Bikram Yoga Training and Physical Fitness in Healthy Young Adults

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Abstract

Tracy, BL and Hart, CEF. Bikram yoga training and physical fitness in healthy young adults. *J Strength Cond Res* 27(3): 822–830, 2013—There has been relatively little longitudinal controlled investigation of the effects of yoga on general physical fitness, despite the widespread participation in this form of exercise. The purpose of this exploratory study was to examine the effect of short-term Bikram yoga training on general physical fitness. Young healthy adults were randomized to yoga training ($N = 10$, 29 ± 6 years, 24 sessions in 8 weeks) or a control group ($N = 11$, 26 ± 7 years). Each yoga training session consisted of 90-minute standardized supervised postures performed in a heated and humidified studio. Isometric deadlift strength, handgrip strength, lower back/hamstring and shoulder flexibility, resting heart rate and blood pressure, maximal oxygen consumption (treadmill), and lean and fat mass (dual-energy x-ray absorptiometry) were measured before and after training. Yoga subjects exhibited increased deadlift strength, substantially increased lower back/hamstring flexibility, increased shoulder flexibility, and modestly decreased body fat compared with control group. There were no changes in handgrip strength, cardiovascular measures, or maximal aerobic fitness. In summary, this short-term yoga training protocol produced beneficial changes in musculoskeletal fitness that were specific to the training stimulus.

Key Words strength, body composition, cardiovascular, flexibility, alternative medicine, hot yoga

Introduction

Interest has grown in alternatives to traditional mainstream exercise training programs (2,35). For example, many studies have documented the efficacy of Tai Chi training in ameliorating clinically important deficits of aging, such as balance impairments (22,24,44,45), muscle weakness (6,22,45), and impaired muscle steadiness (6). Hatha yoga, the branch of yoga that involves regular performance of defined physical postures, has been practiced for centuries. It has been extensively studied and clinically applied in India (9,10,27,30,32,39) and has gained substantial popularity and widespread acceptance in the Western fitness industry as a beneficial exercise program (8,14). Accordingly, many studies have examined various health outcomes in association with yoga participation (21,31). Two review articles found that the evidence indicates beneficial effects of yoga on clinical conditions, cardiopulmonary function, glucose metabolism, lipid profiles, fibrinolysis, oxidative stress, and sympathoadrenal function (15,16,21,31). Importantly, however, the methodological limitations of many investigations (e.g., uncontrolled confounders, nonrandomized, small sample sizes) were clearly acknowledged.

Various longitudinal training studies have shown yoga participation to be associated with improved exercise tolerance (30), increased muscle strength (10,27,40), improved flexibility (32,38,40), increased maximal aerobic capacity (33), and improved neuromuscular control of force (20,28). However, some of these studies were not controlled (27,30,40). Yoga participation has even been shown to help cancer survivors with weight maintenance after treatment (25) and improve physical function in stroke survivors (3). In light of the magnitude of the potential impact on population fitness and health owing to the popularity of yoga participation, there has been only a modest amount of systematic, controlled, peer-reviewed longitudinal research on the effects of yoga on general physical fitness. Additionally, the large variability in the type, intensity, and duration of the yoga intervention chosen for any particular study can cloud the interpretation of conclusions from studies of yoga. Thus, any controlled longitudinal study of yoga represents a significant addition to the body of knowledge in this specific area. Practical questions that emerge from the existing literature on yoga and physical fitness include (a) What are the effects of regular yoga participation on objective, controlled, measures of physical fitness? (b) Is there a way to study a more standardized exercise dose of yoga to generalize the fitness adaptations more precisely?

Bikram yoga is a specific type of practice that is growing in popularity (29), with hundreds of licensed studios worldwide. This strictly standardized and legally trademarked exercise

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program is unique, in that it consists of a series of 26 postures guided via a standardized instructor dialog, performed in the same manner, in the same order, and held for the same duration–across instructors and studios (see Methods). This program of yoga is therefore uniquely suited for scientific study. It is a vigorous form of yoga performed in a heated humidified studio and is thus also known as hot yoga. The postures require lengthy, forceful, and well-controlled contractions of all major muscle groups. The combination of rapid transition between postures and environmental heat stress produces a substantial cardiovascular response and muscle fatigue. This contrasts with other common but less standardized forms of Hatha yoga for which the metabolic and cardiovascular demands are of low intensity (7,19) and the intensity, duration, and postural details are extremely variable across instructors and studios. Given the intensity and cardiovascular stress of Bikram yoga, there may be substantial fitness benefits associated with regular participation.

For evidence-based exercise prescription to be supported, it is important for the effects of training programs to be well characterized. We are not aware of any published studies that examined the physical fitness effects of this popular type of yoga; therefore, there is a need for data that describe the adaptations. Therefore, the purpose of this exploratory study was to determine the effects of 8-week Bikram yoga training on general physical fitness in healthy young adults. Although there is no published data that objectively describe the acute physiological responses to the physical demands of Bikram yoga, subjective observation suggests that there are substantial muscle force, range of motion, cardiovascular, and metabolic demands. Therefore, our approach was to measure muscle strength, flexibility, cardiovascular fitness, and body composition before and after yoga training and compare the responses with control subjects who performed no training. Because of the intensity of the exercise stimulus provided by this form of yoga, and the findings of generally increased fitness after yoga training (40), we hypothesized improvements in all of the measures. The data have been presented previously in abstract form (13), and other motor control data from this project have been published elsewhere (20).

Methods

Experimental Approach to the Problem

We tested the hypotheses via a randomized controlled longitudinal study. To test the hypothesis of improvement in physical fitness with training, select features of physical fitness were assessed in a group of subjects who performed yoga training for 8 weeks at a local studio. The same assessments were performed in a group of control subjects before and after an 8-week control period. The control subjects received an equivalent amount of free yoga participation after the control period. Testing consisted of 2 experimental sessions completed within a 7-day period. The sessions were performed at the same time of day within subjects, across time points. One of the experimental sessions consisted of the physical fitness and body composition assessments presented here. The other experimental session consisted of measurements of neuromotor control of force and balance; those data were published previously (20).

Subjects

Thirty-two young adults were oriented to the study procedures and provided written informed consent at the beginning of the initial visit. They were relatively sedentary, reporting less than 2 hours per week of purposeful exercise no more than moderate in intensity, no experience with yoga exercise for at least 4 months before the study, and no medical condition or medications that could influence the dependent measures or affect participation. By blindly picking group assignment slips, 11 subjects were randomized into the control group and 21 into the yoga group. More subjects were randomized into the yoga group to compensate for expected dropouts. The recruitment and randomization occurred over a period from May to August in a staggered fashion according to the availability of research personnel and facilities, and the testing study was finished by October. A total of 10 subjects completed yoga training (29.0 ± 6.1 years, range: 21–39 years, 4 men and 6 women) and 11 completed the control period (25.1 ± 5.0 years, range: 21–39 years, 6 men and 5 women). The yoga and control groups were similar in age, height, and body mass before training ($p = 0.37$, 0.40, 0.36, respectively). Dropouts from the yoga group were attributed to scheduling and dissatisfaction with the training program. The subjects were instructed to get adequate sleep before a testing day, eat a light meal a few hours before testing, arrive adequately hydrated, and abstain from caffeine intake for 4 hours before testing. The Human Research Committee at the Colorado State University approved the procedures in accordance with the Declaration of Helsinki.

Procedures

Yoga Training. Subjects randomized to the yoga group participated in the 8-week training, which consisted of three 90-minute, instructor-led class sessions per week (24 classes in total). Each session consisted of a series of 26 postures (Figure 1) performed in a heated (35–41° C) and humidified (approximately 60% relative humidity) studio. Unlike most other forms of yoga popularized in the fitness industry, this form of yoga (Bikram) is a trademarked and strictly standardized program across instructors and studio locations. For a studio to be franchised and legally carry the Bikram name, the owners and instructors must have undergone the 9-week, full-time intensive teacher training offered by Bikram's Yoga College of India. During this training, the exact details of how to perform and instruct each posture is learned and the trademarked instructor dialog that accompanies each posture is memorized verbatim. At official Bikram-franchised studios, therefore, every class session is instructed in precisely the same manner. Each posture is performed twice in the same order. The first 60 minutes of the class involve standing and

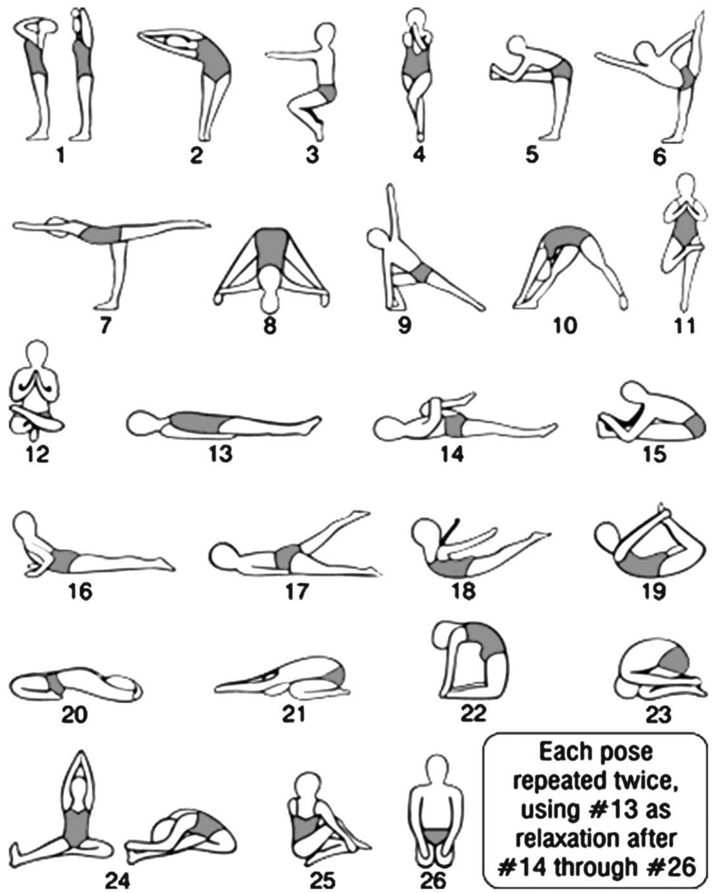

Figure 1. The Bikram series of yoga postures.

balance postures, and the last 30 minutes involve seated postures. The combination of postures requires lengthy contractions of all major muscle groups and a substantial excursion of the range of motion of the joints in the legs, spine, and upper body. A significant cardiovascular and metabolic response is produced because of the combination of exertion and heat stress. Although we did not measure acute cardiovascular responses to the training sessions, proper performance of the postures required a very high level of focus and physical exertion. The instructors maintain close observation and supervision of participants and continually correct the form. Fluid intake was encouraged before, during, and after training sessions. An attendance log was maintained; the average attendance over the 8 weeks was 22.5 ± 2.3 classes. One subject attended 17 classes but did not exhibit attenuated responses to the training compared with the other subjects. The others attended 22–25 classes in the 8-week period. Both the control and yoga subjects were asked not to change their baseline physical activity levels or diet during the entire training or control period. No diet records or physical activity logs were kept.

Isometric Deadlift. This task was performed with an electronic load cell device (Jackson Strength Evaluation System Model 32628CTL; Lafayette Instrument Co, Lafayette, IN, USA) and a standard technique. Subjects stood on a platform grasping a sturdy bar attached to the load cell with an adjustable chain. The testing position was standardized and consistent between subjects and time points. Foot position relative to the load cell was kept constant across time points with calibrated marks. During the task, the chain connecting the load cell to the bar was kept vertical, and the back was straight with the hips and knees bent; trials deviating from this standard were discarded. Subjects were instructed to increase their force to maximum in 1–2 seconds and pull straight up as forcefully as possible while exhaling, looking straight ahead, and keeping the back straight. The digital readout on the device displayed the peak force produced during the trial. At least 1 minute of rest was given between trials. The greatest force from 3 trials was recorded.

Hand Grip Strength. Subjects held the handgrip dynamometer (Jamar Model 5030J1, Patterson Medical Holdings, Bolingbrook, IL, USA) in their right hand while standing with the elbow fully extended and arm at the side of the body. Subjects were instructed to exert a maximal grip force for 2–3 seconds with strong verbal encouragement. The dynamometer displayed the peak force from the trial. At least 1 minute of rest was given between trials. The greatest force from 3 trials was recorded.

Lower Back/Hamstring Flexibility. The standard sit-and-reach test was used (1). Subjects sat on the floor with the legs extended in front of them and feet flush against the sit-and-reach box (Acuflex I; Novel Products, Inc., Rockton, IL, USA). With one hand on top of the other, subjects slowly reached as far over their toes as possible. Subjects were not allowed to stretch before the test, which was performed at the same time of day across study time points. The greatest distance (centimeters) reached from 3 trials was recorded.

Shoulder Flexibility. The shoulder elevation test was used (1). While in the prone position with arms extended straight above the head and hands shoulder-width apart, subjects grasped a wooden rod using a pronated grip. The test involved raising the arms as far as comfortably possible above the floor while maintaining grip on the rod and keeping the chin on the floor. The distance from the floor to the bottom of the rod was measured (centimeters). Three trials were performed; the maximal value was taken as the outcome.

Cardiovascular Measures. Resting blood pressure (standard sphygmomanometer) and heart rate (3-lead electrocardiogram) was measured while seated and after 20 minutes of rest in the supine position. Maximal oxygen consumption was measured using a modified Balke treadmill protocol. The speed of the treadmill was set to a moderate sustainable running pace, and the grade was increased 2% after the first minute and 1% every minute thereafter. Subjects were instructed to run on the treadmill until exhaustion and were strongly encouraged during the test. Oxygen consumption was measured for the duration of the test using a metabolic cart (TrueOne 2400; Parvomedics, Sandy, UT, USA) and standard indirect calorimetry technique. The ventilation measurement was calibrated at a variety of flow rates with a 3-L syringe, and the gas analyzers were calibrated with gases of known concentration before each use. Oxygen consumption was measured and averaged over 15 seconds periods. The criterion for the determination of maximal oxygen consumption was the observation of at least a 1-minute plateau in oxygen consumption when the treadmill grade was increased.

Anthropometry/Body Composition. Body mass and height were determined using a standard clinical scale. A dual-energy x-ray absorptiometry (DEXA) scanner was used to estimate percent fat and lean mass (Model DPX-IQ; Lunar Corporation, Madison, WI, USA). The scanner was calibrated each morning using the manufacturer-prescribed technique. Whole-body percent fat (in percentage) and lean mass (in grams) was recorded from the standard output.

Statistical Analyses

The hypothesis of different changes for the yoga group compared with the control group was tested using repeated-measures analysis of variance. The between-subjects independent variable was group (yoga, control). The within-subjects, repeated-measures independent variable was time point (before training, after training). Comparison of the dependent variables between time points and comparison of changes in the dependent variables between experimental groups (group × time point interaction) were made using within-subjects planned contrasts in SPSS (SPSS version 17, IBM, Armonk, NY, USA). Baseline values of the dependent variables at the pre-training time point were compared between groups using one-way analysis of variance. To assess whether the changes with training were related to the initial values for the dependent variables, bivariate Pearson correlations were computed to determine the relation between baseline values and change scores. The p values <0.05 are described as significant.

The main dependent variables were maximal isometric deadlift strength (kilograms), maximal handgrip strength (kilograms), sit-and-reach score (centimeters), shoulder elevation distance (centimeters), systolic blood pressure (millimeters of mercury), maximal oxygen consumption (milliliters of oxygen per kilogram of body mass per minute), percent body fat (in percentage), and lean body mass (in grams). To determine the reliability of the measures across time for the control subjects, intraclass correlation coefficients (ICC) were calculated for each dependent variable between the values from week 0 and week 8; the ICC's were 0.89, 0.99, 0.97, 0.96, 0.77, 0.97, 0.99, and 0.99 for the dependent variables listed above.

Results

Muscle Strength

Isometric Deadlift. Before training, maximal isometric deadlift force was similar ($p = 0.94$) between the yoga and control groups. The statistical trend for a 13.1% increase after training for the yoga group (82.9 ± 35.6 kg to 92.5 ± 41.7 kg, $p = 0.09$, statistical power = 0.40) was significantly greater (group × time point interaction, $p = 0.04$) than the change for the control group (83.8 ± 17.4 kg to 80.0 ± 16.0 kg, $p = 0.28$, Figure 2A). The strength gain values were not correlated with the pre-training strength values.

Grip Strength. Maximal handgrip force was similar between the yoga and control groups before training (41.3 ± 10.8 kg vs. 45.6 ± 15.1 kg, $p = 0.37$, Figure 2B). The values were unaltered with training for both groups ($p = 0.30$).

Flexibility

Lower Back/Hamstring Flexibility. Sit-and-reach scores were similar ($p = 0.18$) for the yoga and control groups before

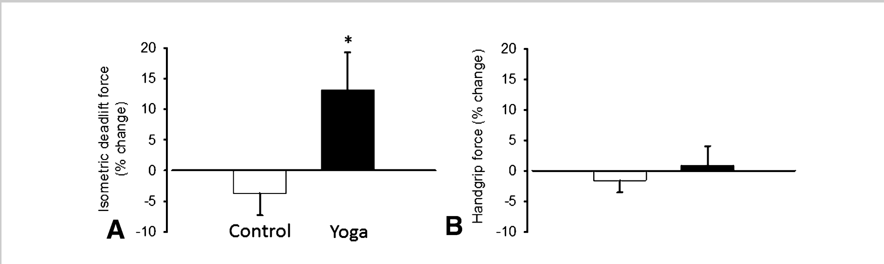

Figure 2. Percent change in A) isometric deadlift force, and B) maximal handgrip force for yoga (black bars) and control (white bars) subjects after the training period. The change in deadlift strength for the yoga group was significantly different (asterisk indicates group × time interaction $p = 0.04$) than control. There was no significant change in grip strength for either group ($p = 0.30$).

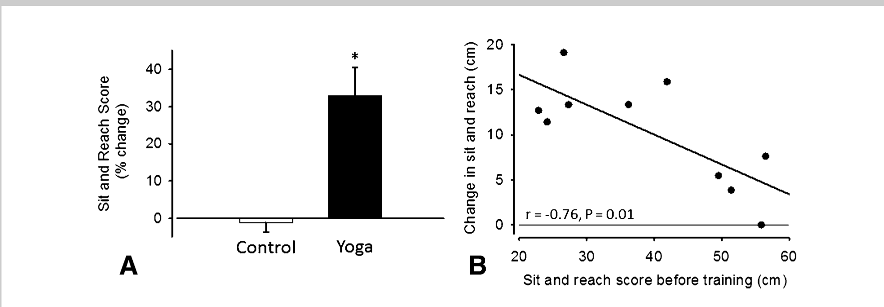

Figure 3. A) Percent change in sit-and-reach score for yoga (black bars) and control (white bars) subjects after the training period. The change in flexibility for the yoga group was significantly different (asterisk indicates group × time interaction $p < 0.001$) than control. B) Pre-training sit-and-reach score plotted against the change in sit-and-reach score for each yoga subject. The significant negative correlation ($r = -0.76$, $p = 0.01$) indicates that the less flexible subjects experienced the greatest gains after training.

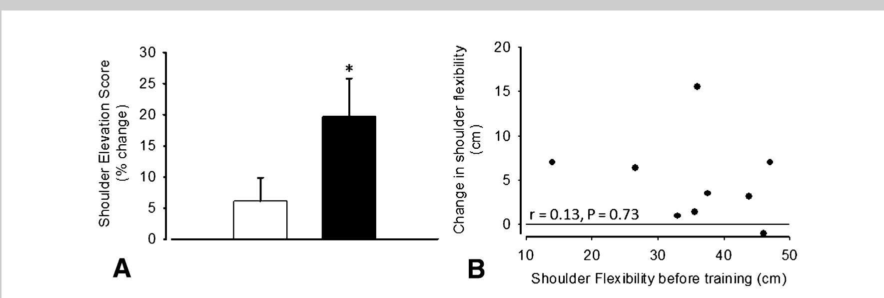

Figure 4. A) Percent change in shoulder elevation score for yoga (black bars) and control (white bars) subjects after the training period. The change in shoulder range of motion for the yoga group was different than control (asterisk indicates group × time point interaction $p = 0.058$). B) The pre-training shoulder elevation score was not correlated with the change in shoulder elevation score for the yoga group.

training. The increase in sit-and-reach score with training was significantly greater ($p < 0.001$) for the yoga group (Δ: 10.27 ± 7.3 cm, 33.0 ± 23.8%, statistical power = 1.0) compared with the control group (Δ: −0.81 ± 3.5 cm, −1.14 ± 8.1%) (Figure 2A). For the yoga subjects, the percent increase in sit-and-reach score ranged from 0 to 72%. The absolute change in sit-and-reach score was negatively correlated with the sit-and-reach score before training ($R = -0.76$, $p = 0.01$, Figure 2B); the subjects who had the lowest scores before yoga training exhibited greater increases in scores after training.

Shoulder Flexibility. Shoulder elevation distance was similar between the control and yoga groups before training (35.4 ± 13.8 cm vs. 36.7 ± 10.6 cm, $p = 0.8$). The increase in shoulder elevation distance was greater for the yoga group than the control group (6.50 ± 6.86 cm vs. 1.32 ± 4.85 cm, group × time interaction $p = 0.058$, Figure 3A). The statistical power for the change in the yoga group was 0.76. The change in shoulder flexibility was not correlated with shoulder flexibility before training (Figure 3B).

Cardiorespiratory/Blood Pressure

Maximal oxygen consumption (37.9 ± 7.9 $ml \cdot kg^{-1} \cdot min^{-1}$) and resting systolic blood pressure (120 ± 7.8 mm Hg) were similar ($p = 0.60$) between yoga and control groups before training. There were no changes in these values for yoga or control groups over the training period ($p = 0.27$ and 0.33, respectively).

Body Composition

Body mass (73.8 ± 20.7 kg vs. 64.9 ± 13.4 kg, $p = 0.11$) and waist-to-hip ratio (0.816 ± 0.113 vs. 0.796 ± 0.062, $p = 0.08$) were similar between groups before training and did not change with training for the yoga or control group ($p = 0.47$ and 0.56, respectively). Despite random assignment to yoga or control groups, body fat percentage was greater for the yoga compared with the control group before training (28.4 ± 6.0% vs. 20.8 ± 8.1%, $p = 0.03$). The yoga group experienced a 1.1% decrease in body fat percent to 27.3 ± 6.3% after training ($p = 0.04$, statistical power = 0.54), and the control group was unchanged (21.0 ± 8.4%, $p = 0.23$). When percent fat values were converted to logarithmic values to remedy the pre-training differences between groups, there was no change in the log values for the control group ($p = 0.98$), the changes trended toward significance for the yoga group ($p = 0.069$), and there was no group by time point interaction ($p = 0.23$).

Lean body mass was similar between the yoga and control groups before training (50.1 ± 13.3 kg vs. 47.8 ± 11.4 kg, $p = 0.7$). Although the slight increase in lean mass (1.1%) for the yoga group (50.1 ± 13.3 kg to 50.7 ± 13.7 kg) trended toward being greater (group × time point interaction, $p = 0.052$) than the slight decrease (−0.7%) experienced by the control group (47.9 ± 11.4 kg to 47.5 ± 11.2 kg), the changes within the yoga and control group were not significant ($p = 0.17$ and 0.2, respectively).

Discussion

This exploratory study examined the effect of a relatively short-term period (8 weeks) of Bikram yoga training on a battery of basic measures of physical fitness in healthy, sedentary young adults. Deadlift strength, lower back/hamstring flexibility, and shoulder flexibility was increased after yoga training and was unchanged for controls. There was a trend toward modestly reduced body fat for yoga participants after training compared with control subjects. Resting blood pressure, maximal aerobic capacity, and handgrip strength were unchanged in yoga and control subjects.

The yoga training did not produce a change in handgrip strength. This was somewhat unexpected, given that handgrip strength has been shown to increase after yoga training by 21% in an uncontrolled study (26) and significantly in adults (12–27% increase), children (9–16% increase), and arthritis patients (22–148% increase) in a controlled study (10). A potential explanation may be that only 6 of the 26 postures in the standard Bikram series required forceful use of the handgrip muscles. Therefore, for these young adults, the training stimulus for the handgrip muscles over this period of time was apparently insufficient to produce the neural and muscular adaptations that underlie changes in strength. A longer duration of training might have elicited detectable changes in handgrip strength. From a practical standpoint, this finding suggests that short-term yoga training of this type would not be expected to improve handgrip strength in young adults.

In contrast to the findings for handgrip strength, the weak trend ($p = 0.09$) for a 13% increase in isometric deadlift strength in the yoga subjects was statistically greater (interaction $p = 0.04$) than the change in control subjects. This finding agrees with other studies that observed significantly improved lower and upper body strength after a period of yoga participation (40,41). The deadlift action requires contractions of the knee extensors, hip extensors, spine/lumbar extensors, shoulder muscles, and finger flexors. Thus, the observed strength adaptation is most probably explained by the multifaceted muscular requirements of this yoga training program: (a) 19 of the 26 postures required forceful contractions of the knee extensor muscles, (b) 4 postures required intense maintenance of a form of the leg press action (simultaneous ankle plantarflexion, knee extension, and hip extension), and (c) many postures involved forceful contractions of the trunk and shoulder muscles. These changes in strength must be interpreted cautiously, in the context of the confidence limits of this small sample size. Nonetheless, the 8-week training stimulus does at least appear sufficient to produce modest and reasonably consistent changes in maximal force in a task using multiple large muscle groups simultaneously. This suggests that modest whole-body strength increases are among the fitness benefits to be derived from 2 months of regular performance of this type of yoga.

Flexibility of the shoulders, as measured by the shoulder elevation test, improved significantly more for the yoga group than control (Figure 4). This suggests that the postures, many of which involve pushing the limits of shoulder joint range of motion, increased the extensibility of the muscle and connective tissue surrounding the shoulder. One caveat is that the shoulder elevation test used here was not a passive range of motion test but rather it required active hyperflexion of the shoulder posterior to the frontal plane while in the prone position. Because deadlift strength was greater after the yoga training, it is possible that increased shoulder muscle strength produced by the yoga training partially contributed to the change in the ability to increase the active range of motion after yoga training. The positive results for the shoulder are consistent with other observations of enhanced shoulder flexibility with yoga training (4,17,40), thus forming the basis for an expectation of improved shoulder flexibility resulting from participation in this type of yoga.

The 33% increase (range 0–73%) in sit-and-reach score for the yoga group was significantly greater than the control group. This represents a substantial and consistent increase in the flexibility of the lower back and hamstring muscles over the 8-week program. The adaptation was quite specific to the requirements of the yoga program because 19 of the 26 postures involved prolonged flexion, hyperextension, or lateral flexion of the trunk. These findings agree with one controlled (38) and one uncontrolled study (40) that reported increased flexibility after yoga participation. Also, although our young healthy subjects did not report back pain and we did not track back pain during the training, the results concur with clinical studies that have examined the effect of yoga training on low back pain. For example, Iyengar yoga therapy reduced pain ratings, pain medication usage, back-related functional disability, and depression in adults with low back pain (42,43). Participation in various yoga protocols has been associated with improved flexibility, improved function, and reduction in chronic low back pain in clinical populations (17,18,36–38). We also found that the change in flexibility with training was greatest for those with the least flexibility before training. This lends some practical and clinical significance to these results; those with poor flexibility can derive the greatest benefit from just 8 weeks of consistent Bikram yoga training. Indeed, improved spine flexibility has been shown to accompany higher ratings of quality of life after yoga training in older adults (17). After a relatively brief period of Bikram yoga training, a young adult can expect to experience substantially increased flexibility of the lower back and hamstring muscles. The practical importance of this finding is greater range of spine motion in daily life, which may reduce low back pain, a common and disabling detractor from quality of life across the adult lifespan.

The yoga group carried more body fat than control before training and experienced a decrease in body fat percentage of 1.1%. After correcting for pre-training differences between the yoga and control groups via log transformation of the values, there was still a trend ($p = 0.07$) for a decrease in body fat in the yoga group after training. Thus, it appears that the energy expenditure required by the consistent yoga participation for 8 weeks likely contributed to a modest change in body fat. We instructed the subjects not to change their diet over the course of the study, but importantly, these findings must be interpreted in the context of no diet records or experimental control over caloric intake for the subjects during the study period. The finding agrees directionally with an epidemiological scale study that found an association between the practice of yoga and reduced weight gain in middle-aged men and women (23). Two studies (7,19) that measured acute energy expenditure during standard Hatha yoga routines showed that the metabolic rate was 2–2.5 times the resting metabolic rate, which is approximately half the metabolic rate of treadmill walking at a moderately brisk 3.5 mph. These studies suggested that energy expenditure during the typical Hatha yoga session is insufficient to meet the metabolic criteria typically recommended to produce significant changes in body fat (11). There have been no studies that measured the metabolic requirements of a standard Bikram yoga session. Given the heat stress and demanding series of poses, it is likely that the energy expenditure during a Bikram session is greater than was elicited in these studies. In this study, it is impossible to know if the dietary energy intake increased in the yoga group, despite our instructions to the contrary. The reason this is important is that modest increases in caloric intake by the yoga group subjects could have blunted the improvement in body fat that might be expected by 8 weeks of vigorous hot yoga training.

Although the changes in lean mass were significantly different for yoga than control (interaction $p = 0.05$), the changes within each group were not significant. This 8-week yoga program was therefore insufficient to increase lean mass (as estimated by DEXA). With tight control over dietary intake and a longer period of training, it is possible that the substantial muscle contractions required during Bikram yoga could produce muscle hypertrophy that would be detectable in a larger sample of young adults. For aging adults, there are significant metabolic, functional, and quality of life consequences of sarcopenia (12). Given the documented beneficial health effects of yoga for older adults (34), it would be of interest to determine the muscle anabolic potential of Bikram yoga training if it can be safely and consistently performed by typical older adults in a controlled, randomized longitudinal trial.

There were no changes in maximal aerobic capacity, resting heart rate, or resting blood pressure after the period of yoga training. This indicates that the yoga did not elicit a cardiovascular or metabolic training stimulus robust enough to produce the adaptations typically expected from a consistent endurance exercise program. This finding contrasts with uncontrolled studies that found an increase in maximal aerobic capacity after yoga training (33,40) and with other studies that found improvement in indices of submaximal cardiovascular exercise tolerance (30,32). In the minimal literature devoted to describing the acute cardiovascular and metabolic responses to yoga (7,19), typically performed Hatha yoga has been shown to elicit a heart rate response that is below the threshold recommended by the American College of Sports Medicine for improving cardiovascular fitness in sedentary adults (5). Although there is no published data that describe acute cardiovascular and metabolic responses to a session of Bikram yoga, it is likely to be somewhat greater than the typical Hatha yoga session. In this study, however, the repeated cardiovascular stress of the yoga sessions did not produce consistent adaptations that were detectable by our measures in this small sample of healthy, young sedentary adults. It is possible that the subjects experienced a metabolic adaptation to the training that improved submaximal exercise tolerance, but measures of submaximal responses were not conducted in this study.

This is the first published description of changes in physical fitness in response to Bikram yoga training. Eight weeks of this increasingly popular and highly standardized form of hot yoga training produced large increases in low back/hamstring and shoulder flexibility and modest improvement in muscle strength and body fat in healthy, young sedentary adults. To more definitively determine the magnitude of the health effects, larger, controlled longitudinal trials should examine the effects of Bikram yoga on various features of health and fitness.

Practical Applications

The evidence-based application of these results is limited to healthy young adults. These findings suggest that there are focused fitness benefits from short-term regular participation in Bikram yoga. For those who can acclimate to the heat stress inherent in this strictly standardized yoga program and maintain adherence to regular participation, the evidence from this exploratory scale study indicates that participation is highly likely to substantially improve flexibility and reasonably likely to improve muscle strength. For older adults, the results of long-term application of this specific program has not been systematically studied or published in the peer-reviewed scientific literature. Thus, the practical impact of this particular study is that it forms the basis for practitioners to recommend this form of yoga as a means of improving flexibility and strength in healthy young adults.

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Conflict of interest statement: B. Tracy is currently a consultant to the Bikram Yoga College of India (Los Angeles, CA, USA). This relationship, initiated in 2011, did not overlap with the execution of this study or the analysis of the data pertaining to this article.

The results of this study do not constitute endorsement of Bikram yoga by the authors or the National Strength and Conditioning Association.

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