

**Editor-in-Chief**

Tommy Boone, PhD, MBA

Review Board

Deepmala Agarwal, PhD

Todd Astorino, PhD

Julien Baker, PhD

Steve Brock, PhD

Lance Dalleck, PhD

Eric Goulet, PhD

Robert Gotshall, PhD

Alexander Hutchison, PhD

M. Knight-Maloney, PhD

Len Kravitz, PhD

James Laskin, PhD

Yit Aun Lim, PhD

Lonnie Lowery, PhD

Derek Marks, PhD

Cristine Mermier, PhD

Robert Robergs, PhD

Chantal Vella, PhD

Dale Wagner, PhD

Frank Wyatt, PhD

Ben Zhou, PhD

Official Research Journal of
the American Society of
Exercise Physiologists

ISSN 1097-9751

Physiological Characteristics of Long-Term Bikram Yoga Practitioners

Allison N. Abel¹, Lisa K. Lloyd¹, James S. Williams¹, Brian K. Miller²

¹The Human Performance Laboratory, Department of Health and Human Performance, Texas State University, San Marcos, Texas, USA, ²Department of Management, Texas State University, San Marcos, Texas, USA

ABSTRACT

Abel AN, Lloyd LK, Williams JS, Miller BK. Physiological Characteristics of Long-Term Bikram Yoga Practitioners. **JEPonline** 2012;15(5):32-39. The effects of yoga training on health and fitness are unclear despite widespread participation. The primary purpose of this cross-sectional study was to describe the resting heart rate, blood pressure, lung function and aerobic fitness characteristics of long-term Bikram yoga practitioners. A secondary purpose was to examine the relationship between previous Bikram yoga experience and these physiological measures. Thirty-one Bikram yoga practitioners were placed into 2 groups according to years of experience (low = <3 months and high = =1 yr). All subjects completed a battery of tests to measure resting blood pressure and heart rate, pulmonary flow rates and capacities, and aerobic fitness. Unpaired t-tests demonstrated no significant differences between the two groups in any of the measured variables. A significant but weak correlation was detected between Bikram yoga experience and both percentage of predicted forced vital capacity ($r = 0.38$, $P < 0.05$) and forced expiratory volume in the first second ($r = 0.37$, $P < 0.05$). These results suggest that this form of yoga training does not provide an adequate stimulus to alter resting hemodynamics, pulmonary function or aerobic fitness.

Key Words: Cardiovascular, Pulmonary, Metabolic, Training

INTRODUCTION

An abundance of research has consistently shown that regular yoga training improves pulmonary function (7,8,10,11,20,25). Though the magnitude of change varies considerably, research has demonstrated that yoga training improves maximum voluntary ventilation (MVV), an index of ventilatory capacity (7,8,10). Yoga training studies have also reported increases in forced vital capacity (FVC) (7), forced expiratory volume in the first second (FEV_{1.0}) (7,10), peak expiratory flow rate (PEFR) (7,20), and vital capacity (VC) (10). These positive findings have been attributed, in part, to *pranayama* (i.e., breathing exercises).

Since yoga is a slow-paced movement exercise separated by periods of static stretching, it is not considered an aerobic activity. Thus, it is unlikely that yoga is beneficial to the cardiovascular system (6,15). Nevertheless, the effects of yoga on measures of cardiovascular health, such as maximal oxygen consumption (VO₂ max), resting blood pressures (BP), and resting heart rate (HR), have been investigated and demonstrate mixed results (3,7,13,16-20,22). For example, yoga training has been reported to result in slight increases in VO₂ max (3,18,22), modest reductions in exercise HR (18), and varying reductions in both resting BP and resting HR (3,13,19,20).

It appears that yoga provides some cardiovascular and pulmonary health benefits and, therefore, should be included in a regular fitness program. Research is lacking, however, on the effects of different styles of yoga on cardiovascular and pulmonary function. Bikram yoga (also referred to as hot yoga) is a style of yoga that was developed and popularized by Bikram Choudhury in the early 1970s. A typical Bikram class is 90 min in duration, consists of a set series of 26 Hatha yoga postures and 2 breathing exercises, and is performed in a room heated to 41° C (105° F) with 40% humidity (5). Though Bikram Yoga is a rapidly growing fitness trend and booming business throughout the United States, only one research study was found that investigated the effects of Bikram yoga training on cardiovascular fitness (21), and no research has explored its effects on pulmonary function. Hence, the primary purpose of this study was to describe the resting hemodynamic, lung function, and cardiorespiratory fitness characteristics of Bikram yoga practitioners. A secondary purpose was to examine the relationship between previous Bikram yoga experience and these physiological measures.

METHODS

Subjects

The study population consisted of 31 Bikram yoga subjects with varying levels of training experience. Informed consent was obtained prior to enrollment. The study was approved by the local institutional review board. Participation in the study was restricted to apparently healthy adults. They were at least 18 yrs of age with no signs or symptoms suggestive of heart, pulmonary or metabolic disease. Each subject completed a health history questionnaire (1). Then, they were divided into 2 groups according to Bikram yoga training experience: <3 months (n =17) and =1 yr (n =14).

Procedures

Prior to testing, the subjects were asked to: (a) drink plenty of fluids over the 24-hr period preceding the test; (b) avoid food, tobacco, nicotine, alcohol, and caffeine for at least 3 hrs prior to the test; (c) avoid strenuous physical activity the day of the test; and (d) get at least 6 hrs of sleep the night before the test (1). Each subject was measured for height and weight in light clothing without shoes using a calibrated physician's scale (Detecto Scale Co.). After 10 min of seated rest (while in the seated position), resting BP (Baumanometer, Standby Model) and resting HR (Polar Heart Rate Monitor, Model FT4).

Pulmonary flow rates and capacities were measured with a hand-held pneumotach and custom spirometry software (TrueOne, Parvomedics). The pneumotach was calibrated prior to each test according to the manufacturer's specifications. The primary variables measured included forced vital capacity (FVC), forced expired volume in one second (FEV_1), FVC/ FEV_1 , peak expiratory flow rate (PEFR), and maximal voluntary ventilation (MVV). All testing was conducted in accordance with the American Thoracic Society/European Respiratory Society (ATS/ERS) guidelines (12). The prediction equations provided by Crapo, Morris, and Gardener (4) were used for analysis.

Oxygen consumption (VO_2) and associated gas exchange variables were determined during a graded exercise test (GXT) on a stationary cycle (Monark Ergonomic, Model 894E). After a 3- to 5-min warm-up, the GXT began at 60 W and the subjects were asked to maintain a 60 rpm pace. Every 2 min, the resistance was increased by 30 W for males and 15 W for females. Expired air was analyzed on a breath-by-breath basis with an automated metabolic measurement cart (TrueOne, ParvoMedics). Calibration of the cart was performed prior to each subject's test in accordance with the manufacturer's specifications. Gas exchange variables were calculated from 60-sec averages. At the end of each stage, HR was recorded (Polar, Model FT4).

Statistical Analyses

Standard demographic data were collected for each group. Unpaired t-tests were used to determine differences between the 2 groups in cardiovascular, metabolic, and pulmonary responses. Bivariate correlations for the relationships between these variables and both previous Bikram yoga experience and average number of days per week that the subjects were engaged in Bikram yoga were calculated. The level of significance was set at $P < 0.05$. All values are reported as mean \pm SD.

RESULTS

Descriptive data for the 2 groups and all subjects combined are provided in Table 1. There were no differences ($P > 0.05$) between the groups for age, height or weight. The pulmonary function results of the Bikram yoga practitioners are summarized in Table 2. No differences were observed between the groups for any of the pulmonary function variables. Significant but weak correlations were found between previous Bikram yoga experience and % predicted forced vital capacity ($r = 0.38$, $P < 0.05$) and between Bikram yoga experience and FEV_1 ($r = 0.37$, $P < 0.05$). Average Bikram attendance per week was unrelated to any of the measured variables. Cardiovascular and metabolic variables are presented in Table 3. No differences ($P > 0.05$) were found between groups for resting BP and HR, peak VO_2 , minute ventilation (V_E), respiratory exchange ratio (RER), and tidal volume (V_T).

Table 1. Descriptive Data of the Subjects Grouped by Experience (Mean \pm SD).

Variables	Low	High	Combined
Age	43.88 \pm 11.54	38.29 \pm 9.31	40.50 \pm 11.39
Weight (kg)	70.42 \pm 12.95	66.95 \pm 13.3	68.73 \pm 12.85
Height (cm)	165.82 \pm 8.04	166.37 \pm 7.08	166.55 \pm 7.37
Previous Bikram experience (yrs)	0.07 \pm 0.06	4.16 \pm 2.80	1.84 \pm 2.65
Average days per week attending Bikram	5.24 \pm 1.98	3.96 \pm 1.168	4.68 \pm 1.55

Table 2. Pulmonary Function Variables Grouped by Experience (Mean±SD).

Variables	Low	High	Combined
Forced vital capacity (FVC)	4.43±0.96	4.85±1.19	4.60±1.02
% predicted FVC	114±14.58	122.79±16.73	118.24±15.45
Forced expiratory volume in the 1 st sec (FEV _{1.0})	3.34±0.77	3.84±1.00	3.57±0.86
% predicted FEV _{1.0}	110.25±14.65	116.50±19.92	113.44±16.39
FEV _{1.0} /FVC	80.15±5.70	79.19±5.78	79.94±5.45
Peak expiratory flow rate (PEFR)	7.42±1.82	7.44±2.55	7.48±2.09
Maximum voluntary ventilation (MVV)	135.82±34.15	132.84±30.19	132.68±31.78
% predicted MVV	115.31±15.28	113.71±18.55	114.29±17.31

Table 3. Cardiovascular Variables Grouped by Experience (Mean±SD).

Variables	Low	High	Combined
Resting			
Systolic blood pressure	123.41±10.72	119.93±9.75	119.88±10.01
Diastolic blood pressure	80.71±7.38	75.71±9.86	77.35±8.12
Heart rate	67.35±5.14	67.57±8.23	67.21±6.47
Peak			
Oxygen consumption (ml·kg ⁻¹ ·min ⁻¹)	34.76±10.48	35.45±7.64	34.78±9.06
Heart rate	132.69±45.21	174.54±13.15	168.19±33.98
Minute ventilation (V _E)	80.72±19.60	78.54±26.12	78.30±23.28
Respiratory exchange ratio (RER)	1.14±0.08	1.15±0.09	1.13±0.11
Respiratory rate (RR)	44.31±9.51	39.23±8.45	41.22±9.85
Tidal volume (V _T)	2.28±0.59	2.44±0.47	2.35±0.51

DISCUSSION

This study describes the resting hemodynamic, pulmonary function, and cardiorespiratory fitness characteristics of Bikram yoga practitioners presenting with various levels of training experience.

Major findings of the study suggest that there are no significant differences in these physiological parameters between 2 groups of subjects with and without long-term Bikram yoga training.

Resting Heart Rate and Blood Pressure Measures

To our knowledge, only one study has reported the effects of Bikram yoga on resting hemodynamics (21). Our cross-sectional data are consistent with the findings of Tracy and Hart (21) who showed no changes in cardiovascular measures. However, when compared to national data sets (14,24), our study shows that those who practice Bikram yoga regularly have lower mean blood pressures and resting heart rates than the general population. These positive changes may be due to a reduction in sympathetic activity (20) and/or an increase in vagal activity (3) resulting from the relaxation and breathing techniques, which have been purported to affect autonomic balance (23).

Pulmonary Function

From a health-related fitness perspective, regular yoga training is widely recognized as beneficial to the pulmonary system (7-11,20,25). These positive findings have been attributed to the deep breathing exercises associated with many types of yoga training. Interestingly, greater improvements are seen when more time is devoted to deep breathing exercises during a yoga training session. Results from our study suggest that Bikram yoga training had no effect on the major variables of pulmonary function. This could be explained by the fact that this style of yoga does not include as great an amount of deep breathing exercises as many forms of regular yoga.

A weak correlation was found between years of experience with Bikram yoga training and some parameters of pulmonary function (FEV_1 , $r = 0.37$ and % pred FVC, $r = 0.38$). Although these findings appear to suggest that Bikram yoga training may influence pulmonary function over an extended period of time, it is important to understand the correlations in light of the coefficient of determination (r^2). It is useful because it gives the proportion of the variance of one variable that is predictable from the other variable. Hence, for an $r = 0.37$, then $r^2 = 0.137$, which means that 14% of the total variation in y can be explained by the linear relationship between x and y (as described by the regression equation). The other 86% of the total variation in y remains unexplained.

Maximal Aerobic Capacity

Average VO_2 max among our Bikram yoga practitioners was $35 \text{ ml}\cdot\text{kg}^{-1}\cdot\text{min}^{-1}$. When organized by gender, average VO_2 max was $40 \text{ ml}\cdot\text{kg}^{-1}\cdot\text{min}^{-1}$ for the men and $33 \text{ ml}\cdot\text{kg}^{-1}\cdot\text{min}^{-1}$ for the women, placing both groups at a “good” classification according to ACSM guidelines (1). Interestingly, these values are far lower than the averages reported in a large national data set of healthy women and men (2). Similar to most other variables measured in this study, VO_2 max did not vary with Bikram yoga experience or days per week practiced.

Our findings are again in agreement with Tracy and Hart (21). They found no significant improvement in VO_2 max following a period of Bikram yoga training. This finding indicates that Bikram Yoga is not performed at an aerobic intensity high enough to stimulate adaptations necessary to improve aerobic fitness (6,15). In agreement, Clay and colleagues (6) reported that the metabolic cost of Hatha yoga performed in an unheated environment resulted in only 15% of the VO_2 reserve used during a yoga training session. It is possible that the additional metabolic cost of performing Bikram yoga in a hot environment may increase these percentages. However, based on our findings, it does not appear that the threshold required for an aerobic training effect is met with regular Bikram yoga practice.

CONCLUSIONS

This is the first study that describes the cardiorespiratory responses of Bikram yoga practitioners with and without long-term training. It appears that regular Bikram yoga practice, regardless of experience and the number of times per week practiced, may lower resting HR and BP when compared to national averages. But, more research is needed to verify this point. Meantime, it is clear from this study that Bikram yoga training has no effect on pulmonary function or maximal aerobic capacity. Additional studies are needed and should be designed to determine the metabolic cost of Bikram yoga to better understand the energy requirement and the intensity at which it is performed. Furthermore, it is important that the future studies are longitudinal with a larger sample size and include multiple comparison groups.

ACKNOWLEDGMENTS

We sincerely acknowledge Jeff and Mardy Chen from Pure Bikram Yoga in Austin, Texas, for allowing us to use their facilities for data collection and helping us recruit subjects. We also acknowledge Blake Spoon for assisting with data collection.

Address for correspondence: Abel AN, MEd, Department Health and Human Performance, Texas State University, San Marcos, Texas, USA, 78666. Phone (512)245-2246; FAX: (512)245-8678; Email: AA1229@txstate.edu.

REFERENCES

1. American College of Sports Medicine. **Guidelines for Exercise Testing and Prescription**. 8th Edition. Philadelphia: Lippincott, Williams and Wilkins, 2010.
2. Aspenes ST, Nilsen TI, Skaug EA, Bertheussen GF, Ellingsen Ø, Vatten L, Wilsoff U. Peak oxygen uptake and cardiovascular risk factors in 4631 healthy women and men. **Med Sci Sports Exerc**. 2011; 43(8):1465-1473.
3. Bowman AJ, Clayton RH, Murray A, Reed JW, Subhan MMF, Ford GA. (1997). Effects of aerobic exercise training and yoga on the baroreflex in healthy elderly persons. **Eur J Clin Invest**. 27, 443-449.
4. Crapo RO, Morris AH, Gardner RM. Reference spirometric values using techniques and equipment that meet ATS recommendations. **Am Rev Respir Dis**. 1981;123:659-664.
5. Choudhury B. **Bikram Yoga: The Guru Behind Hot Yoga Shows the Way to Radiant Health and Personal Fulfillment**. New York: Harper Collins Publishers, 2007.
6. Clay CC, Lloyd LK, Walker JL, Sharp KR, Pankey RB. The metabolic cost of Hatha yoga. **J Strength Cond Res**. 2005;19(3):604-610.
7. Harinath K, Malhotra AS, Pal K, Prasad R, Kumar R, Kain TC, Rai L, Sawhney RC. Effects of Hatha yoga and Omkar meditation on cardiorespiratory performance, psychologic profile and melatonin secretion. **J Altern Complement Med**. 2004;10(2):261-268.

8. Joshi LN, Joshi VD, Gokhale LV. Effect of short term 'pranayam' practice on breathing rate and ventilatory functions of lung. *Indian J Physiol Pharmacol.* 1992;36(2):105-108.
9. Madanmohan, Thombre DP, Balakumar B, Nambinarayanan TK, Thakur S, Krishnamurthy N, Chandrabose A. Effect of yoga training on reaction time, respiratory endurance and muscle strength. *Indian J Physiol Pharmacol.* 1992;36(4):229-233.
10. Makwana K, Khirwadkar N, Gupta HC. Effect of short term yoga practice on ventilatory function tests. *Indian J Physiol Pharmacol.* 1987;32(3):202-208.
11. Mandanmohan, Jatiya L, Udupa K, Bhavanani AB. Effect of yoga training on handgrip, respiratory pressures and pulmonary function. *Indian J Physiol Pharmacol.* 2003;47(4):387-392.
12. Miller MR, Hankinson J, Brusasco V, Burgos F, Casaburi R, Coates A, et al. Standardization of Spirometry. *Eur Respir J.* 2005;26:319–338. doi: 10.1183/09031936.05.00034805
13. Murugesan R, Govindarajulu N, Bera TK. Effect of selected yogic practices on the management of hypertension. *Indian J Physiol Pharmacol.* 2000;44(2):207-210.
14. Oshtega Y, Porter KS, Hughes J, Dillon CF, Nwankwo T. Resting pulse rate reference data for children, adolescents, and adults: United States, 1999-2008. *Natl Health Stat Report.* 2011;41:1-17.
15. Prasad KVV, Ramana YV, Raju PS, Reddy MV, Murthy KJR. Energy cost and physiological efficiency in male yoga practitioners. *J Exerc Physiol Online.* 2001;4(3):38-44.
16. Raju PS, Kumar KA, Reddy SS, Madhavi S, Gnanakumari K, Bhaskaracharyulu C, et al. Effect of yoga on exercise tolerance in normal healthy volunteers. *Indian J Physiol Pharmacol.* 1985;30:121-132.
17. Raju PS, Madhavi S, Prasad KVV, Reddy MV, Reddy ME, Sahay BK, Murthy KJ. Comparison of effects of yoga and physical exercise in athletes. *Indian J Med Res.* 1994;100:81-87.
18. Raju PS, Prasad KVV, Venkata RY, Murthy KJR, Reddy MV. Influence of intensive yoga training on physiological changes in 6 adult women: A case report. *J Altern Complement Med.* 1997;3(3):291-295.
19. Ray US, Mukhopadhyaya S, Purkayastha SS, Asnani V, Tomer OS, Prashad R, et al. Effect of yogic exercises on physical and mental health of young fellowship course trainees. *Indian J Physiol Pharmacol.* 2001;45(1):37-53.
20. Telles S, Nagarathna R, Nagendra HR, Desiraju T. Physiological changes in sports teachers following 3 months of training in yoga. *Indian J Med Sci.* 1993;47(10):235-238.
21. Tracy BL, Hart CE. Bikram yoga training and physical fitness in healthy young adults. *J Strength Cond Res.* 2012;May 15[Epub ahead of print].

22. Tran MD, Holly RG, Lashbrook J, Amsterdam EA. Effects of Hatha yoga practice on the health-related aspects of physical fitness. *Prev Cardiol.* 2001;4(4):165-170.
23. Wenger MA, Bagchi BK. Studies of autonomic functions in practitioners of yoga in India. *Behavioral Science.* 1961;6(4):312-323.
24. Wright JD, Hughes JP, Ostchega Y, Yoon SS, Nwankwo T. Mean systolic and diastolic blood pressure in adults aged 18 and over in the United States, 2001-2008. *Natl Health Stat Report.* 2011;March 25(35):1-22,24.
25. Yadav RK, Das S. (2001). Effect of yogic practice on pulmonary functions in young females. *Indian J Physiol Pharmacol.* 2001;45(4):493-496.

Disclaimer

The opinions expressed in **JEPonline** are those of the authors and are not attributable to **JEPonline**, the editorial staff or the ASEP organization.