FITNESS

Effect of a 16-Week Yoga Program on Blood Pressure in Healthy College Students

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Abstract

The purpose of this study was to examine the effect of a 16-week yoga program on blood pressure (BP) in healthy college students. Twenty-five students (M_{age} = 28.24, SD = 10.64) participated in yoga class twice per week for 16 weeks. Thirty-one students (M_{age} = 28.77, SD = 7.23) attended a lecture (control condition) at approximately the same time as yoga. Resting systolic blood pressure (SBP) and diastolic blood pressure (DBP) were assessed at the beginning and end of the 16-week semester. Repeated measures ANCOVAs with pre-study BP as the covariate were used to test group BP differences across time (pre- to post-study). The SBP ANCOVA indicated yoga had a moderate statistically significant greater effect on lowering SBP compared to the control condition (p = .03, ES = .61). The DBP ANCOVA revealed that yoga produced a small statistically nonsignificant greater effect on lowering DBP compared to the control condition (p = .22, ES = .24). After the additional demographic variables were considered, regression

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analyses showed that the effect of yoga on lowering SBP compared to the control remained significant (p = .04), and the effect of yoga on lowering DBP compared to the control remained nonsignificant (p = .32). The results support regular yoga practice as a method of lowering SBP in healthy college students.

High blood pressure is present in about 3% of U.S. children, and the number of children and adolescents with high blood pressure-related conditions has nearly doubled from 1997 to 2006 (Tran et al., 2012). Consequently, young people are not immune to high blood pressure, and many will eventually develop the condition. High blood pressure, also called hypertension, is defined as a resting blood pressure (BP) of 140 over 90 mmHg or greater ("High blood pressure," 2012). Persons considered "normotensive" have normal BP readings of approximately 120 over 80 mmHg.

Lifestyle modifications such as exercise are associated with lower BP. A single session of aerobic exercise (e.g., Kenney & Seals, 1993) and regular aerobic exercise (e.g., Cornelissen & Fagard, 2005) have been shown to lower resting BP, and the BP lowering effects of aerobic exercise have been found in hypertensive and normotensive participants (Whelton, Chin, Xin, & He, 2002).

Yoga is a popular exercise-related activity (Birdee et al., 2008). Yoga positively affects mental and physical health, resulting in lower anxiety and improved emotional, social, and spiritual well-being (Ross & Thomas, 2010). Yoga is associated with reduced systolic BP (SBP) and diastolic BP (DBP) in hypertensive adults (McCaffrey, Ruknui, Hatthakit, & Kasetsomboon, 2005; Murthy, Rao, Nandkumar, & Kadam, 2011) and prehypertensive adults (Devasena & Narhare, 2011; Ramos-Jiménez, Hernández-Torres, & Wall-Medrano, 2011) and with lower SBP in adults with type 2 diabetes (Yang et al., 2011). As a result, yoga has been recommended for managing hypertension in at-risk groups (Douglas, Bakris, Epstein, Ferdinand, & Ferrario, 2003), although a number of studies lack a control group to validate experimental findings (e.g., Devasena & Narhare, 2011; Murthy et al., 2011; Ramos-Jiménez et al., 2011).

Yoga has not been recommended, however, as a method for reducing or maintaining BP in normotensive populations even though the majority of yoga participants are normotensive (Birdee et al., 2008). In fact, the National High Blood Pressure Education Program recommends lifestyle changes in normotensive persons as part of a preventive health strategy against high BP (Whelton, He, et al., 2002). Consequently, experimental research is needed on the potential for yoga to affect BP in healthy normotensive groups.

Therefore, the purpose of the present research was to assess the effect of yoga on resting BP in healthy college students as a way of testing the potential utility of yoga as a preventive health practice. Such preventive health practices align with the philosophy of physical education. Based on the existing literature, we tentatively hypothesized that participants completing a 16-week yoga program would show lower resting SBP and DBP compared to a sample of their peers in a lecture class control group.

Methods

Participants

The sample size was based on a statistical power estimate of .80 to detect an effect for the main analysis related to the hypothesis: Condition (yoga vs. control) × Time (pre- vs. post-study) BP interaction effect. The power analysis using G-Power software (Faul, Erdfelder, Buchner, & Lang, 2009) called for a sample of 52 participants. However, oversampling was employed because we anticipated students would drop or withdraw from class. Eighty-two students consented to participate, but 26 dropped out or were excluded because of poor attendance. Poor attendance was defined as missing more than 2 weeks of class (four sessions). After exclusions, 25 students were in the yoga class (experimental group) and 31 students were in the lecture class (control group) for a total of 56 participants. Four participants had taken the yoga class previously, although none of them had taken yoga in the semester prior to the study.

Procedure

Participants in the yoga class and lecture class were given the opportunity to earn bonus points toward their final grade by participating in the study. Students completed a demographic and health history questionnaire along with a university-approved consent form indicating they may withdraw from the study at any time without penalty. Students who chose not to participate remained in class. None of the students in the lecture course were enrolled in yoga, and none of the students in yoga were registered for the lecture course. Students in the experimental group participated in a 16-week (twice per week, 45-min per session) introductory hatha yoga class taught by an experienced yoga instructor. The yoga class followed the format of pre-relaxation, warm-up, main yoga postures, and final relaxation. Students in the control group were enrolled in a lecture format introductory exercise physiology course that also met twice per week at approximately the same time as the yoga class. Participants in the yoga and lecture class had their BP taken by a trained exercise physiologist during the first and final week of the semester. BP measurements were taken on nonexam days. BP measurements were assessed using manual auscultatory cuff sphygmomanometry with an Omron® Sprague Rappaport stethoscope and nylon Velcro cuff (Lakeforest, IL). In the yoga group, the first week BP (pre-study) was taken during pre-relaxation after students had been seated for 5 min. In the lecture class, the first week BP was taken after students arrived and were seated for 5 min before the start of the lecture. For the final week assessment (post-study), BP was taken during final relaxation in the yoga group and at the end of the lecture in the control condition. Participants were in a seated position for BP measurements. Standardized BP procedures were followed closely (Pickering et al., 2005). A student assistant recorded BP measurements and noted cuff size and arm (right or left) for purposes of replication at final week assessment. To reduce measurement error, all BP measurements were taken twice, and the average of the two assessments was used for data analysis.

Statistical Analyses

Preliminary analysis. Data were analyzed with SPSS 18.0 (SPSS, Chicago, IL) and *p*-values less than or equal to 0.05 were considered statistically significant. Means and standard deviations were computed for the numerical variables of BP, age, body mass index (BMI), and years of education. Two-tailed *t* tests were used to assess pre-study group differences on these variables. A chi-square was used to assess pre-study group differences for the categorical variable of gender.

Main analysis. Although pre-study SBP and DBP group differences were not statistically significant, the differences were far enough apart to warrant controlling for pre-study BP when examining Group (yoga vs. control) × Time (pre-study to post-study) BP changes. Accordingly, we performed a 2 (yoga vs. control) × 2 (pre-study to post-study) repeated measures analysis of covariance (ANCOVA) with pre-study BP as the covariate. One ANCOVA was conducted for SBP, and one ANCOVA was conducted for DBP. ANCOVA assumptions were tested and verified (Mertler & Vannatta, 2010). To complement the ANCOVA results, effect sizes were calculated to estimate the magnitude of the effect of yoga on pre- to post-BP change compared to the effect of the control on pre- to post-BP change. Effect sizes were calculated separately for SBP and DBP and judged as small, medium, or large using criteria developed by Hopkins (2011). Effect sizes were computed by subtracting the control group BP change score ($M_{\text{pre-study}} - M_{\text{post-study}}$) from the yoga group BP change score ($M_{\text{pre-study}} - M_{\text{post-study}}$) and dividing the difference by the pooled *SD* for the pre-study BP values (Hedges & Olkin, 1985). The pooled *SD* formula is shown below where n_y = yoga sample size, SD^2_y = yoga pre-study BP SD^2 value, n_c = control sample size, and SD^2_c = control pre-study BP SD^2 value.

$$SD\text{pooled} = \sqrt{\frac{(n_y - 1) \times SD_y^2 + (n_c - 1) \times SD_c^2}{n_y + n_c - 2}}$$

To further confirm the ANCOVA results, regression analyses were conducted to test the effect of yoga on BP compared to the control condition while accounting for additional participant characteristics. One regression was performed with post-study SBP as the dependent variable, and one regression was performed using post-study DBP as the dependent variable. The independent variables were age, BMI, gender (male = 0, female = 1), educational level, pre-study SBP or DBP (i.e., the ANCOVA covariate), and group (control = 0, yoga = 1). Assumptions were tested and verified (Mertler & Vannatta, 2010); in particular, the homogeneity of regression slope assumption was met as preanalyses showed no significant interaction between the categorical predictor of interest (group) and the covariate of interest (pre-study SBP or DBP). The regression independent variables were selected using the enter method, and the analyses were conducted with the default type III sum of squares.

Results

Preliminary Analysis

Table 1 displays results for pre-study participant characteristics for numerical variables. No statistically significant differences were found between yoga and control on any of the variables tested. The results for gender were yoga, 75% female, 25% male; control, 26% female, 74% male, $\chi^2(1) = 13.96$, $p < .001$, indicating a significant difference in the gender ratio between the yoga and control conditions.

Table 1
Pre-Study Participant Characteristics for Numerical Variables

Variable	*n*	*M*	*SD*	*t*	(95% CI) LL UL	*p*
Age (years)						
Yoga	25	28.24	10.64	0.22	(−4.27, 5.33)	0.82
Control	31	28.77	7.23			
BMI (kg/m^2)						
Yoga	24	27.17	5.95	−0.05	(−3.30, 3.15)	0.96
Control	25	27.10	5.88			
Education (years)						
Yoga	25	14.52	2.18	0.44	(−1.28, 0.82)	0.66
Control	28	14.75	1.60			
Pre-study SBP (mmHg)						
Yoga	25	117.48	12.33	1.38	(−10.29, 1.89)	0.17
Control	31	121.68	10.41			
Pre-study DBP (mmHg)						
Yoga	25	79.16	8.08	−1.13	(−1.97, 6.99)	0.26
Control	31	76.65	8.49			

Note. CI = confidence interval; LL = lower limit; UL = upper limit; BMI = body mass index.

Main Analysis

ANCOVA. The 2 × 2 SBP repeated measures ANCOVA showed a significant main effect for time, $F(1, 53) = 64.32$, $p < .001$, and a significant Group × Time interaction, $F(1, 53) = 5.05$, $p = .03$. The interaction result shows that after pre-study SBP was controlled, participants in the yoga condition experienced a significantly greater reduction in SBP from pre- to post-study compared to participants in the control condition. The SBP ES was .61 indicating a moderate effect of yoga on lowering SBP compared to the control. Specifically, the yoga treatment produced six tenths of a *SD* greater reduction in SBP compared to the control condition. The 2 × 2 DBP repeated measures ANCOVA revealed a significant main effect for time, $F(1, 53) = 36.38$, $p < .001$, indicating that after pre-study DBP was controlled, post-study DBP was lower in both groups. The Group × Time interaction was not significant, $F(1, 53) = 1.56$, $p = .22$. The

DBP ES was .24, indicating a small effect of yoga on lowering DBP compared to the control. Specifically, the yoga condition produced about a quarter of a *SD* greater reduction in DBP compared to the control condition, although this effect was not statistically significant. Table 2 displays pre- and post-study *M* and *SD* values for the yoga group and control group.

Table 2
Blood Pressure (mmHg) for Yoga and Control Conditions

	Pre-Study		Post-Study	
Condition	***M***	***SD***	***M***	***SD***
Yoga				
SBP	117.48	12.33	110.48	8.65
DBP	79.16	8.08	72.41	6.75
Control				
SBP	121.68	10.41	116.26	8.69
DBP	76.65	8.49	74.01	8.13

Note. SBP = systolic blood pressure; DBP = diastolic blood pressure.

Regression. After pre-study SBP, age, BMI, gender, and educational level were controlled, the regression coefficient and corresponding t value for group (control = 0, yoga = 1) remained statistically significant: $t(49) = -2.14$, $p = .04$. As was found with the ANCOVA, this result indicates a significantly lower post-study SBP in the yoga group compared to the control. After pre-study DBP, age, BMI, gender, and educational level were controlled, the regression coefficient and corresponding t value for group (control = 0, yoga = 1) remained nonsignificant: $t(49) = -0.84$, $p = .32$. As was found with the ANCOVA, this result indicates a nonsignificantly lower post-study DBP in the yoga group compared to the control.

Discussion

This study examined the BP responses of healthy college students enrolled in a 16-week yoga class (experimental group) compared to students in a lecture class (control group). The analysis revealed that participants in the yoga condition experienced a moderate statistically significant greater reduction in SBP and a small nonsignificant greater reduction in DBP compared to participants in the control group. After additional variables with regression analysis were considered, the effect of yoga on lowering SBP compared to the control remained significant and the effect of yoga compared to the control on lowering DBP remained nonsignificant. Therefore, the results support the hypothesis for SBP and partially support the hypothesis for DBP.

The SBP results in the present study agree with McCaffrey et al. (2005) and Murthy et al. (2011) for hypertensive persons and with Ramos-Jiménez et al. (2011) for prehypertensive individuals. Several factors may account for the significant reduction in SBP in the yoga condition. First, stress tends to raise BP and increase the risk of developing hypertension in susceptible persons (e.g., Hamer & Steptoe, 2012), whereas consistent yoga reduces stress, produces a calming effect, and therefore likely lowers resting BP. College students often are stressed, and although the sample was normotensive, they likely were experiencing some stress, and the stress lowering effect of yoga may have contributed to lower SBP at the end of the semester. Second, yoga has been shown to produce a positive effect on mental and physical health by downregulating the hypothalamic–pituitary–adrenal axis (HPA axis) and sympathetic nervous system (Ross & Thomas, 2010). A less active sympathetic nervous system results in lower levels of catecholamines (epinephrine and norepinephrine), a slower heart rate and decreased stroke volume, and therefore lower SBP (Koeppen & Stanton, 2008). Additionally, yoga postures involving supine positions allow the heart rate to slow down (Jones et al., 2003) and thereby help reduce SBP. The effect of regular yoga on lower resting SBP found in the current study may be related to these physiological mechanisms.

The present research found a small but nonsignificant effect of yoga on lowering DBP compared to the control. One potential explanation for the nonsignificant finding is the challenge of detecting DBP changes in a normotensive sample. The average pre-study DBP in both groups was less than 80 mmHg, possibly creating a floor effect, making it difficult to detect changes. A longer treatment period may have allowed for further decreases in DBP, and a larger sample may have produced greater statistical power to identify a change. However, despite the nonsignificant result, the yoga group showed a 7.0 mmHg mean reduction in DBP from pre- to post-study.

The yoga and control group showed a mean reduction in SBP and DBP from pre- to post-study. Although this was not expected, one possible explanation is that both groups experienced a "semester effect" in that students are often more anxious at the start of the semester before they settle into the routine and get to know their peers and instructors. This may explain why both groups showed decreases in SBP and DBP.

This study has several strengths. First, uniform BP procedures were employed to increase accuracy and reduce measurement error. Second, unlike several studies in this area, a control group allowed for a standard of comparison alongside the yoga condition. Third, a trained and experienced yoga instructor taught all yoga sessions over the 16-week period. The study also has limitations such as non-random assignment to the yoga and control conditions and a relatively high attrition rate (i.e., 26 participants dropped out or were excluded from a total of 82). In addition, participants were not queried about other stress-reducing activities such as exercise outside of class, which could confound the results. Readers should consider these limitations when interpreting the findings.

Despite limitations, this study adds to the literature by providing evidence for a link between consistent yoga practice and lower resting BP in healthy young adults. The results also offer support for yoga as a preventive health activity. For example, high BP is a major risk factor for cardiovascular disease, and this research shows yoga as a potentially effective method for decreasing BP even in normotensive samples, a group for whom lifestyle modifications are encouraged for preventing hypertension (Chobanian et al., 2003). The relevance of this study, therefore, is related to creating awareness of the health benefits of regular yoga practice and to propose including yoga as part of a well-rounded physical education and health curriculum.

Recommendations for future research include tracking physical activity, body weight, and stress levels during yoga and control conditions to determine whether changes in these variables moderate the effect of yoga on BP. Researchers also may consider measuring BP during yoga sessions, particularly during postures hypothesized to impart changes in BP. These suggestions may lead to additional insights about the effect of yoga on SBP and DBP. Further study is important because lifestyle modifications are associated with lower resting BP and may even prevent hypertension.

In conclusion, this study provides evidence that a 16-week yoga class significantly lowers resting SBP compared to a lecture class control group. Yoga also lowered DBP, but the effect was small and nonsignificant relative to the control condition. The results support regular yoga practice as a means of lowering SBP in healthy college students.

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