

# Impact of yoga on exercise and blood pressure in adolescents

## Abstract

**Background:** Adolescents with elevated body mass index (BMI) are at increased risk for future development of obesity-related diseases as adults. The applications of stress reduction programs such as yoga, especially for youth, are few. This study tested the impact of yoga, (yoga stretching and postures, meditation, alternate nostril breathing) delivered in a high school setting. The objective was to determine the impact of yoga on exercise habits and blood pressure (BP) among a population of overweight adolescents. Methods: Forty adolescents (21 Female/19 Male; 34 Black/6 White, mean age 16.1±1.7yrs) with BMI for age  $\geq$ 95th percentile by gender, (BMI:  $\geq$ 28 for girls;  $\geq$ 27 for boys) from high school health/physical education classes were randomly assigned to 10 weekly 50min. sessions of yoga at school (n=20), or evaluation only control (n=20) conditions. Participants were evaluated at pre- and 3months post-test, and at 3months follow up. Ambulatory BP measurements were obtained over 24hour periods in the natural setting using Space Labs 90207 BP monitors. A lifestyle behavior survey assessed exercise habits and physical activity.

**Results:** Self-reported yoga home practice averaged 29min/day; range=10-60min/day; mean= 4.1times per week; range 1-14times per week. Differences between groups at baseline did not reach statistical significance. A significant group by time interaction was observed for 24-hr systolic BP such that the yoga group decreased from 118.8±9.7 to 114.9±8.6mmHg compared to an increase (115.9±6.2 to 119.4±7.5mm Hg) in the control group across the 6-month study ( $p<.05$ ). 24-hr diastolic BP decreased in the yoga group from 66.1±6.1 to 64.1±6.5mm Hg while the controls increased from 65.0±4.2 to 66.0±7.5mm Hg across the 6-month study ( $p<.07$ ). The yoga group increased in days/week of >20 min of hard aerobic exercise from 2.2±2.0 to 2.9±1.6 compared to a decrease in the control group (3.1±2.2 to 2.1±1.7) across the 6-month study ( $p<.04$ ).

**Conclusion:** The findings were observed over a relatively short intervention period and suggest beneficial impact of yoga upon blood pressure and exercise in overweight adolescents. Replication and verification in a larger group with a longer follow-up is warranted.

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## Background

Adolescents with high body mass index (BMI) are at increased risk for future development of obesity-related diseases as adults.<sup>1</sup> Overweight in children and adolescents can result in a variety of adverse health outcomes, including hypertension, dyslipidemia, and the metabolic syndrome.<sup>2</sup> These problems present an urgent public health issue reflecting the effects of a sedentary lifestyle. Increased overweight and obesity in youth are a major contributor to pediatric hypertension.<sup>3</sup> Higher BMI has been associated with elevated systolic and diastolic blood pressure (BP) levels, indicating the importance of incorporating strategies for promoting educational programs on healthy lifestyles to prevent hypertension in adolescents.<sup>4</sup> There is a paucity of clinical trial evidence in this population, and development of prevention interventions for adolescents is a priority at the National Institutes of Health. Implementation of school-based primary prevention programs may over time help reduce the burden of obesity and the physiological/psychological burden associated with cardiovascular disease.

Yoga has become popular as a school-based approach.<sup>5</sup> Previous studies<sup>6</sup> have been limited by lack of objective measurement and randomization, factors which may be limited in generalizability and acceptance. Schools present a lucrative opportunity for yoga intervention programs,<sup>7</sup> and schools can implement changes that affect physical education and the acceptability of healthy behaviors.

Results suggest that school-based yoga programs may be appropriate for promoting healthy behaviors.<sup>8</sup> However, conclusions regarding efficacy of school-based obesity prevention programs are limited.<sup>9</sup> Although some school-based interventions have reported effects on overweight or obesity,<sup>10-12</sup> most, particularly those involving large cohorts,<sup>13,14</sup> have not,<sup>15</sup> and several short-term, school-based programs had little effect on BMI.<sup>16,17</sup> School-based prevention programs have been shown to be feasible, acceptable, and desirable for improving students' health status,<sup>18</sup> and improving school-related behavior.<sup>19</sup>

Yoga techniques to restore and maintain health, and to bring balance to the mind as well as the body, dates back as far as 5-8000years.<sup>20</sup> Yoga techniques have been documented to give a wide range of health benefits in adults. With regard to BP, yoga has shown decreases of 2.6% to 21.3% in systolic BP (SBP) and 4.9% to 24.2% in diastolic BP (DBP) (depending on the study design and subject population).<sup>5</sup> Although results are promising,<sup>21</sup> many studies have methodological shortcomings.<sup>22</sup> Cognitive-based programs providing hands-on experience have been particularly important for adolescents.<sup>23</sup> Meditation is an important component of yoga practice and has been shown to be an effective intervention in the treatment of physiological, psychosocial, and behavioral conditions among youth. Meditation studies with youth have shown compelling results, with median effect sizes slightly smaller than those obtained from adult samples, ranging from 0.16 to 0.29 for physiologic outcomes, and 0.27 to 0.70 for psychosocial and behavioral outcome.<sup>24</sup>

A number of studies have been conducted with adolescents with Transcendental Meditation<sup>TM</sup><sup>19,25-27</sup> and breathing awareness meditation (BAM).<sup>28-32</sup> A trial with BAM in normotensive 7<sup>th</sup> graders revealed significant improvements in resting SBP, daytime ambulatory SBP, DBP and heart rate (HR).<sup>28,33</sup> BAM has not only lowered BP but also has been shown to improve sodium handling and reduced hostility in adolescents.<sup>29,34,35</sup>

In a study with prehypertensive (high normal SBP) African American adolescents, decreases were observed of 3.9 mm Hg in daytime ambulatory SBP and 2.4 mm Hg in daytime ambulatory DBP in the TM group compared to a control group across 4-month visits and at 4-months follow-up.<sup>26</sup> At follow-up, significant changes from pre- to post-intervention were observed between BAM and control groups for school SBP, HR and nighttime SBP.<sup>29</sup> In summary, results with yoga are promising; however, few studies have been conducted in at-risk overweight adolescents.<sup>36,37</sup> Yoga practice fosters an increase in physical activity, promote flexibility in the physiology and provide coping skills such as relaxation. The hypothesis tested was that students who participate in a yoga intervention will exhibit lowered mean ambulatory daytime systolic blood pressure (SBP) and increased exercise levels (number of days per week of at least 20min of hard aerobic exercise activity), as compared to control students.

## Methods

The Human Assurance Committee of the Medical College of Georgia approved the study. The research was conducted in two Augusta Richmond County Georgia high schools in 2009. Written informed consent was obtained for forty adolescents (21F/19M; 34B/6W) with BMI  $\geq 95^{\text{th}}$  percentile for age and gender, (BMI:  $\geq 28$  for girls,  $\geq 27$  for boys) who were recruited from high school health/physical education classes. All subjects were healthy with self-report of no history of congenital heart defect, sickle cell disease, diabetes or any chronic illness or health problem requiring pharmacological treatment that would affect the study results (e.g., asthma medication). Subjects were randomly assigned to a 10-session intervention (n=20) or control (n=20) conditions. Using established protocols, anthropometric measurements were taken at school to screen for height (via stadiometer, to nearest 0.1 cm) and weight (via Detecto scale, to nearest 0.1 kg).<sup>38</sup>

Ambulatory BP monitoring (ABPM) has been shown to be relatively free of placebo effects, highly reproducible, and sensitive to small changes in average BP.<sup>39</sup> A major advantage of ABPM is that multiple readings obtained over a prolonged period of time provide a more reliable measure of overall BP while eliminating 'white coat' effects.<sup>40</sup> The ABPM methodology facilitates observing BP measures in real-life (at school and at night), assessing the generalization of treatment effects in out-of-laboratory situations.<sup>41</sup> Ambulatory BP measurements were obtained over 24-hour periods in the natural setting using SpaceLabs 90207 BP monitors (SpaceLabs, Inc., Redmond, WA). This monitor has been well-documented for its validity in children,<sup>42-45</sup> i.e., suitable for studies assessing 24-hour BP profiles, and has been in use in our laboratory for over 20years. Reproducibility findings with this monitor from a similar study are documented.<sup>46</sup> Our findings in youth have indicated that ambulatory SBP is stable across periods of time varying from 1 to 4years.<sup>47</sup> Participants were evaluated at pre-test, post-test at 3 mo. immediately following intervention and follow-up, 3months after intervention ended.

Questionnaires were selected based on their previous use in

youth behavior/cardiovascular health studies. Self-report surveys were chosen that place a minimal burden on the participant. All questionnaires were completed on scannable forms in the classroom and data was entered at the Georgia Prevention Institute. The subjects completed the following questionnaires at pre-test, post-test at 3 mo. immediately following intervention and follow-up, 3months after intervention ended: a Lifestyle behavior survey assessing exercise habits and physical activity;<sup>48</sup> and Youth Risk Behavior Surveillance lifestyle behavior questionnaire surveys intensity of physical activity.<sup>49</sup>

Yoga training provided in this study had two components: Somatic techniques including the sun-salutation stretching exercise and *yoga postures (asanas)*, and relaxation techniques including BAM and alternate nostril breathing (*pranayama*).<sup>50</sup> The techniques have different effects, e.g., *yoga postures* are practiced for greater strength, balance and flexibility. During asana practice, attention is directed to the breath, and awareness is brought to the area of the body that is being stretched or strengthened.<sup>51</sup> *Yoga postures* were provided that did not require special skill, and facilitated 'tuning in' to the body. BAM<sup>52</sup> is a simple technique using the breath as an object of focus and involves sitting upright in a comfortable position with eyes closed. Ten 1-hour yoga sessions were conducted (1 session per week for 10weeks) in a private location at school. The yoga and control groups were randomly selected from different schools in order to minimize cross-contamination. In between weekly sessions, and after the 10-week intervention, subjects were instructed to practice the yoga intervention at home on a daily basis. Compliance was monitored by self-report. Each instructional session was presented in a single 50min school class period. The yoga intervention was conducted during regular school class periods. An 'evaluation only' control was chosen based on study designs from other large scale studies.<sup>53</sup> Control subjects did not receive an intervention but received the regular health/physical education curriculum. 24-hr ambulatory SBP, DBP and HR and exercise behavior habits were analyzed using mixed model repeated measures ANOVAs, i.e., 2 (group: yoga vs. CTL) by 3 (time: pre-test vs. 3-and 6-month posttest) across the visits.

## Results

Demographic and anthropometric characteristics of the subjects at pre- and post- intervention are presented in Table 1.

**Table 1** Demographic and Anthropometric Characteristics

Characteristic	Yoga (n=20)	Control (n=20)
Age (years)	15.6 (1.6)	16.50 (1.9)
Sex (M/F)	10/10	9/11
Height (in)	67.0 (3.2)	66.4 (3.2)
Weight (lb)	243.6 (48.8)	247.6 (66.0)
BMI	38.0 (6.1)	39.3 (9.5)
SBP (mmHg)	118.8 (9.7)	115.9 (6.2)
DBP (mmHg)	66.1 (6.1)	65.0 (4.2)
HR (bpm)	78.1 (9.1)	81.8 (10.2)
20 min exercise (days/wk)	3.1 $\pm$ 2.2	2.2 $\pm$ 2.0

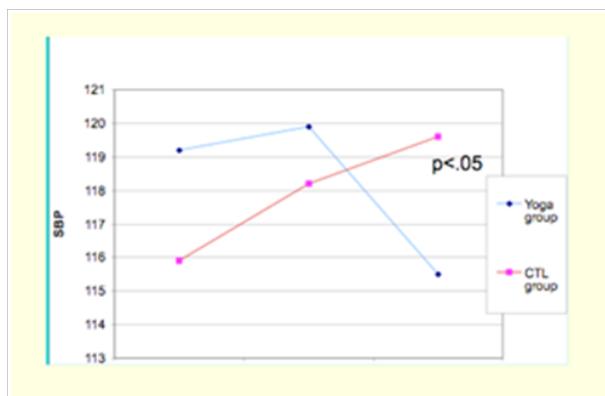
Values are mean ( $\pm$ SD). BMI: body mass index. SBP: systolic blood pressure. DBP: diastolic blood pressure.

HR: heart rate.

\* $p<0.05$  for pre to post intervention comparisons

Statistically significant changes in age, height, weight, waist circumference and body mass index (BMI) were observed across the three-month study period (all  $p<0.001$ ). However, no between-group differences were found for any anthropometric characteristics

(all  $p > .05$ ). Self-reported yoga home practice (mean=4.1 times per week; range 1-14 times per week) and number of minutes home practice each day (mean=29 min; range=10-60 min) indicated compliance with the intervention. A significant group by time interaction was observed for 24 hr systolic BP such that the yoga group decreased from  $118.8 \pm 9.7$  to  $114.9 \pm 8.6$  mmHg compared to an increase ( $115.9 \pm 6.2$  to  $119.4 \pm 7.5$  mmHg) in the control group (see Figure 1,  $p < .05$ ) across the 6-month study. 24-hr diastolic BP decreased in the yoga group from  $66.1 \pm 6.1$  to  $64.1 \pm 6.5$  mmHg while the controls increased from  $65.0 \pm 4.2$  to  $66.0 \pm 7.5$  mmHg ( $p < .07$ ). The yoga group increased in number of days per week with at least 20 min of hard aerobic exercise activity from  $2.2 \pm 2.0$  to  $2.9 \pm 1.6$  compared to a decrease ( $3.1 \pm 2.2$  to  $2.1 \pm 1.7$ ) in the control group ( $p < .04$ ) across the 6-month study.



**Figure 1** SBP changes at 3-mo posttest and 3-mo follow up.

## Discussion

This study reports effectiveness of yoga techniques upon 24-hr ambulatory blood pressure and exercise activity in overweight youth. Experience from this study suggests the feasibility of implementing such a program with adolescents during school hours. A critical barrier to progress in the field of childhood obesity is the lack of attention in interventions to the importance of the mind-body connection. A school-based approach has been shown to be suited for teaching behavioral skills.<sup>5,7,8,32,49,54</sup> A proposed mechanism by which a yoga training program may reduce BP and increase exercise activity has been suggested.<sup>55</sup> By directly stimulating the vagus nerve, mind-body training via yoga enhances parasympathetic output and shifts the autonomic nervous system balance from sympathetic to parasympathetic. This leads to favorable changes in cardiac-vagal tone.<sup>5</sup> Along with promotion of feelings of well-being, and increased energy, yoga training fosters beneficial effects on neuroendocrine status, metabolic function, and related inflammatory responses. Greater capacity for balance, homeostasis<sup>56</sup> and regulation of physiological signals may bring about a change in exercise behaviors and a wide range of side-benefits. Yoga training fosters better health and healthier behavior in adolescents.<sup>57</sup>

Although the findings of this pilot study are promising they should not be over-interpreted. The results require replication with a larger sample of youth. If replicable patterns are observed in studies with overweight adolescents and other at-risk groups, firmer conclusions could be drawn and a greater case for personalized cardiovascular disease prevention treatment programs in youth could be made. Our successful implementation of this approach suggests that replication and verification in a larger group with a longer follow-up is warranted.

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## Conflicts of interest

Author declares there are no conflicts of interest.

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