While the *Second Step* curriculum is likely to support the principles of mindful yoga, it is also possible that it promoted focused attention for all children (control and intervention classes), thus limiting the unique impact of the mindful yoga intervention. Another possibility is that the children in the intervention classroom were already performing at average to above-average levels of focused attention, as indicated by their significantly higher scores at pretest, which made it difficult to see change on a standardized measure of attention. Given that some mindfulness-based interventions only show improvements for children with poor attention (e.g., Napoli et al. 2005), it is possible that such benefits are possible for at-risk preschoolers, but we were unable to detect them in this small, non-clinical sample. Thus, future studies should use more comprehensive attention tasks with preschoolers, such as the child version of the Attention Network Task (ANT; Rueda et al. 2004), which provides more detailed indices of executive attention.

There was limited support for children's initial self-regulation as a moderator of the intervention. Specifically, the interaction between the pretest score and intervention status was significant for the toy wrap and pencil-tapping tasks. The pattern of results, however, varied between these two outcomes, such that participation in the intervention predicted performance on the pencil-tapping task for all children, but was stronger for children with lower levels of initial inhibitory control. This pattern is consistent with the results of curricula-based programs that suggest that the children with the lowest levels of initial EF benefit most from the intervention (Bierman et al. 2008). In contrast, participation in the intervention predicted performance on the toy wrap task only for children with low initial levels of delay of gratification. This pattern is consistent with other studies of this nature that find effects of the intervention only among the children who were most at risk of self-regulatory problems (e.g., Tominey and McClelland 2011). Additional research with more comprehensive batteries of EF and EC is necessary to determine the extent to which these patterns are dependent on the specific measures used versus inherent differences between EC and EF.

Finally, the effect of the intervention was limited to direct assessments of children's EC and EF. Thus, in contrast to similar research with young children, we did not find differences between children in the intervention and control classrooms on parent-reported measures of self-regulation (Flook et al. 2010). Interestingly, recent evidence suggests that performance-based measures and ratings of EF assess different skills, such that the former captures the efficiency of cognitive processing, while the latter taps success in goal pursuit (Toplak et al. 2013). Thus, it is possible that the intervention was successful in promoting key self-regulatory processes, which were assessed under standardized conditions, but was less successful in enhancing children's use of self-regulation in every day problem-solving situations. Another possibility, however, is that intervention children were better able to regulate at school, but this did not transfer over to home. Such an explanation is consistent with research showing that children often behave differently across the home and school conditions (Achenbach et al. 1987; Bierman and Smoot 1991). Given that our teachers were not blind to their condition, objective reports of children's behavior were not feasible. Future research, however, should include teacher-reported behavior as well as observations of children's behavior at home and school, to better document change in self-regulation across different contexts.

Conclusions and Limitations

In sum, our findings highlight the benefits of a mindful yoga intervention for young children's self-regulation. In particular, children in the intervention classroom showed advantages in both measures of both EC and EF at the end of the school year compared to their peers in the control classroom. Thus, the current study adds to a small, but growing, body of research that supports the use of mindfulness-based practice with young children. An advantage of this program, in particular, was that the intervention teacher did not follow a packaged curriculum, but rather was free to integrate mindful yoga into her daily routine while meeting her primary curriculum objectives. While this lack of standardization can make replicability challenging, it allowed for flexibility in the program and increased the ecological validity of the intervention. Thus, in contrast to packaged curricula that include a set number of lesson plans implemented over a specified number of weeks (e.g., Mindful Schools K-12, Biegel and Brown 2012; MindUp, Schonert-Reichl and Stewart Lawlor 2010), this study suggests that teachers familiar with mindfulness and yoga can promote self-regulation in their classroom by implementing strategies that fit with their existing practices. Indeed, there are simple suggestions for introducing mindfulness to children (Hooker and Fodor 2008; Hanh 2011) that teachers may be able to implement more quickly and easily than standardized curricula.

To our knowledge, this is the first study to examine the benefits of a mindful yoga intervention on specific facets of preschoolers' self-regulation. Nonetheless, there are several limitations of this study. First, as previously mentioned, measurement issues included ceiling effects for the

EC tasks (i.e., gift wrap), which limited variability, and the lack of teacher-reported self-regulation. The small sample size also restricted the analyses, as we had limited power and thus did not include covariates other than the pretest score in the models, and may have also restricted our ability to detect differences between the two groups in terms of key background characteristics. In particular, children in the intervention group were slightly older, proportionately more female, of a different ethnic background, and much more likely to have parents with some college education. Thus, it is possible that this different composition of the intervention group allowed them to more fully benefit from a year of preschool in training self-regulation.

In addition, this was a quasi-experimental design, which means that the children were not randomly assigned to the treatment or control condition. Although we examined differences in key background characteristics and controlled for differences in pre-test scores in our final models, it is possible that the intervention and control groups differed in other characteristics that were not measured, but that contributed to the findings. Thus, future studies should collect more comprehensive child and family characteristics that are associated with self-regulation, such as child temperament (Rothbart and Bates 2006) and instability in the home (Evans and English 2002), to limit omitted-variable bias. In addition, it would be beneficial to collect more data on the teachers' background and classroom practices. Given that the intervention teacher had experience in mindfulness training while the control teacher did not, it is possible that there were differences between the two teachers' personality and teaching styles outside of the implementation of mindful yoga and that difference in self-regulation at the end of the year may have stemmed from these factors rather than the specific training. Moreover, given that we only followed one intervention and one control teacher, replication with a larger sample is needed to determine the generalizability of the findings beyond these two classrooms. The current study also did not allow for long-term follow-up of these children or the collection of other behavioral or academic outcomes associated with self-regulation, such as social-emotional competence or achievement. Thus, future work is needed to determine whether the benefits in early self-regulation follow children into elementary school and influence their social-emotional and/or academic trajectories. Finally, this program only targeted children. Evidence suggests that mindful parenting programs have been successful in reducing stress and improving the parent–child relationship (Coatsworth et al. 2010; van der Oord et al. 2012). Also, there are an increasing number of resources for parents that include activities on how to bring mindfulness and yoga to their children (e.g., Garabedian 2008; Greenland 2010; Hanh 2011). Thus, our findings prompt future interventions that incorporate these practices for parents as well as for children, as family based practice may promote both effectiveness and sustainability.

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