Restorative Yoga in Adults with Metabolic Syndrome: A Randomized, Controlled Pilot Trial

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Abstract

Background: Metabolic syndrome increases the risk of diabetes and cardiovascular disease. Yoga improves some metabolic parameters, but it has not been studied in persons with metabolic syndrome. We conducted a randomized controlled pilot trial to determine whether a restorative yoga intervention was feasible and acceptable in underactive, overweight adults with metabolic syndrome.

Methods: Twenty six underactive, overweight adult men and women with metabolic syndrome were randomized to attend 15 yoga sessions of 90 minutes each over 10 weeks or to a wait-list control group. Feasibility was measured by recruitment rates, subject retention, and adherence. Acceptability was assessed by interview and questionnaires. Changes in metabolic outcomes and questionnaire measures from baseline to week 10 were calculated.

Results: A total of 280 people were screened by phone, and 93 with high likelihood of metabolic syndrome were invited to a screening visit. Of the 68 who attended screening visits, 26 (38%) were randomized, and 24 (92%) completed the trial. Attendance at yoga classes and adherence to home practice exceeded our goals. In the yoga group, all participants gave the study the highest possible satisfaction rating, and the majority (87%) felt that the yoga poses were easy to perform. There was trend to reduced blood pressure ($p = 0.07$), a significant increase in energy level ($p < 0.009$), and trends to improvement in well-being ($p < 0.12$) and stress ($p < 0.22$) in the yoga versus control group.

Conclusions: Restorative yoga was a feasible and acceptable intervention in overweight adults with metabolic syndrome. The efficacy of yoga for improving metabolic parameters in this population should be explored in a larger randomized controlled trial.

Introduction

ONE QUARTER OF THE U.S. adult population has the metabolic syndrome,¹ which is a major risk factor for the development of type 2 diabetes^{2,3} and cardiovascular disease (CVD).^{3–5} Several large trials have shown that the risk of developing diabetes can be decreased with rigorous lifestyle interventions involving weight loss and increased physical activity.^{6–8} People who are overweight and sedentary are at highest risk for metabolic syndrome, but their ability to participate in and to adhere to a vigorous exercise regimen may be limited.

Stress may play a role in the development of metabolic syndrome,^{9–13} and relaxation techniques such as yoga could

serve as effective adjuncts to other lifestyle modifications. Clinical trials have demonstrated the benefits of yoga in diabetes,¹⁴ hypertension,¹⁵ dyslipidemia,¹⁶ and atherosclerosis.¹⁷ No studies have specifically examined the effects of yoga in patients with obesity or metabolic syndrome, but a recent comprehensive review of the literature found that yoga improved specific metabolic risk factors, including blood pressure, lipid profiles, body mass index (BMI), and insulin sensitivity.¹⁸ We conducted a randomized, controlled pilot trial to evaluate the feasibility and acceptability of restorative yoga in overweight, underactive adults with metabolic syndrome. We also estimated the preliminary efficacy of yoga on metabolic outcomes, stress level, and quality of life.

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Methods

Design and participants

Participants were men and women aged 30–65 who met the National Cholesterol Education Program (NCEP) criteria for metabolic syndrome,¹⁹ defined as three or more of the following indicators: fasting blood sugar ≥ 100 mg/dL; systolic blood pressure ≥ 130 mmHg, diastolic blood pressure ≥ 85 mmHg, or use of antihypertensive medication; high-density lipoprotein cholesterol (HDL-C) < 40 mg/dL for men or < 50 mg/dL for women; triglycerides ≥ 150 mg/dL; and waist circumference ≥ 102 cm for men or ≥ 90 cm for women. We excluded persons who engaged in any moderate exercise for more than 150 minutes per week. Other exclusion criteria were pregnancy or lactation, coronary heart disease event or hospitalization in the preceding 6 months, use of medications that affect insulin sensitivity, substance abuse, and regular yoga practice. We also excluded those who had unstable medical or psychiatric conditions that would limit their ability to complete the study.

All interested persons were screened by telephone to assess preliminary eligibility. We used self-reported height and weight to calculate body mass index (BMI). To optimize recruitment of participants who would meet criteria for metabolic syndrome, those who reported a BMI ≥ 25 kg/m² and at least one other risk factor for metabolic syndrome were invited for a visit. At the screening visit, we measured seated blood pressure and waist circumference and obtained fasting venous blood for determination of glucose, HDL-C, and triglycerides. If the participant fulfilled the criteria for metabolic syndrome, they were invited for a second visit. At this baseline visit, participants provided a medical history, had fasting venous blood drawn for laboratory measures and a 2-hour oral glucose tolerance test, completed questionnaires, and had blood pressure and anthropometry measurements.

Randomization and interventions

At the end of the visit, we randomized participants to the yoga or control group within four strata defined by sex and race/ethnicity (white vs. nonwhite) using blocks of size 2. The yoga group attended a 3-hour introductory class followed by 90-minute classes twice weekly during weeks 1–5 and weekly during weeks 6–10. All yoga classes were taught by two certified yoga instructors. The control group received no intervention during the study. Participants in both groups were asked not to make any changes to their diet and exercise regimens during the study. After completion of the final study visit, control group participants received a gift certificate for restorative yoga classes and a set of yoga props and instruction materials identical to those used by the yoga group. The study was approved by the Institutional Review Board of the University of California, San Francisco, and all participants provided written informed consent prior to enrollment in the study.

The intervention included restorative yoga poses, a form of yoga that emphasizes relaxation and uses props to provide total support of the body. We convened an expert panel of four certified yoga teachers, each with years of experience in teaching yoga to persons with a variety of health conditions and flexibility limitations. This panel reached a consensus that restorative yoga postures would be the most fea-

sible in this study population and would maximize the relaxation response.

Each group yoga class consisted of a brief series of warm-up stretches and breathing exercises followed by 10 poses that were held for 5–10 minutes each. Poses included Half-Dog at the Wall, Wall Hang, Seated Bound Angle Pose, Seated Wide Angle Pose, Reclining Twist, Supported Bridge, Supported Legs Up the Wall, Child's Pose, Supported Lying Down Bound Angle, and Deep Relaxation Pose. Standard modifications were used if participants experienced any discomfort in the poses. Participants in the yoga group were instructed to practice at home for at least 30 minutes three times per week and received a practice log book. To assist with home practice, each participant received all necessary yoga props, a manual with photos and instructions for each pose, and an audio compact disc describing the postures.

Outcomes and follow-up

Feasibility and acceptability measures. Feasibility was measured by the number of telephone and in-person screening visits and the rate of participant recruitment. We measured adherence to the yoga intervention by attendance at the yoga classes and self-reported frequency and duration of home yoga practice. We requested that all participants assigned to the yoga group attend at least 13 of the 15 group yoga classes over the course of the 10-week pilot trial. Acceptability and satisfaction were measured through an interview at the final yoga class and through questionnaires at the final visit.

Metabolic measures. Weight and height were measured using standard protocols with participants wearing light clothing without shoes. BMI was calculated by dividing weight in kilogram by height in meters squared. Abdominal circumference was measured twice with a flexible tape measure midway between the lowest rib and the iliac crest. Two measures of blood pressure were taken with a mercury sphygmomanometer after the participant was seated for at least 5 minutes, and systolic and diastolic blood pressure were estimated as the mean of the two measures. At the baseline and final visit, a venous catheter was inserted into a hand or arm vein. Participants then drank a 75-gram glucose solution, and blood samples were drawn at 0, 30, 60, 90, and 120 minutes. We calculated the insulin sensitivity index as described by Matsuda and colleagues ($10,000/\text{square root of } [\text{fasting glucose} \times \text{fasting insulin}] \times [\text{mean glucose} \times \text{mean insulin during the oral glucose tolerance test}]$). This insulin sensitivity index is highly correlated with the euglycemic clamp technique.²⁰ Plasma glucose was measured at the University of California, San Francisco, using an automated analyzer with an immobilized enzyme biosensor (YSI 2300 STAT Plus, YSI Life Sciences, Yellow Springs, OH). Plasma insulin was measured in duplicate by radioimmunoassay (Millipore, St. Charles, MO). Triglycerides and HDL-C were measured with enzymatic calorimetric methods (Quest Diagnostics, San Jose, CA). LDL-C was calculated using Friedewald's formula.²¹

Questionnaire measures. We obtained demographic information (sex, age, race/ethnicity, education, and marital

TABLE 1. BASELINE CHARACTERISTICS OF PARTICIPANTS BY TREATMENT GROUP

Characteristic	Yoga group (n = 12)	Control group (n = 12)
Demographic data		
Mean age (SD), years	52 (9)	52 (8)
Women (%)	75	92
White (%)	67	25
African American (%)	17	17
Latino/Hispanic (%)	8	33
Asian/Pacific Islander (%)	8	25
Some college (%)	50	42
Bachelor's degree or higher	50	58
Number of metabolic syndrome criteria (SD)	3.5 (0.7)	3.4 (0.7)
Waist circumference > 102 cm (m), >88 (f)	100	100
Blood pressure $\geq$ 130/85 or medication	67	92
Fasting glucose $\geq$ 100 mg/dL	83	58
HDL-C $\leq$ 40 mg/dL (m), $\leq$ 50 (f)	50	58
Triglycerides $\geq$ 150 mg/dL	42	42
Mean body mass index (SD), kg/m ²	37 (6)	35 (6)
Medication use		
ACE inhibitors/ARBs (%)	42	17
Beta blockers (%)	8	17
Statins (%)	8	8

Note: SD = standard deviation; m = male; f = female; ACE = angiotensin converting enzyme; ARB = angiotensin receptor blocker; HDL-C = high-density lipoprotein cholesterol.

status) and information about chronic diseases. Stress was measured with Cohen's Perceived Stress Scale, a 10-item questionnaire that is widely validated and used clinically.²² We used the 2005 Block Food Frequency questionnaire, a 110-item instrument, to assess total caloric intake and percentage of calories derived from fats, carbohydrates, and protein.²³ To measure physical activity, we used a validated 24-item questionnaire that asked participants to rate their hourly participation in various activities over the previous 4 weeks.^{24,25} Energy level and psychological well-being were measured with validated subscales of the Medical Outcomes Study Short-Form 36-Item Health Survey (SF-36).^{26,27} We assessed depression with the 10-item Center for Epidemiologic Studies Depression Scale (CES-D).^{28,29} Participants also rated their overall health from "poor" to "excellent" on a 5-point Likert scale.

Statistical analysis

All participants with outcome measures were included in the primary analyses. Differences in baseline characteristics for the yoga and control groups were compared using *t*-tests for continuous variables and Wilcoxon or chi-squared tests for dichotomous variables. Changes from baseline to week 10 in continuous outcome variables comparing the yoga versus control group were analyzed using the Student *t*-test with a level of significance of $\alpha = 0.05$, two-tailed.

We conducted sensitivity analyses that excluded 2 participants in the control group who started diets during the intervention and had lost over 5-kg each and 1 participant in the yoga group who had uncontrolled diabetes with highly variable glucose values from the analyses of physical examination and laboratory outcomes. All analyses were performed using SAS software (version 9.0).

Results

Baseline characteristics

Baseline characteristics of the participants are shown in Table 1. The mean age was 52 ± 9 years old, 83% were women, and 54% were nonwhite. Participants had an average of 3.5 ± 0.7 metabolic syndrome criteria, with all participants fulfilling the waist circumference criterion and the majority meeting criteria for hypertension, fasting glucose, and HDL-C. Mean BMI was 36 ± 6 kg/m², and 92% of the participants were obese (BMI ≥ 30 kg/m²).

Feasibility and retention

We interviewed 280 people by phone, of whom 93 (33%) were eligible to attend the screening visit (Figure 1). The main reasons for exclusion based on telephone screening were scheduling conflicts with the yoga classes or a BMI below the cut off for overweight. Of those who were eligible, 68 (73%) attended the screening visit and 30 (44%) of these fulfilled study eligibility criteria and were invited to enroll. Of the 30 eligible participants, 2 (7%) did not attend a baseline visit and 2 (7%) did not complete the visit due to problems with phlebotomy and the glucose tolerance test. A total of 26 participants were randomized (14 to yoga and 12 to the control group).

One man in the yoga group dropped out before starting yoga training due to transportation difficulties and 1 woman in the yoga group dropped out after attending three classes, citing difficulties with both childcare and transportation. All 24 (92%) of the remaining participants (12 in each group) returned for the final study visit at the end of the 10-week trial.

The mean number of yoga classes attended was 14 ± 2 (range 11–17). With the exception of one participant, who

FIG. 1. Study design.

did not return her practice logs, the mean home practice time was 117 ± 49 minutes per week.

Acceptability

Feedback from the final study interviews was positive, with the majority of participants stating they enjoyed learning yoga and felt that participating in the study had been beneficial. All participants in the yoga group reported being “very satisfied” with the intervention. The majority (87%) felt that practicing restorative yoga was “very easy” or “moderately easy,” and the remaining 13% responded that the yoga intervention was “neither easy nor difficult.” There were no adverse effects reported. Participants felt the most bothersome requirement of the study was practicing yoga at home (33%).

Metabolic outcomes

We found trends toward improvement in systolic blood pressure (9.2 mmHg difference between the yoga and control groups; $p = 0.07$) and diastolic blood pressure (4.6 mmHg difference; $p = 0.10$) (Table 2). Although change in weight and BMI favored the yoga group, these differences were not statistically significant. Laboratory measures did not differ between the treatment groups. Excluding the 2 control participants who violated the study protocol and the 1 yoga group participant with uncontrolled diabetes strengthened the trends for less weight gain ($p = 0.13$), lower increase

in BMI ($p = 0.10$), and reduced diastolic blood pressure ($p = 0.07$) but did not substantially change the results for laboratory measures.

Questionnaire outcomes

The yoga group had significant improvements in energy level ($p < 0.009$) and trends towards improvement in psychological well-being ($p < 0.12$) and stress ($p < 0.22$) (Table 2). Change in physical activity and dietary intake from baseline to end of study did not significantly differ between the groups.

Discussion

Our results demonstrate that it is feasible to recruit overweight, underactive individuals with metabolic syndrome for a randomized trial of restorative yoga. Despite their lack of experience with yoga and their generally sedentary lifestyles, participants easily learned the yoga postures and were able to practice them at home. Attendance at study visits was excellent in both study groups, and the yoga group exceeded our goals for adherence to classes and to home practice. In addition, we had excellent retention of study participants and high rates of participant satisfaction. Although this pilot study was not designed to determine efficacy based on changes in metabolic measures, we observed trends toward lower blood pressure and better weight maintenance in the yoga group. Compared to the control group, the yoga

TABLE 2. CHANGES IN BASELINE TO WEEK 10 IN PHYSICAL EXAMINATION, LABORATORY, AND QUESTIONNAIRE MEASURES

Variable	Change in yoga group (n = 12)	Change in control group (n = 12)	Absolute difference in change	p value
Physical exam measures				
Weight (kg)	-0.1 (2.7)	+2.2 (9.0)	2.3	0.36
BMI (kg/m ²)	-0.1 (0.9)	+0.8 (2.7)	0.9	0.30
Waist circumference (cm)	-2.7 (3.0)	-2.7 (5.0)	0.0	0.99
Systolic bp (mmHg)	-3.6 (13.9)	+5.6 (9.3)	9.2	0.07
Diastolic bp (mmHg)	-3.0 (6.4)	+1.6 (6.9)	4.6	0.10
Laboratory measures				
Insulin sensitivity index	-0.1 (1.0)	+0.2 (1.0)	0.3	0.44
Fasting glucose (mg/dL)	+2.6 (9.3)	-2.0 (9.3)	-4.6	0.24
2-hour glucose (mg/dL)	-6.0 (35.1)	-11.6 (22.5)	-5.6	0.66
Total cholesterol (mg/dL)	-5.1 (32.4)	10.2 (22.2)	15.3	0.19
LDL-C (mg/dL)	-1.4 (21.0)	6.9 (23.2)	8.3	0.36
HDL-C (mg/dL)	-2.0 (9.9)	+1.7 (3.5)	3.7	0.24
Triglycerides (mg/dL)	-8.8 (59.8)	+7.9 (49.1)	16.7	0.46
Questionnaire measures				
Perceived Stress Scale	-0.3 (0.6)	-0.1 (0.4)	0.3	0.22
Energy level	0.7 (0.7)	0.02 (0.5)	-0.7	0.009
Psychological well-being	0.3 (0.5)	0.02 (0.4)	-0.3	0.12
Depression	-0.1 (0.5)	-0.1 (0.4)	0.1	0.69
Self-rated health	0.2 (0.6)	-0.1 (0.7)	-0.3	0.34
Diet (total kCal/day)	233 (1462)	154 (546)	-78	0.86
Physical activity (hrs/wk)	2.0 (9.1)	1.6 (3.9)	-0.4	0.89
Physical activity (METs)	114 (1611)	-47 (597)	-161	0.75

Note: BMI = body mass index; LDL-C = low-density lipoprotein cholesterol; HDL-C = high-density lipoprotein cholesterol; MET = metabolic equivalent task.

group had significantly improved energy levels and trends toward improved psychological well-being and perceived stress.

To our knowledge, this is the first trial of a yoga intervention in individuals with metabolic syndrome. Prior studies have examined the use of yoga in people with diabetes and the effects of yoga on components of the metabolic syndrome. A controlled trial among 35 diabetics demonstrated that yoga significantly reduced fasting and postprandial blood glucose, insulin-glucose ratio, and requirements for oral hypoglycemics and insulin.³⁰ In another controlled trial of 21 type 2 diabetics, a 12-week integrated yoga program resulted in a significant reduction in fasting blood glucose and glycosylated hemoglobin.³¹ A more recent uncontrolled study of 24 type 2 diabetics who were trained in yoga for 40 days found significantly decreased fasting glucose (-48.6 mg/dL, $p = 0.001$), postprandial glucose (-74.7 mg/dL, $p = 0.001$), and glycosylated hemoglobin (-1.2%, $p = 0.03$) after the yoga intervention.³²

A recent systematic review of yoga for treatment of metabolic risk factors identified 12 randomized controlled trials of the effects of yoga on blood pressure.¹⁸ Of these, 9 (75%) found significant improvements in blood pressure in the yoga versus control groups with reductions ranging from 3 to 21% for systolic and 5 to 24% for diastolic blood pressure. However, four of these studies included other interventions, such as exercise or biofeedback, making it difficult to isolate the effects of yoga. The same review identified five randomized controlled trials of yoga for lipid lowering. All involved participants with CVD risk factors or established CVD. One small trial of 35 participants found no significant

difference in lipid levels. Of the remaining four trials, three found significant reductions in total cholesterol, low-density lipoprotein cholesterol (LDL-C), and triglycerides in the yoga versus control groups whereas one found significant improvement only in triglycerides.

Although no trial has been specifically designed to evaluate the effect of yoga on adiposity or body composition, several have reported change in body weight as an ancillary outcome. A 1-year randomized controlled trial of a comprehensive yoga program versus conventional risk factor control in 42 men with angiographically confirmed coronary artery disease found a statistically significant weight reduction among those randomized to yoga (-6.8%) compared to control (0%, $p = 0.005$).¹⁷ In another randomized controlled trial of yoga versus conventional cardiac risk factor control, there was a trend toward greater weight loss in the yoga group (-3.8%) compared with control (-0.6%).¹⁶ In these studies, the baseline mean weight for both of the groups was 72-74 kg, with no mention of BMI, waist circumference, or other measures of adiposity or fat distribution. The results of these trials may overestimate the benefits of yoga if participants assigned to yoga changed their diet or physical activity resulting in weight loss. We specifically instructed our participants not to make any new lifestyle changes, and, with the exception of the 2 control group participants who started diets, detailed dietary and physical activity questionnaires revealed no significant changes in either group.

Our restorative yoga intervention differs from standard exercise interventions aimed at improving components of the metabolic syndrome. Restorative yoga poses involve resting with the body supported for several minutes at a time. While

in these poses, participants were instructed to relax and focus on their breathing. In contrast to other lifestyle interventions, such as walking or traditional exercise classes, our intervention did not involve aerobic activity. If this form of yoga is effective in reducing metabolic risk factors, the mechanism is likely through relaxation and stress reduction. Although we did not have the resources or power to examine mechanism of metabolic improvement in this pilot trial, several prior studies have addressed this topic. Stress hormones released by the sympathetic nervous system, such as cortisol, norepinephrine, and epinephrine, oppose the action of insulin and can lead to hyperglycemia and insulin resistance.⁹ Elevated cortisol is also linked to dyslipidemia, increased visceral adiposity, and higher blood pressure.³³ Impaired autonomic function, marked by increased sympathetic and decreased parasympathetic nervous system activity, is associated with increased morbidity and mortality in persons with CVD^{34–36} and increased complications in those with diabetes.^{37–39} Small trials have found that yoga is associated with lower levels of sympathetic hormones and reductions in cortisol.^{40,41} Other uncontrolled studies have shown that yoga increases heart rate variability and decreases oxygen consumption, heart rate, and blood pressure, all indicative of decreased sympathetic nervous system activity.^{15,42,43}

Our study findings are limited by the small number of participants included in this pilot study and the fact that it was not possible to blind participants to the intervention. The small sample size and relatively brief follow-up period may have limited our ability to demonstrate significant metabolic changes. Group dynamic is an important component of any group activity and may have influenced our results, rather than the yoga poses. However, participants spent the majority of the yoga session interacting with the instructors or quietly holding the yoga poses, minimizing group effects, and our physical exam and metabolic outcomes were “hard” measures.

In conclusion, we found that a restorative yoga intervention was both feasible and acceptable in a group of overweight and underactive participants with metabolic syndrome. We had excellent rates of participant retention and satisfaction. Although this study was not large enough or long enough to determine the efficacy of yoga as a treatment for metabolic syndrome, we did see trends toward improvement in blood pressure, psychological well-being, and weight stabilization. These results, as well as the mechanisms through which yoga may work, should be explored in a larger randomized controlled trial.

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Author Disclosure Statement

No competing financial interests exist.

References

1. Park YW, Zhu S, Palaniappan L, Heshka S, Carnethon MR, Heymetabolic syndromefield SB. The metabolic syndrome: prevalence and associated risk factor findings in the US population from the Third National Health and Nutrition Examination Survey, 1988–1994. *Arch Intern Med* 2003;163:427–436.
2. Laaksonen DE, Lakka HM, Niskanen LK, Kaplan GA, Salonen JT, Lakka TA. Metabolic syndrome and development of diabetes mellitus: application and validation of recently suggested definitions of the metabolic syndrome in a prospective cohort study. *Am J Epidemiol* 2002;156:1070–1077.
3. Sattar N, Gaw A, Scherbakova O, et al. Metabolic syndrome with and without C-reactive protein as a predictor of coronary heart disease and diabetes in the West of Scotland Coronary Prevention Study. *Circulation* 2003;108:414–419.
4. Isomaa B, Almgren P, Tuomi T, et al. Cardiovascular morbidity and mortality associated with the metabolic syndrome. *Diabetes Care* 2001;24:683–689.
5. Lakka HM, Laaksonen DE, Lakka TA, et al. The metabolic syndrome and total and cardiovascular disease mortality in middle-aged men. *JAMA* 2002;288:2709–2716.
6. Pan XR, Li GW, Hu YH, et al. Effects of diet and exercise in preventing NIDDM in people with impaired glucose tolerance. The Da Qing IGT and Diabetes Study. *Diabetes Care* 1997;20:537–544.
7. Knowler WC, Barrett-Connor E, Fowler SE, et al. Reduction in the incidence of type 2 diabetes with lifestyle intervention or metformin. *N Engl J Med* 2002;346:393–403.
8. Tuomilehto J, Lindstrom J, Eriksson JG, et al. Prevention of type 2 diabetes mellitus by changes in lifestyle among subjects with impaired glucose tolerance. *N Engl J Med* 2001;344:1343–1350.
9. Rosmond R. Stress induced disturbances of the HPA axis: a pathway to Type 2 diabetes? *Med Sci Monit* 2003;9:RA35–39.
10. Tsigos C, Chrousos, GP. Stress, obesity, and the metabolic syndrome: soul and metabolism. *Ann NY Acad Sci* 2006;1083:i–iii.
11. Chandola T, Brunner E, Marmot M. Chronic stress at work and the metabolic syndrome: prospective study. *Br Med J* 2006;332:521–525.
12. Branth S, Ronquist G, Stridsberg M, et al. Development of abdominal fat and incipient metabolic syndrome in young healthy men exposed to long-term stress. *Nutr Metab Cardiovasc Dis* 2007;17:427–435.
13. Diamanti-Kandarakis E, Economou F. Stress in women: metabolic syndrome and polycystic ovary syndrome. *Ann NY Acad Sci* 2006;1083:1–10.
14. Jain SC, Uppal A, Bhatnagar SO, Talukdar B. A study of response pattern of non-insulin dependent diabetics to yoga therapy. *Diabetes Res Clin Pract* 1993;19:69–74.
15. Patel C. 12-month follow-up of yoga and bio-feedback in the management of hypertension. *Lancet* 1975;1:62–64.
16. Mahajan AS, Reddy KS, Sachdeva U. Lipid profile of coronary risk subjects following yogic lifestyle intervention. *Indian Heart J* 1999;51:37–40.
17. Manchanda SC, Narang R, Reddy KS, et al. Retardation of coronary atherosclerosis with yoga lifestyle intervention. *J Assoc Physicians India* 2000;48:687–694.
18. Innes KE, Bourguignon C, Taylor AG. Risk indices associated with the insulin resistance syndrome, cardiovascular disease, and possible protection with yoga: a systematic review. *J Am Board Fam Pract* 2005;18:491–519.

19. Grundy S, Cleeman J, Daniels S, et al. Diagnosis and management of the metabolic syndrome: an American Heart Association/National Heart, Lung, and Blood Institute Scientific Statement. *Circulation* 2005;112:2735–1752.
20. Matsuda M, DeFronzo RA. Insulin sensitivity indices obtained from oral glucose tolerance testing: comparison with the euglycemic insulin clamp. *Diabetes Care* 1999;22:1462–70.
21. Friedewald W, Levy R, Fredrickson D. Estimation of the concentration of low-density lipoprotein cholesterol in plasma, without use of the preparative ultracentrifuge. *Clin Chem* 1972;18:499–502.
22. Cohen S, Williametabolic syndromeon G. Perceived stress in a probability sample of the United States. In: Spacapan S, Oskamp S, eds. *The Social Psychology of Health: Claremont Symposium on Applied Social Psychology*, Newbury Park, CA; 1988.
23. Block G, Woods M, Potosky A, Clifford C. Validation of a self-administered diet history questionnaire using multiple diet records. *J Clin Epidemiol* 1990;43:1327–1335.
24. Harada ND, Chiu V, King AC, Stewart AL. An evaluation of three self-report physical activity instruments for older adults. *Med Sci Sports Exerc* 2001;33:962–970.
25. Resnicow K, McCarty F, Blissett D, Wang T, Heitzler C, Lee RE. Validity of a modified CHAMPS physical activity questionnaire among African-Americans. *Med Sci Sports Exerc* 2003;35:1537–1545.
26. Stewart AL, Hays RD, Ware JE. Health perceptions, energy/fatigue, and health distress measures. In: Stewart AL, Ware JE, eds. *Measuring Functioning and Well-being: The Medical Outcomes Study Approach*, Durham, NC: Duke University Press; 1992:143–72.
27. Stewart AL, Ware JE, Sherbourne CD. Psychological distress/well-being and cognitive function measures. In: Stewart AL, Ware JE, eds. *Measuring Functioning and Well-being: The Medical Outcomes Study Approach*, Durham, NC: Duke University Press; 1992:102–142.
28. Andresen EM, Malmgren JA, Carter WB, Patrick DL. Screening for depression in well older adults: evaluation of a short form of the CES-D (Center for Epidemiologic Studies Depression Scale). *Am J Prev Med* 1994;10:77–84.
29. Irwin M, Artin KH, Oxman MN. Screening for depression in the older adult: criterion validity of the 10-item Center for Epidemiological Studies Depression Scale (CES-D). *Arch Intern Med* 1999;159:1701–1704.
30. Sahay BK. Yoga and diabetes. *J Assoc Physicians India* 1986;34:645–648.
31. Monro R, Power J, Coumar A, Nagarathna R, Dandona P. Original research: yoga therapy for NIDDM: a controlled trial. *Complement Med J* 1992;6:66–83.
32. Malhotra V, Singh S, Singh KP, et al. Study of yoga asanas in assessment of pulmonary function in NIDDM patients. *Indian J Physiol Pharmacol* 2002;46:313–320.
33. Whitworth JA, Williametabolic syndromeon PM, Mangos G, Kelly JJ. Cardiovascular consequences of cortisol excess. *Vasc Health Risk Manag* 2005;1:291–299.
34. Heart rate variability for risk stratification of life-threatening arrhythmias. American College of Cardiology Cardiovascular Technology Assessment Committee. *J Am Coll Cardiol* 1993;22:948–950.
35. La Rovere MT, Bigger JT, Jr., Marcus FI, Mortara A, Schwartz PJ. Baroreflex sensitivity and heart-rate variability in prediction of total cardiac mortality after myocardial infarction. ATRAMI (Autonomic Tone and Reflexes After Myocardial Infarction) Investigators. *Lancet* 1998;351:478–484.
36. Nolan J, Batin PD, Andrews R, et al. Prospective study of heart rate variability and mortality in chronic heart failure: results of the United Kingdom heart failure evaluation and assessment of risk trial (UK-heart). *Circulation* 1998;98:1510–1516.
37. Gottsater A, Ahlgren AR, Taimour S, Sundkvist G. Decreased heart rate variability may predict the progression of carotid atherosclerosis in type 2 diabetes. *Clin Auton Res* 2006;16:228–234.
38. Kudat H, Akkaya V, Sozen AB, et al. Heart rate variability in diabetes patients. *J Int Med Res* 2006;34:291–296.
39. Liao D, Carnethon M, Evans GW, Cascio WE, Heiss G. Lower heart rate variability is associated with the development of coronary heart disease in individuals with diabetes: the atherosclerosis risk in communities (ARIC) study. *Diabetes* 2002;51:3524–3531.
40. Damodaran A, Malathi A, Patil N, Shah N, Suryavanshi, Marathe S. Therapeutic potential of yoga practices in modifying cardiovascular risk profile in middle aged men and women. *J Assoc Physicians India* 2002;50:633–640.
41. Schell FJ, Allolio B, Schonecke OW. Physiological and psychological effects of Hatha-Yoga exercise in healthy women. *Int J Psychosom* 1994;41:46–52.
42. Vempati RP, Telles S. Yoga-based guided relaxation reduces sympathetic activity judged from baseline levels. *Psychol Rep* 2002;90:487–494.
43. Udupa K, Madanmohan, Bhavanani AB, Vijayalakshmi P, Krishnamurthy N. Effect of pranayam training on cardiac function in normal young volunteers. *Indian J Physiol Pharmacol* 2003;47:27–33.

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