HHS Public Access

Author manuscript

J Evid Based Complementary Altern Med. Author manuscript; available in PMC 2016 January 01.

Published in final edited form as:

J Evid Based Complementary Altern Med. 2015 January ; 20(1): 41–49. doi:10.1177/2156587214557695.

Effects of a Classroom-Based Yoga Intervention on Cortisol and Behavior in Second- and Third-Grade Students: A Pilot Study

Bethany Butzer, Ph.D.[1], **Danielle Day, Ph.D.**[2], **Adam Potts, DPT, CSCS**[2], **Connor Ryan, DPT, CSCS**[2], **Sarah Coulombe, DPT, CSCS**[2], **Brandie Davies, DPT**[2], **Kimberly Weidknecht, BS**[2], **Marina Ebert, M.A.**[3], **Lisa Flynn, B.A., E-RYT, RCYT**[4], and **Sat Bir S. Khalsa, Ph.D.**[1]

[1]Department of Medicine, Brigham and Women's Hospital, Harvard Medical School, Boston, MA

[2]Department of Physical Therapy, University of Massachusetts-Lowell, Lowell, MA

[3]Yale Center for Emotional Intelligence, Yale University, New Haven, CT

[4]ChildLight Yoga and Yoga 4 Classrooms, Dover, NH

Abstract

This uncontrolled pilot study examined the effects of a classroom-based yoga intervention on cortisol concentrations and perceived behavior in children. A 10-week Yoga 4 Classrooms® intervention was implemented in one second- and one third-grade classroom. Students' salivary cortisol responses were assessed at three time points. Classroom teachers also documented their perceptions of the effects of the intervention on students' cognitive, social and emotional skills. Second, but not third, graders showed a significant decrease in baseline cortisol from before to after the intervention. Second and third graders both showed significant decreases in cortisol from before to after a cognitive task, but neither grade showed additional decreases from before to after

Please address all correspondence to: Bethany Butzer, Ph.D., Brigham and Women's Hospital, Harvard Medical School, Division of Sleep Medicine, 900 Commonwealth Ave., C1341, Boston, MA 02215, bbutzer@partners.org, 617-278-0154.

AUTHOR CONTRIBUTION/ROLES

BB conducted the primary data analyses and wrote the majority of the final manuscript. AP, CR, SC, BD, and KW worked together on a preliminary version of this study as the thesis requirement for their Doctor of Physical Therapy degree at the University of Massachusetts Lowell. These authors also wrote and reviewed sections of the final manuscript. DD supervised AP, CR, SC, BD, and KW during their thesis work, and also wrote and reviewed sections of the final manuscript. DD, LF, ME, and SBSK worked together to conceptualize the study design, including methodology and outcome measures, and wrote/reviewed sections of the final manuscript.

ETHICAL APPROVAL

All study procedures and materials were approved by the University of Massachusetts Lowell Institutional Review Board (IRB). Letters approved by the University of Massachusetts Lowell IRB were sent to each student's parents explaining the Y4C program as well as the research study. Parents who did not wish their child to participate had the option to decline and their child was not entered into the study. Participants did not receive any type of compensation for participation, nor were any students/teachers given a penalty for opting not to participate.

DECLARATION OF CONFLICTING INTERESTS

LF is the founder of ChildLight Yoga and Yoga 4 Classrooms (Y4C). LF conceptualized the idea for the present study and developed the yoga intervention that was used in this research. However, LF was not involved in administering the intervention or in data collection/analysis. Her role was limited to providing logistical support during implementation of the intervention, as well as writing the intervention description for the current paper. ME received research consulting funds from Y4C while this study was being conducted, however she was not involved in the intervention administration or data analysis.

FINANCIAL DISCLOSURE/FUNDING

This study was funded by a grant from David McGillivray and was supported by the DMSE Children's Fitness Foundation as well as UMass-Lowell faculty start-up funds. BB and SBSK were supported in part by a grant from the Institute for Extraordinary Living of the Kripalu Center for Yoga and Health. SBSK was also supported in part by a grant from the National Institute on Drug Abuse of the NIH (Grant No. 5R34DA032756-02).

a single yoga class. The second-grade teacher perceived significant improvements in several aspects his/her students' behavior. The third-grade teacher perceived some, but fewer, improvements in his/her students' behavior. Results suggest that school-based yoga may be advantageous for stress management and behavior.

Keywords

Yoga; school; cortisol; stress; behavior

INTRODUCTION

Yoga for Stress Management

Yoga is a holistic system of mind-body practices for mental and physical health involving multiple components such as physical postures and exercises to promote strength and flexibility, breathing exercises to enhance respiratory functioning, deep relaxation techniques to cultivate the ability to mentally and physiologically release tension and stress, and meditation/mindfulness practices to enhance mind-body awareness and improve attention and emotion regulation skills. Systematic research reviews suggest that yoga is effective at reducing stress and enhancing mood and well-being in adults.[1–5] Salivary cortisol, a potential biological marker of stress, tends to increase as part of the physiological stress response.[6–8] While this stress response is generally considered adaptive, chronically heightened cortisol concentrations as a result of repeated stressors may have detrimental long-term effects on mental and physical health[9], suggesting that interventions that reduce cortisol levels may be beneficial.

Evidence exists suggesting that participation in yoga may reduce cortisol concentrations in adults.[10–13] However the literature in this area is inconsistent, with some studies failing to show associations between yoga and cortisol concentrations.[14,15] In addition, one study of women with fibromyalgia showed that participation in yoga increased cortisol concentrations.[16] Very little research exists on the effects of yoga on cortisol concentrations in children; however one study showed that hospitalized children who participated in a relaxation therapy class that included yoga showed decreases in cortisol.[17]

Yoga, which often includes practices that are specifically focused on calming the nervous system, may be ideally suited to prevent or alleviate the psychological and physiological stressors encountered by youth. A NIH/CDC Complementary and Alternative Medicine (CAM) therapy survey revealed that 2.1% of children under 18 practice yoga and that 4.8% of child/adolescent CAM users were specifically targeting anxiety and stress.[18] Two systematic reviews and one clinical review paper on the therapeutic effects of yoga for youth indicated improvements in physical and mental health.[19–21] In addition, research on children and adults suggest that yoga-based breathing exercises are beneficial for reducing physiological and psychological stress.[22–26]

Yoga in Schools

In a comprehensive review proposing the implementation of contemplative practices such as yoga and meditation in education, Davidson and colleagues[27] suggest that the benefits of yoga that have been observed in adults are also relevant for children and adolescents in school-based settings. Research on yoga interventions in schools is in its early stages, however initial results are promising. For example, Serwacki and Cook-Cottone[28] recently reviewed 12 preliminary studies of yoga in schools and concluded that the yoga interventions exerted positive effects on factors such as emotional balance, attentional control, cognitive efficiency, anxiety, negative thought patterns, emotional and physical arousal, reactivity, and negative behavior. Additional research also suggests positive effects of school-based yoga programs on several aspects of mental health such as concentration, attention, anxiety, stress, mood, resilience, emotional arousal, self-esteem, and coping frequency.[23,28–36] It is important to note, however, that existing research on school-based yoga programs is highly preliminary, with most studies suffering from low methodological quality. In addition, prior research on yoga in schools has relied almost exclusively on student self-report, suggesting a need for more objective measures of the effects of these interventions.

Purpose of the Present Study

Preliminary research suggests that providing yoga within the school curriculum may be an effective and feasible way to help youth develop stress management skills. However, limited data exists on school-based yoga interventions, particularly with regard to objective measures of stress such as cortisol concentrations. The high prevalence of stress-related psychiatric disorders among youth[37] suggests that school-based yoga interventions may be advantageous in this regard.[38] The goal of this uncontrolled pilot study is to examine whether a 10-week school-based yoga program has beneficial effects on physiological markers related to stress and behavior in second and third grade students at an elementary school in Maine, USA. This is the first research study to use both subjective and objective data to examine the acute and longitudinal effects of a school-based yoga intervention in young children.

METHODS

Participants

Two classrooms (one second- and one third-grade) at an elementary school in Maine received the Yoga 4 Classrooms (Y4C) yoga intervention (described below). Letters approved by the university Institutional Review Board (IRB) were sent to each student's parents explaining the Y4C program as well as the research study. Parents who did not wish their child to participate had the option to decline and their child was not entered into the study. In total, 18 second-graders (11 male, 7 female) and 18 third-graders (9 male, 9 female) participated in the study. Participants did not receive any type of compensation for participation, nor were any students/teachers given a penalty for opting not to participate.

Procedure

The Y4C program includes an initial 6-hour professional development workshop provided to any interested teachers at the school to learn about the benefits of yoga and how to implement yoga practices in the classroom. This workshop was made available to all teachers at the school in the summer before the school year began. However, only the two participating classrooms received the 10-week yoga intervention, which began in January. These classroom teachers were instructed not to teach any Y4C techniques from September to December. The intervention involved a 30-minute weekly class, taught during regular class time, led by a licensed Y4C yoga instructor (10 yoga sessions total). The lead yoga instructor had completed a 200-hour yoga teacher training, the ChildLight Yoga (children's yoga) Instructor Certification Program, the Y4C Trainer program, and over 95 additional hours of training specifically focused on teaching yoga to children. The classroom teachers were present at each yoga session, and had both attended the 6-hour Y4C professional development workshop described above.

The Y4C program is completely secular and includes 4 key elements of classical yoga: breathing exercises, physical exercises and postures, meditation techniques, and relaxation. The program also incorporated a themed discussion at the start of each session with the intention of engaging the students in learning while promoting self-inquiry and a reflective environment. Finally, a focus on the Y4C approach to self-regulation, including the steps of noticing, mindful choice, regulation, reflection, and integration, was woven throughout the yoga program.

The 30-minute yoga sessions were structured as follows: a 2-minute centering, 5-minute themed discussion, 3-minute breathing exercise, 15 minutes of yoga postures/exercises (modified for a classroom setting), and a 5-minute relaxation and closing. Centering involved a short community-building chant/song and a timed focusing activity which was increased in length each week based on students' progress. Themed discussions focused on yoga-related topics such as: introduction to yoga and mindfulness, breathing for self-regulation, peace/non-violence, and self-care. Breathing exercises were primarily focused on calming and integrating breathing techniques, though energizing breathing techniques were also introduced. Students kept their shoes on and remained sitting at, or standing next to, their desks while practicing yoga posture variations appropriate for use in a typical classroom setting. All yoga activities were accessible and adaptable for all physical abilities, and emphasis was placed on listening to one's body and modifying as needed. Relaxation involved students progressively relaxing into 'Desk Rest Pose' (heads down on the desk) while listening to a themed visualization, followed by a closing song/chant and a few final deep breaths.

Data collected included results from the Attention Network Test (ANT-C) described below (the results of which are not the focus of the present study), saliva samples later analyzed for cortisol concentrations, and surveys completed by teachers assessing observed changes in student behaviors. Study staff collected data at the school on the first and last day of the 10-week intervention, for a total of two experimental days per classroom. The ANT-C was administered immediately before a single yoga class on each experimental day. Saliva samples were collected at three time points on each experimental day: immediately prior to

the ANT-C test (Cortisol 1), immediately after the ANT-C (Cortisol 2), and immediately after a single yoga class (Cortisol 3). Subjective surveys were given to teachers at the beginning and end of the 10-week intervention and were returned to study staff within approximately 1 week.

Outcome Measures

Attention Network Test (ANT-C)—The ANT-C is an attention test that involves responding to a target that is surrounded by flankers that point in either the same or opposite direction. All stimuli were displayed on a computer screen. Each trial began with a central fixation cross. The target array was a yellow colored line drawing of either a single yellow fish or a horizontal row of five yellow fish, presented above or below fixation, over a blue–green background. The participant was to respond based on whether the central fish was pointing to the left or right by pressing the corresponding single finger press (left click) or double finger press (right click) on the mouse. On congruent trials the flanking fish were pointing in the same direction, on incongruent trials the flankers point in the opposite direction from the central fish, and on neutral trials the central fish appeared alone.[39] Participants completed one round of 24 practice trials followed by three experimental blocks of 48 trials each, with the entire session taking between 18–25 minutes. Total reaction time and response accuracy were used as indicators of students' attention and ability to inhibit inappropriate responses. The results of the ANT-C are not the focus of the present paper, however this measure is described due to changes in cortisol concentrations that occurred from before to after the ANT-C (described below).

Salivary Cortisol—Collection of saliva involved asking the students to "drool" into a plastic conical tube until approximately 1 mL of saliva had been collected, excluding air bubbles. The vial was then capped and frozen to later be analyzed for free cortisol, with each subject's full set of samples run in the same batch. Salivary cortisol concentrations were measured using enzyme-linked immunosorbent assay (ELISA, Salimetrics, Inc., State College, PA). Absorbance was converted to cortisol concentration based on the standard curve using line of best fit (www.Myassays.com). Saliva samples were collected immediately prior to the ANT-C test (Cortisol 1), immediately after the ANT-C (Cortisol 2), and immediately after a single yoga class (Cortisol 3). Statistical comparisons on both the second and third grade classes were performed to determine if significant changes occurred between the following time points:

- Cortisol 1 (Week 1) vs. Cortisol 1 (Week 10) (longitudinal, baseline comparison)
- Cortisol 1 vs. Cortisol 2 (Weeks 1 and 10; pre vs. post-ANT-C)
- Cortisol 2 vs. Cortisol 3 (Weeks 1 and 10; post-ANT-C vs. post-yoga)

Perceived Behavior Change—The second and third grade teachers were asked to complete a behavioral observation survey (created by the present researchers) during Week 1 of the yoga intervention and at Week 10 following the intervention to record the perceived behavioral changes of each student over the 10-week period. The teachers rated each student on the following criteria using a 5-point scale (1 = Poor; 5 = Good): social interaction with classmates, respect for others, ability to be in control of their behavior, ability to manage

their anger, attention span, ability to concentrate on work, ability to stay on task, creativity, academic performance, ability to deal with stress and anxiety, confidence/self-esteem, and overall mood.

Data Analysis

Independent-samples *t*-tests were used to examine whether any differences existed between second and third graders at baseline. Data were then analyzed using a series of 2 x 2 split-plot ANOVAs, in which grade served as the between-subjects factor, and time served as the within-subjects factor, to examine whether cortisol concentrations and perceived behaviors changed significantly for second and third graders over time. The alpha level used to determine statistical significance was $p < .05$ for all analyses. Data are reported as mean ± standard deviation.

RESULTS

Baseline Differences Between Grades

No statistically significant baseline differences were detected between the two grades for salivary cortisol, however second and third graders did show statistically significant baseline differences on 8 of the 12 items of the behavioral observation survey. In particular, at baseline, third graders were rated significantly higher than second graders on their social interaction with classmates, attention span, ability to concentrate on work, ability to stay on task, academic performance, ability to deal with stress/anxiety, confidence/self-esteem, and overall mood. Thus, data were analyzed separately for each grade by including grade as a between-subjects factor in the 2 x 2 ANOVAs described above.

Salivary Cortisol

Means and standard deviations for the salivary cortisol data are displayed in Table 1. The longitudinal, baseline comparison of Cortisol 1 at Week 1 vs. Cortisol 1 at Week 10 revealed a significant interaction between grade and time in which second, but not third, graders showed a significant decrease in baseline cortisol concentrations from before (M = 0.18±0.09 ug/dL) to after (M = 0.12±0.06 ug/dL) the 10-week intervention, $F(1,30) = 9.77$, $p < 0.01$ (see Figure 1).

In addition, a significant main effect of Time emerged for the Week 1 testing session in which, regardless of grade, participants showed a significant decrease in cortisol concentrations from before (M = 0.14±0.06 ug/dL) to after (M = 0.09±0.04 ug/dL) the ANT-C cognitive task, $F(1,27) = 48.25$, $p < 0.001$. However, neither grade showed additional decreases in cortisol concentrations from before to after a single yoga class during the Week 1 testing session, $F(1,27) = 1.06$, *ns*. A similar pattern of results emerged for the Week 10 testing session, in which, regardless of grade, participants showed a significant decrease in cortisol concentrations from before (M = 0.13±0.06 ug/dL) to after (M = 0.11±0.07 ug/dL) the ANT-C cognitive task, $F(1,34) = 16.12$, $p < 0.001$, however neither grade showed additional decreases in cortisol concentrations from before to after a single yoga class, $F(1,35) = 1.83$, *ns*.

Perceived Behavior Change

Means and standard deviations for the behavioral observation survey are displayed in Table 2. Analyses of the teacher ratings revealed a pattern of significant interactions between grade and time in which the second grade teacher perceived significant improvements on several cognitive, social and emotional skills from before to after the 10-week intervention, whereas the third grade teacher perceived little or no change. In particular, the second grade teacher perceived significant improvements in his/her students' social interaction with classmates (pre $M = 3.17 \pm 0.79$; post $M = 4.39 \pm 0.61$), attention span (pre $M = 2.94 \pm 1.00$; post $M = 4.08 \pm 0.69$), ability to concentrate on work (pre $M = 2.89 \pm 0.83$; post $M = 4.11 \pm 0.68$), ability to stay on task (pre $M = 2.67 \pm 0.91$; post $M = 4.06 \pm 0.73$), academic performance (pre $M = 3.11 \pm 0.92$; post $M = 4.11 \pm 0.68$), ability to deal with stress/anxiety (pre $M = 2.72 \pm 0.83$; post $M = 4.17 \pm 0.71$), confidence/self-esteem (pre $M = 2.67 \pm 1.19$; post $M = 4.31 \pm 0.71$), and overall mood (pre $M = 2.81 \pm 0.93$; post $M = 4.19 \pm 0.75$), however the third grade teacher perceived little or no change in his/her students on these variables (see Figure 2).

A significant main effect of time did, however, emerge for three of the items on the behavioral observation survey, suggesting that both the second and third grade teacher perceived significant improvements in their students' creativity (pre $M = 3.43 \pm 0.99$; post $M = 4.31 \pm 0.90$), ability to be in control of their behavior (pre $M = 3.71 \pm 1.20$; post $M = 4.15 \pm 1.02$), and ability to manage anger (pre $M = 3.54 \pm 1.18$; post $M = 4.40 \pm 0.98$) after the 10-week intervention. The remaining item on the behavioral observation survey (respect for others) was not significantly different between grades or over time.

DISCUSSION

Salivary Cortisol

The results revealed that second graders showed a longitudinal effect in which baseline cortisol concentrations significantly decreased from before to after the entire 10-week intervention, a finding that is consistent with prior studies of the longitudinal effects of yoga on cortisol in adults.[10–12] This result should be interpreted cautiously, however, due to the lack of a control group. For example, other variables could have contributed to changes in cortisol concentrations in the second graders over the 10-week period such as the children becoming more comfortable with the yoga instructor or with the classroom environment in general.

Interestingly, second- and third-graders both showed significant decreases in cortisol concentrations from before to after the ANT-C cognitive task at Weeks 1 and 10. The mechanisms underlying this effect are unclear, however it is possible that the presence of the researchers and the disruption of the typical school schedule could have caused the students to experience performance anxiety prior to the ANT-C, which may have resulted in increased cortisol concentrations that were relieved after the task was complete. Alternatively, prior research suggests that participating in cognitive tasks that are designed to train attention may improve executive functioning by training individuals to pay close attention to incongruent stimuli. It is thought that the improvements in attention that occur as

a result of this cognitive training may be similar to the attentional improvements that have been found following activities such as meditation.[40] Thus, it could be the case that having something finite to focus on during the ANT-C, similar to what occurs during meditation, could have had a calming effect on the children.

Cortisol secretion follows a diurnal pattern that peaks 20–30 minutes after awakening, decreases to approximately half by mid-afternoon, and is lowest by midnight.[41,42] In their research on normative cortisol concentrations in children aged 4–10, McCarthy and colleagues[41] found that cortisol concentrations decreased from 0.24 mcg/dl at 9am to 0.16 mcg/dl at 12pm and 0.12 mcg/dl at 3pm. This represents a decrease of 0.08 mcg/dl over 3 hours from 9am–12pm and a decrease of 0.04 mcg/dl over 3 hours from 12pm–3pm. Given that the average decrease in cortisol concentrations from before to after the ANT-C in the present study was 0.05 mcg/dl over a period of only 25 minutes, it is unlikely that diurnal reductions can account for these changes, although time of day may have had a minor contribution.

The present findings also suggest that there was no acute effect of a single yoga class on cortisol concentrations in second or third graders. Prior research on short-term changes in cortisol after yoga participation has been inconsistent, with some studies showing acute decreases in cortisol[13] whereas other studies have not found acute effects.[15] Prior research also suggests that participating in physical activity can actually increase cortisol concentrations over the short-term.[13,43,44] Consistent with the present findings for second graders, some studies have found longitudinal decreases in cortisol concentrations when cortisol is measured before and after participation in longer-term yoga interventions (typically lasting several weeks).[10–12] Thus, it could be the case that a relatively short (30 minute) yoga class may not have been a long enough time period to initiate and/or detect a decrease in cortisol concentrations. Additional research is needed that compares the acute vs. long-term effects of yoga practice on cortisol concentrations, particularly in children.

Perceived Behavior Change

The second grade teacher generally perceived more behavioral changes in his/her students than the third grade teacher. In particular, significant improvements were perceived in second graders', but not in third graders', social interaction with classmates, attention span, ability to concentrate on work, ability to stay on task, academic performance, ability to deal with stress/anxiety, confidence/self-esteem, and overall mood. However, students in both grades demonstrated perceived improvements in creativity, ability to be in control of behavior, and ability to manage anger. These improvements in social and emotional learning (SEL) skills underlie the core SEL competencies of self-management, social awareness and responsible decision-making[45], suggesting that yoga may have beneficial effects on the skills that are targeted by SEL goals.

In general, these results support prior research suggesting that yoga may increase mental health and well-being, positive behaviors, and SEL skills in children and adolescents.[19–21,33,34,46,47] However it is unclear why second graders exhibited greater perceived positive behavior changes than third graders. Due to the lack of a control group, these results should be interpreted with caution, as the findings could be attributed to several

factors such as differences in teacher rating styles as well as other circumstances that may have changed over the course of the school year, including maturational improvements (children developing and changing rapidly over the course of the year) or class dynamics.

Comparison of Objective and Subjective Data

One of the strengths of the present study is that it involved the simultaneous collection of subjective data (teacher ratings of student behavior) and objective data (salivary cortisol). The results from these two forms of data were quite consistent with one another. In particular, second graders generally exhibited a greater number of improvements than third graders on both the subjective teacher ratings and their objective cortisol concentrations. The subjective findings for perceived behavior change, namely that second graders showed greater improvements on several social and emotional skills than third graders, was, in a sense, confirmed by the objective findings for salivary cortisol, in which second graders, but not third graders, showed significant decreases in baseline cortisol concentrations from before to after the 10-week intervention. In other words, it is possible that the behavioral changes that the second grade teacher observed in his/her students may have been valid and may not have simply been due to maturational differences between the grades or differences between the teacher rating styles, however this suggestion is highly preliminary and would need to be investigated in future research.

Limitations

The main limitation of this study is the lack of a control group. Without the use of a control group it is difficult to determine if the results were caused solely by the yoga intervention or by other factors. For example, the results could be attributed to the fact that the children were maturing naturally over time, that they had a new teacher (the yoga instructor) coming into their class, or differences in the behavioral rating styles between the two teachers. Thus, it cannot be determined with certainty that it was the yoga intervention alone that caused the results.

Another limitation of this study was the timing of the cortisol samples. Due to the age of the students involved in the study, the collection of cortisol samples was dependent on the school schedule. According to the recommended best practices for collecting saliva samples to determine cortisol concentrations, saliva samples shouldn't be taken within 60 minutes of eating.[48,49] Alterations to the school schedule, such as the time of lunch, could not be made by the researchers. Attempts were made to address this issue by, for example, giving students a 20-minute reading exercise after lunch, however some saliva samples were collected within 60 minutes of lunch. School scheduling constraints also required the sample collection procedure to differ between the second and third graders. In particular, for third graders, all of the experimental procedures (including saliva samples) occurred *before* lunch, whereas for second graders all of experimental procedures occurred *after* lunch. These various scheduling differences could have affected the observed differences between the two grade levels' cortisol concentrations. In addition, there are other factors that can influence cortisol responses that were not controlled for in this study. For example, age/developmental stage, sex, weight, temperament, coping style, social competency, and pain sensitivity can also have an effect on cortisol concentrations.[41]

Finally, the subjective behavior ratings were performed by two teachers, whose individual biases for or against their students could have affected the results. For example, third-graders were rated significantly higher on several items of the behavioral observation survey at baseline than second-graders, such as attention span, ability to stay on task, and ability to concentrate on work. This finding may be due to actual age-related developmental and maturational differences between the students in each grade; however these results could also be due to differences in the behavioral rating styles between the two teachers.

Future Research

The limitations of the present study are not surprising given the pilot nature of this research; thus it will be important for future studies to confirm the findings by employing more rigorous designs that include larger sample sizes and random assignment to intervention and control groups. In addition, future research will benefit from the inclusion of developmentally appropriate tests of emotional skills, such as emotion understanding and awareness.[50] To supplement observational data, interviews or self-report questionnaires could also be used to assess students' social and emotional skills. It will also be important for future studies to further examine acute vs. long-term changes in cortisol concentrations as a result of yoga class participation, and to take into consideration the complexities involved in cortisol measurement, such as time of day and baseline levels of stress. Finally, future research should continue to collect data using both subjective and objective methods in order to enrich our knowledge above and beyond the information that can be gathered from self-report surveys alone.

Conclusions

Overall no statistically significant findings emerged regarding the acute effects of a single yoga class on elementary-aged children's cortisol concentrations, however there was an acute reduction in cortisol concentrations after taking a computer based attention network test (ANT-C). In contrast, a statistically significant longitudinal reduction in baseline salivary cortisol from before to after the 10-week yoga intervention did emerge in the second-grade students. More research is warranted to further investigate these results. The subjective information gained from the behavioral observation scale revealed significant perceived improvements, particularly for the second-grade students.

Acknowledgments

The authors thank the principal, teachers, parents, and students at the elementary school that was involved in this study. The authors also gratefully acknowledge Sharon Trull, MS, E-RYT, RCYT, who conducted the Yoga 4 Classrooms professional development workshop for the classroom teachers, administered the Yoga 4 Classrooms intervention in the classrooms, served as a liaison between the school and research team, and coordinated many logistical aspects of the present study. We are also grateful for the contribution of Amanda LoRusso, who assisted with the preparation of this article for publication.

References

1. Sharma M. Yoga as an alternative and complementary approach for stress management A systematic review. Journal of Evidence-Based Complementary & Alternative Medicine. 2014; 19(1):59–67. [PubMed: 24647380]

2. Kirkwood G, Rampes H, Tuffrey V, Richardson J, Pilkington K. Yoga for anxiety: A systematic review of the research evidence. Br J Sports Med. 2005; 39(12):884–91. [PubMed: 16306493]
3. Li AW, Goldsmith CA. The effects of yoga on anxiety and stress. Altern Med Rev. 2012; 17(1):21–35. [PubMed: 22502620]
4. Pilkington K, Kirkwood G, Rampes H, Richardson J. Yoga for depression: The research evidence. J Affect Disord. 2005; 89(1–3):13–24. [PubMed: 16185770]
5. Chong CS, Tsunaka M, Tsang HW, Chan EP, Cheung WM. Effects of yoga on stress management in healthy adults: A systematic review. Altern Ther Health Med. 2011; 17(1):32–38. [PubMed: 21614942]
6. Bruce J, Davis EP, Gunnar MR. Individual differences in children's cortisol response to the beginning of a new school year. Psychoneuroendocrinology. 2002; 27(6):635–650. [PubMed: 12084657]
7. Gunnar MR, Bruce J, Hickman SE. Salivary cortisol response to stress in children. Adv Psychosom Med. 2001; 22:52–60. [PubMed: 11477939]
8. Kudielka BM, Buske-Kirschbaum A, Hellhammer DH, Kirschbaum C. HPA axis responses to laboratory psychosocial stress in healthy elderly adults, younger adults, and children: Impact of age and gender. Psychoneuroendocrinology. 2004; 29(1):83–98. [PubMed: 14575731]
9. Charmandari E, Tsigos C, Chrousos G. Endocrinology of the stress response. Annu Rev Physiol. 2005; 67:259–284. [PubMed: 15709959]
10. Banasik J, Williams H, Haberman M, Blank SE, Bendel R. Effect of iyengar yoga practice on fatigue and diurnal salivary cortisol concentration in breast cancer survivors. J Am Acad Nurse Pract. 2011; 23(3):135–142. [PubMed: 21355946]
11. Thirthalli J, Naveen GH, Rao MG, Varambally S, Christopher R, Gangadhar BN. Cortisol and antidepressant effects of yoga. Indian J Psychiatry. 2013; 55(Suppl 3):S405–8. [PubMed: 24049209]
12. Vadiraja HS, Raghavendra RM, Nagarathna R, et al. Effects of a yoga program on cortisol rhythm and mood states in early breast cancer patients undergoing adjuvant radiotherapy: A randomized controlled trial. Integr Cancer Ther. 2009; 8(1):37–46. [PubMed: 19190034]
13. West J, Otte C, Geher K, Johnson J, Mohr DC. Effects of hatha yoga and african dance on perceived stress, affect, and salivary cortisol. Ann Behav Med. 2004; 28(2):114–118. [PubMed: 15454358]
14. Bowden D, Gaudry C, An SC, Gruzelier J. A comparative randomised controlled trial of the effects of brain wave vibration training, iyengar yoga, and mindfulness on mood, well-being, and salivary cortisol. Evid Based Complement Alternat Med. 2012; 2012:234713. [PubMed: 22216054]
15. Tsang HW, Cheung WM, Chan AH, Fung KM, Leung AY, Au DW. A pilot evaluation on a stress management programme using a combined approach of cognitive behavioural therapy (CBT) and complementary and alternative medicine (CAM) for elementary school teachers. Stress Health. 2013
16. Curtis K, Osadchuk A, Katz J. An eight-week yoga intervention is associated with improvements in pain, psychological functioning and mindfulness, and changes in cortisol levels in women with fibromyalgia. J Pain Res. 2011; 4:189–201. [PubMed: 21887116]
17. Platania-Solazzo A, Field TM, Blank J, et al. Relaxation therapy reduces anxiety in child and adolescent psychiatric patients. Acta Paedopsychiatr. 1992; 55(2):115–120. [PubMed: 1585802]
18. Barnes, PM.; Powell-Griner, E.; McFann, K.; Nahin, RL. Seminars in integrative medicine. Vol. 2. Elsevier; 2004. Complementary and alternative medicine use among adults: United states, 2002; p. 54-71.
19. Birdee GS, Yeh GY, Wayne PM, Phillips RS, Davis RB, Gardiner P. Clinical applications of yoga for the pediatric population: A systematic review. Acad Pediatr. 2009; 9(4):212–220. e1–9. [PubMed: 19608122]
20. Galantino ML, Galbavy R, Quinn L. Therapeutic effects of yoga for children: A systematic review of the literature. Pediatr Phys Ther. 2008; 20(1):66–80. [PubMed: 18300936]
21. Kaley-Isley LC, Peterson J, Fischer C, Peterson E. Yoga as a complementary therapy for children and adolescents: A guide for clinicians. Psychiatry (Edgmont). 2010; 7(8):20. [PubMed: 20877530]

22. Bhattacharya S, Pandey US, Verma NS. Improvement in oxidative status with yogic breathing in young healthy males. Indian J Physiol Pharmacol. 2002; 46(3):349–354. [PubMed: 12613400]
23. Conboy LA, Noggle JJ, Frey JL, Kudesia RS, Khalsa SBS. Qualitative evaluation of a high school yoga program: Feasibility and perceived benefits. Explore: The Journal of Science and Healing. 2013; 9(3):171–180.
24. Magarian GJ. Hyperventilation syndromes: Infrequently recognized common expressions of anxiety and stress. Medicine (Baltimore). 1982; 61(4):219–236. [PubMed: 7045570]
25. Martarelli D, Cocchioni M, Scuri S, Pompei P. Diaphragmatic breathing reduces exercise-induced oxidative stress. Evid Based Complement Alternat Med. 2011; 2011:932430. [PubMed: 19875429]
26. Telles S, Nagarathna R, Nagendra HR, Desiraju T. Physiological changes in sports teachers following 3 months of training in yoga. Indian J Med Sci. 1993; 47(10):235–238. [PubMed: 8112782]
27. Davidson RJ, Dunne J, Eccles JS, Engle A, Greenberg M, Jennings P, Vago D. Contemplative practices and mental training: Prospects for american education. Child Dev Perspect. 2012; 6(2): 146–153. [PubMed: 22905038]
28. Serwacki ML, Cook-Cottone C. Yoga in the schools: A systematic review of the literature. Int J Yoga Therap. 2012; (22):101–109.
29. Bothe DA, Grignon JB, Olness KN. The effects of a stress management intervention in elementary school children. J Dev Behav Pediatr. 2014; 35(1):62–67. [PubMed: 24336090]
30. Ehud M, An BD, Avshalom S. Here and now: Yoga in israeli schools. Int J Yoga. 2010; 3(2):42–47. [PubMed: 21170229]
31. Khalsa SB, Hickey-Schultz L, Cohen D, Steiner N, Cope S. Evaluation of the mental health benefits of yoga in a secondary school: A preliminary randomized controlled trial. J Behav Health Serv Res. 2012; 39(1):80–90. [PubMed: 21647811]
32. Mendelson T, Greenberg MT, Dariotis JK, Gould LF, Rhoades BL, Leaf PJ. Feasibility and preliminary outcomes of a school-based mindfulness intervention for urban youth. J Abnorm Child Psychol. 2010; 38(7):985–994. [PubMed: 20440550]
33. White LS. Reducing stress in school-age girls through mindful yoga. Journal of Pediatric Health Care. 2012; 26(1):45–56. [PubMed: 22153143]
34. Sethi JK, Nagendra HR, Sham Ganpat T. Yoga improves attention and self-esteem in underprivileged girl student. J Educ Health Promot. 2013; 2:55-9531.119043. eCollection 2013. [PubMed: 24251291]
35. Klatt M, Harpster K, Browne E, White S, Case-Smith J. Feasibility and preliminary outcomes for move-into-learning: An arts-based mindfulness classroom intervention. The Journal of Positive Psychology. 2013; 8(3):233–241.
36. Telles S, Singh N, Bhardwaj AK, Kumar A, Balkrishna A. Effect of yoga or physical exercise on physical, cognitive and emotional measures in children: A randomized controlled trial. Child Adolesc Psychiatry Ment Health. 2013; 7(1):37. [PubMed: 24199742]
37. Copeland W, Shanahan L, Costello EJ, Angold A. Cumulative prevalence of psychiatric disorders by young adulthood: A prospective cohort analysis from the great smoky mountains study. J Am Acad Child Adolesc Psychiatry. 2011; 50(3):252–261. [PubMed: 21334565]
38. Hyde, AM. The yoga in schools movement: Using standards for educating the whole child and making space for teacher self-care. In: Gorlewski, JA.; Porfilio, B.; Gorlewski, DA., editors. Using standards and high-stakes testing for students: Exploiting power with critical pedagogy. Vol. 17. New York: Peter Lang; 2012. p. 109-126.
39. Fan J, Fossella J, Sommer T, Wu Y, Posner MI. Mapping the genetic variation of executive attention onto brain activity. Proc Natl Acad Sci U S A. 2003; 100(12):7406–7411. [PubMed: 12773616]
40. Tang Y, Posner MI. Attention training and attention state training. Trends Cogn Sci (Regul Ed). 2009; 13(5):222–227. [PubMed: 19375975]
41. McCarthy AM, Hanrahan K, Kleiber C, Zimmerman MB, Lutgendorf S, Tsalikian E. Normative salivary cortisol values and responsivity in children. Applied Nursing Research. 2009; 22(1):54–62. [PubMed: 19171296]

42. Schmidt NA. Salivary cortisol testing in children. Issues Compr Pediatr Nurs. 1998; 20(3):183–190. [PubMed: 9752108]
43. Defrin R, Josefsberg Z, Karp M. The effect of acute physical activity on blood glucose levels of children with insulin-dependent diabetes mellitus. Harefuah. 2004; 143(12):856–60. [PubMed: 15666702]
44. Mendham AE, Donges CE, Liberts EA, Duffield R. Effects of mode and intensity on the acute exercise-induced IL-6 and CRP responses in a sedentary, overweight population. Eur J Appl Physiol. 2011; 111(6):1035–1045. [PubMed: 21088973]
45. Durlak JA, Weissberg RP, Dymnicki AB, Taylor RD, Schellinger KB. The impact of enhancing students' social and emotional learning: A meta-analysis of school-based universal interventions. Child Dev. 2011; 82(1):405–432. [PubMed: 21291449]
46. Koenig KP, Buckley-Reen A, Garg S. Efficacy of the get ready to learn yoga program among children with autism spectrum disorders: A Pretest–Posttest control group design. The American Journal of Occupational Therapy. 2012; 66(5):538–546. [PubMed: 22917120]
47. Stueck M, Gloeckner N. Yoga for children in the mirror of the science: Working spectrum and practice fields of the training of relaxation with elements of yoga for children. Early child development and care. 2005; 175(4):371–377.
48. Salimetrics. [Accessed 03/13, 2014] Saliva collection and handling advice. http://www.salimetrics.com/documents/Saliva_Collection_Handbook.pdfUpdated 2013
49. Keil MF. Salivary cortisol: A tool for biobehavioral research in children. J Pediatr Nurs. 2012; 27(3):287–289. [PubMed: 22405849]
50. Mayer JD, Salovey P, Caruso DR. Emotional intelligence: Theory, findings, and implications. Psychological Inquiry. 2004; 15(3):197–215.

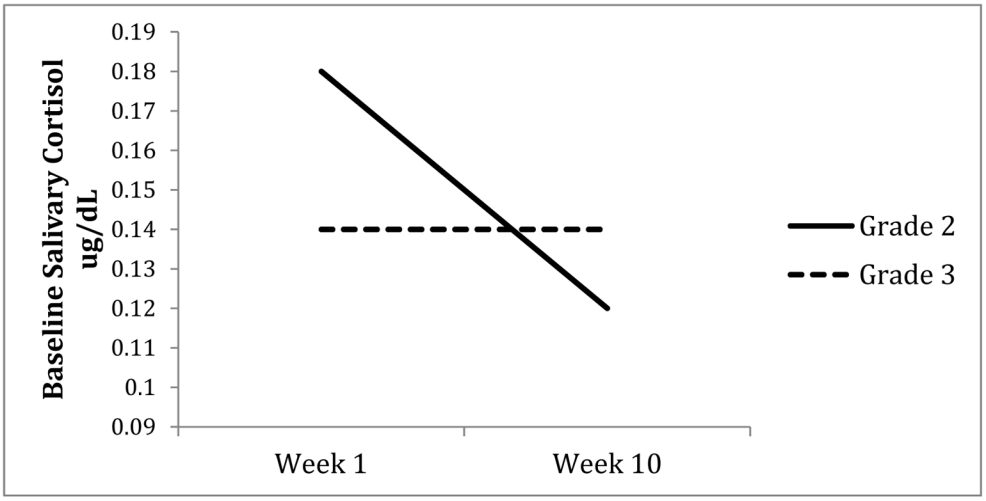

Figure 1.
Interaction between grade and time for baseline cortisol at Week 1 and Week 10 of the yoga intervention ($p < 0.01$)

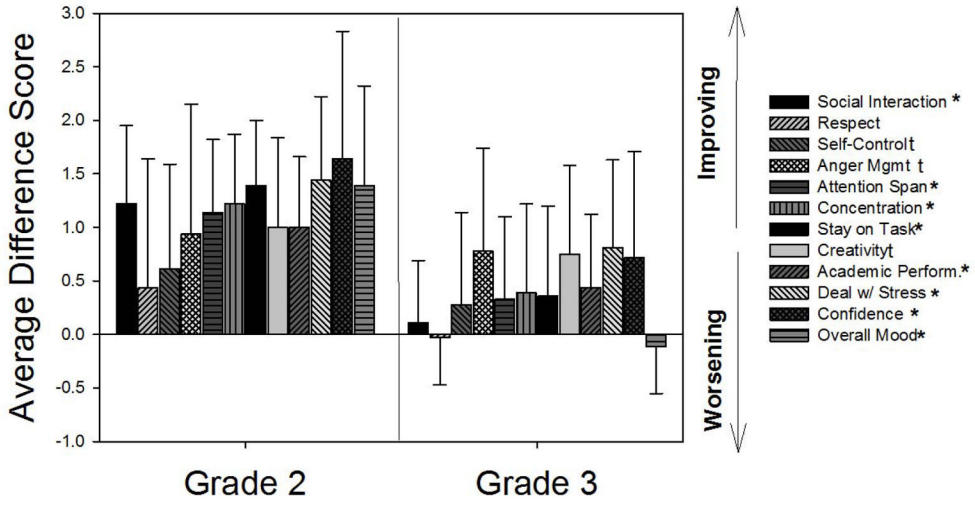

Figure 2.

Differences in teacher-rated behaviors between 2nd and 3rd grade students. Crosses (*t*) indicate a statistically significant ($p < 0.05$) main effect of Time (Week 1 vs. Week 10). Asterisks (*) indicate a statistically significant interaction between Grade (2 vs. 3) and Time (Week 1 vs. Week 10).

Table 1

Mean Salivary Cortisol Concentrations (ug/dL) Before and After the Yoga Program

Testing Session	Grade 2			Grade 3		
	Cortisol 1	Cortisol 2	Cortisol 3	Cortisol 1	Cortisol 2	Cortisol 3
Week 1	0.18±0.09	0.09±0.04	0.11±0.08	0.14±0.05	0.09±0.04	0.10±0.05
Week 10	0.12±0.06	0.10±0.07	0.09±0.07	0.14±0.07	0.12±0.06	0.10±0.06

Note: Data are reported as Mean ± Standard Deviation. “Cortisol 1” samples were gathered before any experimental procedures were preformed, “Cortisol 2” samples occurred after the ANT-C cognitive task was administered, and “Cortisol 3” samples were taken after participation in a single yoga class.

Table 2

Mean Scores on the Teacher-Rated Behavioral Observation Scale Before and After the Yoga Program

Construct	Grade 2		Grade 3		*F*-Statistic		
	Week 1	Week 10	Week 1	Week 10	Grade	Time	Interaction
Social Interaction	3.17±0.79	4.39±0.61	4.17±1.30	4.28±1.27	1.85	36.54***	25.37***
Respect	3.89±1.08	4.33±0.69	4.53±1.04	4.50±1.10	1.89	1.92	2.47
Self-Control	3.56±1.15	4.17±0.79	3.86±1.27	4.14±1.23	0.16	8.37**	1.18
Anger Management	3.56±1.04	4.50±0.62	3.53±1.33	4.31±1.26	0.12	22.38***	0.21
Attention Span	2.94±1.00	4.08±0.69	3.81±1.10	4.14±1.23	2.05	37.05***	11.09*
Concentration	2.89±0.83	4.11±0.68	3.81±1.06	4.19±1.18	2.90	42.05***	11.25*
Ability to Stay on Task	2.67±0.91	4.06±0.73	3.86±1.12	4.22±1.23	4.66*	51.55***	17.78***
Creativity	3.17±0.79	4.17±0.62	3.69±1.13	4.44±1.11	2.08	39.67***	0.81
Academic Performance	3.11±0.92	4.11±0.68	3.89±1.12	4.33±1.15	2.63	41.34***	6.12*
Ability to Deal w/ Stress/Anxiety	2.72±0.83	4.17±0.71	3.47±1.09	4.28±1.18	2.14	70.37***	5.67*
Confidence/Self-Esteem	2.67±1.19	4.31±0.71	3.67±1.18	4.39±1.05	3.29	42.11***	6.35*
Overall Mood	2.81±0.93	4.19±0.75	4.53±0.85	4.42±1.06	12.45**	27.67***	38.13***

Note: Data are reported as Mean ± Standard Deviation.

* = $p < 0.05$;

** = $p < 0.01$;

*** = $p < 0.001$