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CROSS SECTIONAL YOGA STUDY

Hatha yoga and vascular function: Results from cross-sectional and interventional studies

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Summary The aim of this study was to determine the effect of hatha yoga on arterial elasticity and endothelial function. First, a cross-sectional study was performed to determine whether yoga practitioners would demonstrate greater arterial compliance and endothelium-dependent vasodilation than their sedentary peers. Second, an intervention study involving 13 sedentary middle-aged and older adults (51 ± 7 years) was performed to determine whether 12 weeks of hatha yoga would elicit increases in arterial compliance and endothelial function. In the cross-sectional study involving a total of 34 subjects, there were no group differences in body fatness, blood lipid and lipoprotein concentrations, carotid artery compliance or brachial artery flow-mediated dilation (FMD). Hemoglobin A1c was lower in yoga practitioners than in sedentary adults ($P < 0.05$). Total cholesterol and hemoglobin A1c decreased after the intervention ($P < 0.05$) while carotid artery compliance and brachial artery FMD did not change. The results of both cross-sectional and interventional studies indicate that regular practice of hatha yoga is not associated with improvements in vascular functions.

Introduction

Arterial stiffening and endothelial dysfunction occur early in the pathogenesis of vascular disease and progress as a silent asymptomatic disease process. These vascular

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functions are both powerful independent predictors of cardiovascular risk (Boutouyrie et al., 2002, Chan et al., 2003). Accordingly, interventions that can delay or reverse these two key vascular changes hold promise for minimizing future cardiovascular events.

Yoga is a practice that has been performed for over 5000 years in Eastern parts of the world and is gathering increasing popularity in the U.S. as a means of enhancing overall health (Barnes et al., 2008). However, there is very limited information available concerning the effect of hatha yoga on vascular function.

Hatha yoga includes various elements that could potentially and beneficially influence vascular function. For example, stretching is a primary component of various yoga postures. Our laboratory has previously demonstrated that 12 weeks of stretching improved carotid artery compliance in previously sedentary adults (Cortez-Cooper et al., 2008). Negative correlations between trunk flexibility and arterial stiffness have also been reported in middle-aged and older adults (Yamamoto et al., 2009). Another component of hatha yoga that could impact vascular function is the isometric contractions associated with yoga postures. Isometric exercise training has been reported to reduce blood pressure and enhance endothelial function (Mcgowan et al., 2007, Millar et al., 2012). Meditation is another component of hatha yoga that could act as a stress reduction strategy (Melville et al., 2012) that could improve vascular function (Cooper et al., 2010) presumably through reductions in sympathetic vasoconstrictor tone.

Taken together, hatha yoga appears to be an ideal intervention strategy to enhance vascular function judging indirectly from the effect of each constituent of hatha yoga on vascular function. Yet, there were no experimental data to support this hypothesis. One previous cross-sectional study found lower arterial stiffness among yoga practitioners than in sedentary controls, but failed to control for body mass index or physical activity aside from yoga practices (Duren et al., 2008). Therefore, it is still unknown whether yoga elicits improvements in this key outcome variable. To date, no intervention studies have been conducted to determine the role of hatha yoga in modulating arterial stiffness.

Accordingly, the primary aim of the present study was to determine the role of hatha yoga in improving arterial elasticity and endothelium-dependent vasodilation. To comprehensively address this aim, we used two different but related approaches (Tanaka et al., 2000). First, the cross-sectional study was designed to determine whether habitual yoga practitioners would demonstrate greater arterial compliance and endothelium-dependent vasodilation than their sedentary peers. Second, we performed the follow-up intervention study to determine whether 12 weeks of hatha yoga would elicit increases in arterial compliance and endothelial function in previously sedentary adults. We hypothesized that regular practice of hatha yoga would be associated with greater arterial compliance and endothelium-dependent vasodilation. As the tertiary aim, we have also addressed the influence of hatha yoga on risk factors for coronary heart disease as many claims have been made on the association between yoga practices and these measures (Cade et al., 2010; Innes et al., 2005; Yang et al., 2011).

Materials and methods

Subjects

Potential subjects who responded to flyers and yoga studio invitations completed a health history questionnaire in order to determine eligibility. Exclusion criteria for study participation included: i) pregnancy, ii) smoking within the past six months, iii) uncontrolled hypertension, iv) diabetes, and v) other chronic diseases. No subjects were taking any cardiovascular medications at the time of the study.

For the cross-sectional study, a total of 51 subjects (28 sedentary and 23 yoga practitioners) were initially recruited and tested for the current study. Sedentary subjects participated in $<$2 days/week of physical activity for the past 6 months, and yoga practitioners must have practiced at least 1 h of hatha yoga 3 days/week for 3 years prior to their participation in the study. In order to isolate the effect of hatha yoga on key outcome variables as much as possible, yoga practitioners who engaged in aerobic exercise training more than two days per week were excluded. Additionally, in order to eliminate the potential confounding effect of body fatness, individuals with body mass index (BMI) values below 18.5 and above 30 were excluded. After all exclusions were made, a total of 34 apparently healthy subjects (18 sedentary and 16 practitioners) were included in the analyses for the cross-sectional study. For the interventional study, 13 previously sedentary middle-aged and older subjects (51 $\pm$ 7 years) were studied before and after the hatha yoga intervention. The study procedures were approved by the local institutional review board, and all the subjects provided their written informed consent.

Measurements

Subjects were required to fast for at least 12 h prior to testing in order to obtain fasting blood samples. Additionally, at least 4 h of fasting was required for the vascular function measures in order to avert the effects of food consumption and the associated hormonal responses (Giannattasio et al., 2005, Greenfield et al., 2007, Vogel et al., 1997). All vascular measurements were performed in a quiet temperature-controlled laboratory room and in the morning to avoid diurnal changes in dependent variables. Premenopausal female subjects were tested during the early follicular phase of the menstrual cycle.

Body composition

Body composition was estimated via dual-energy X-ray absorptiometry (GE Medical Systems, Fairfield, CT).

Blood lipids, lipoproteins, and glycosylated hemoglobin

Blood samples were obtained and analyzed for total-, HDL- and LDL-cholesterol, and triglyceride concentrations and glycosylated hemoglobin (HbA1c). Blood lipid and lipoprotein concentrations were determined enzymatically. HbA1c was analyzed using the Micromat II (BIO RAD, Hercules, CA).

Carotid artery compliance

Carotid artery compliance was measured by simultaneous acquisition of ultrasonographic arterial diameter images