Short Communication

Effect of 11 months of yoga training on cardiorespiratory responses during the actual practice of Surya Namaskar

Biswajit Sinha, Tulika Dasgupta Sinha[1]

Departments of Physiology, Institute of Aerospace Medicine, Indian Air Force, and [1]Nadgir Institute of Paramedical Sciences, Bangalore, Karnataka, India

Address for correspondence: Dr. Biswajit Sinha,
Department of Physiology, Institute of Aerospace Medicine,
Indian Air Force, Bangalore - 560 017, Karnataka, India.
E-mail: bsinha2001@yahoo.co.in

ABSTRACT

Background: Surya Namaskar (SN), a popular traditional Indian yogic practice, includes practicing 12 physical postures with alternate forward and backward bending movement of the body along with deep breathing maneuvers. The practice of SN has become popular among yoga practitioners and other fitness conscious people. The long-term effect of practicing SN and other yogic practices on cardiorespiratory responses during SN are lacking.

Aim: The present study was conducted to study the effect of yogic training on various cardiorespiratory responses during the SN practice in yoga trainees after a time interval of 3, 6, and 11 months.

Materials and Methods: The present study was conducted on 9 healthy male Army soldiers who underwent training in various yoga postures including SN, meditation, and pranayama for 1 h daily for 11 months. First, second, and third phase of the study was conducted in the laboratory after completion of 3, 6, and 11 months of the yoga training. The participants performed SN along with other yogic practices in the laboratory as per their daily practice schedule. The cardiorespiratory responses of the volunteers were recorded during actual practice of SN.

Statistical Analysis: One-way repeated measure ANOVA followed by Tukey HSD.

Results: Oxygen consumption and heart rate during actual practice of SN was 0.794 ± 0.252, 0.738 ± 0.229, and 0.560 ± 0.165 L/min and 92.1 ± 11.6, 97.9 ± 7.3 and 87.4 ± 9.2 beats/min respectively at 1st, 2nd, and 3rd phase of yoga training. Minute ventilation and tidal volume also reduced from 19.9 ± 4.65 to 17.8 ± 4.41 L/min and 1.091 ± 0.021 to 0.952 L/breath from 1st phase to 3rd phase of yoga training. However, respiratory parameters like breathing rate (f_R) did not show any reduction across the three phases.

Conclusion: The results of the present study indicated that yogic training caused conditioning of cardiorespiratory parameters except $f_{R,}$ which did not reduce across three phases of training.

Key words: Cardiorespiratory response; Surya Namaskar; yoga.

INTRODUCTION

Surya Namaskar (SN) or sun salutation, a traditional Indian yogic practice, renders the benefits of stretching, static, and dynamic exercise. Each round of SN practice involves practicing 12 postures in succession with forward and backward bending along with deep exhalation and inhalation respectively to the maximum possible extent. Many people practice several rounds of SN for their regular physical fitness program.

Access this article online	
Website: www.ijoy.org.in	Quick Response Code
DOI: 10.4103/0973-6131.123493	

The energy cost and other cardiorespiratory responses during the practice of SN were first reported from our laboratory.[1] The author also compared physiological responses of performing SN at two different paces in another study.[2] Mody[3] measured the average energy expenditure for practicing one round of SN in trainees. Bhavanani *et al*.[4] compared differential effects of 6 months of slow and fast SN training on cardiorespiratory parameters and muscle endurance in school children. They observed that effects of fast SN training on physiological variables were akin to the effects produced by other forms of aerobic exercise training, whereas slow SN training are similar to those of yoga training with reduction in cardiovascular parameters toward lower normal values. Hagins *et al*.[5] reported that yoga practice incorporating SN for more than 10 min may constitute some portion of sufficient intense physical activity and can improve cardiorespiratory fitness in unfit or sedentary individuals. Bhutkar *et al*.[6] observed that regular SN practice improved cardiopulmonary efficiency in healthy adolescents and was beneficial for both males and females. Sasi *et al*.[7] reported an increase of systolic blood pressure, peak expiratory flow rate, forced vital capacity, and reduction of respiratory rate, heart rate (HR), and diastolic blood pressure in 115 school children aged 10-14 years after practice of 30-40 min of daily SN for 45 days.

No scientific study is available on the cardiorespiratory responses during the SN practice in yogic practitioners at various phases of training. Hence, the present study was conducted to study the effect of yogic training on various cardiorespiratory responses during SN practice in yoga trainees after a time interval of 3, 6, and 11 months.

MATERIALS AND METHODS

9 healthy male volunteers from a regiment of Indian Army were chosen for the present study. Their age, height, and body weight were 22.3 ± 1.31 years, 172.5 ± 4.60 cm and 62.5 ± 4.10 kg respectively. The participants were non-smokers, vegetarian and non-alcoholic. However, being the Army subjects, they used to practice their daily routine activity and exercise schedule before the recruitment in the study. The subjects underwent training daily in the morning at 6 am for 1 h duration for 5 days a week for 11 months in various yogic practices including SN for 3 min and 40 s.

Participants gave their voluntary informed consent to participate in the study and undertake physiological monitoring on them during the actual performance of SN. They were familiarized with an experimental setup and protocol before the study. The Institute Ethical Committee approved the protocol of the study.

The participants performed SN and other yogic practices in a dimly lit, sound attenuated, and thermoneutral laboratory. It was ensured to provide adequate rest period in between two yogic practices until their cardio-respiratory parameters returned to the pre-yoga baseline values. First, second, and third phase of the study was conducted after completion of 3, 6, and 11 months of the training, i.e. on commencement of the 4^{th}, 7^{th}, and 12^{th} month respectively.

The different ventilatory parameters were recorded during SN with the help of an exercise test assembly (Jaeger Oxycon Champion, Erich Jaeger, Germany). The parameters recorded were oxygen consumption ([$\dot{V}O_2$] in L/min), carbon dioxide output ([$\dot{V}CO_2$] in L/min), minute ventilation ([$\dot{V}E$] in L/min), volume tidal ([VT] in L/breath), breathing rate (f_R in breaths/min). HR (HR in beats/min) was measured by single lead electrocardiography by putting three electrodes on the anterior surface of the chest. Other derived cardiorespiratory parameters like ventilatory equivalent for oxygen (EQO_2) was calculated by dividing $\dot{V}E$ by $\dot{V}O_2$, ventilatory equivalent for carbon dioxide ($EQCO_2$) was calculated by dividing $\dot{V}E$ by $\dot{V}CO_2$ and oxygen pulse (O_2P) was calculated by dividing $\dot{V}O_2$ by HR from main parameters $\dot{V}E$, $\dot{V}O_2$, $\dot{V}CO_2$ and HR. EQO_2 and $EQCO_2$ are measures of pulmonary ventilation required to transfer 1 L of O_2 and 1 L of CO_2 across the alveolo-capillary membrane in the lungs. O_2P is a measure of cardiopulmonary oxygen transport and determines the amount of O_2 delivered to the body tissue per contraction of the heart.

The data were first examined for normality of distribution by Shapiro Wilks "W" statistic. The principal purpose of this study was to examine the variation in certain physiological variables with the yoga training, the data were averaged across 12 postures and one-way repeated measure ANOVA was used to analyze the data. After significant outcome from ANOVA, *post hoc* analysis by Tukey HSD was carried out for inter group comparison.

RESULTS

The effect of yoga training on various cardiorespiratory parameters during SN practice is shown in Table 1. $\dot{V}O_2$ decreased significantly in 3^{rd} phase as compared to 1^{st} phase and 2^{nd} phase ($P < 0.001$ in both the case). HR reduced significantly only in 3^{rd} phase ($P < 0.001$) from 2^{nd} phase. HR did not decrease in 2^{nd} phase as compared to 1^{st} phase. O_2P decreased significantly in 3^{rd} phase from 1^{st} phase ($P < 0.05$).

$\dot{V}CO_2$ reduced significantly in 2^{nd} phase ($P < 0.001$) and 3^{rd} phase ($P < 0.001$) as compared to 1^{st} phase. It also reduced in 3^{rd} phase from 2^{nd} phase ($P < 0.001$).

The ventilatory parameters like $\dot{V}_E$ reduced significantly in 3^{rd} phase from 1^{st} phase ($P < 0.001$) as well as from 2^{nd} phase ($P < 0.001$). f_R did not reduce significantly across three phases of yoga training. $\dot{V}_T$ reduced significantly in 3^{rd} phase as compared to 1^{st} phase ($P < 0.001$) and 2^{nd} phase ($P < 0.01$).

EQO_2 increased significantly in 3^{rd} phase from 1^{st} phase ($P < 0.001$) and from 2^{nd} phase ($P < 0.001$).

Table 1: Cardiorespiratory responses during SN practice at 1st, 2nd and 3rd phases of yoga training. Values are mean±SD

Parameters	1st phase	2nd phase	3rd phase	Significance
$\dot{V}O_2$ (L/min)	0.794±0.252	0.738±0.229	0.560±0.165***,+++	F=20.080, P=0.00001
HR (beats/min)	92.1±11.6	97.9±7.3	87.4±9.2+++	F=7.9063, P=0.00259
O_2P (ml/beat)	8.62±2.52	7.54±3.83	6.46±1.78*	F=4.0754, P=0.0312
$\dot{V}CO_2$ (L/min)	0.650±0.199	0.550±0.177***	0.471±0.136***,+++	F=36.7268, P=0.000
$\dot{V}E$ (L/min)	19.9±4.65	19.98±5.06	17.8±4.41***,+++	F=10.2225, P=0.0007
f_R (breaths/min)	18.81±1.46	19.59±2.72	19.1±2.41	F=0.928, P=0.4103
V_T (L/breath)	1.091±0.021	1.038±0.213	0.952±0.180***,+	F=9.6876, P=0.0009
EQO_2	27.05±4.049	28.09±4.235	32.56±1.580***,+++	F=22.6580, P=0.00000
$EQCO_2$	32.07±3.971	37.73±4.062***	38.94±3.686***	F=56.567, P=0.00000

SN=Surya Namaskar; $\dot{V}O_2$ = Oxygen consumption; HR = Heart rate; O_2P = Oxygen pulse; $\dot{V}CO_2$ = Carbon dioxide output; $\dot{V}E$ = Minute ventilation; f_R = Breathing rate; V_T = Tidal volume; EQO_2 = Equivalent for oxygen; $EQCO_2$ = Equivalent for carbon dioxide. *P<0.05, **P<0.01 and ***P<0.001 respectively, significantly different from 1st phase; +P<0.01, +++P<0.001 significantly different from 2nd phase; SD = Standard deviation

$EQCO_2$ increased significantly in 2nd phase and 3rd phase from 1st phase (P < 0.001 in both cases).

DISCUSSION

In the present study, we determined the effect of yogic training on cardiorespiratory responses during SN practice. It was observed from Table 1 that $\dot{V}O_2$ reduces progressively from 1st phase to 3rd phase of SN practice indicating trainees performed SN consuming lesser oxygen as training progressed. Chaya *et al*.[8] reported that long-term practice of yogic asanas along with pranayama and meditation causes reduced sympathetic activity resulting in reduced metabolic rate and greater metabolic efficiency in yoga practitioners. In the present study, the yoga practitioners practiced asanas, pranayama, and meditation as part of their yogic training schedule. Hagins *et al*.[5] suggested that yoga is a mind-body practice where practice of physical postures is combined with control of breathing, meditation along with stretching exercise, isometric exercise, and dynamic exercises of skeletal muscles. The practice of SN involves alternate backward bending and forward bending postures along with chanting of mantras and breathing maneuver. It is reported in a recent study by Ray *et al*.[9] that improvement in metabolic parameters in yoga practitioners may occur due to adaptation of local muscular metabolism resulting in shifting of lactate threshold toward higher side. This corroborates the findings in the present study where yoga trainees spent lesser energy to perform SN at the 3rd phase of the training as compared to other phases. This is in agreement with the results obtained in a study by Raju *et al*.[10] where female yoga practitioners after intensive yoga training could perform same pre-yoga training work intensity at a lower oxygen cost (P < 0.05), reduced HR (P < 0.05), reduced $\dot{V}O_2$ per unit work (P < 0.05) and $\dot{V}E$ (P < 0.05).

There are number of reports, which show that yogic practices for few weeks or months lead to relative vagal dominance, reduced sympathetic tone and HR and improved cardiovascular function.[3,4,6-8,11-17] Trained practitioners had a lower HR and $\dot{V}_E$ while performing yogic asanas than their untrained counterparts who performed similar poses.[11] Practice of hatha yoga can improve strength and flexibility, and may help control such physiological variables as blood pressure, respiration, HR , and metabolic rate to improve overall exercise capacity[15]. It was reported that regular asana and pranayama practice reduces HR and blood pressure in resting young males and resting elderly males and females.[11] Raju *et al*.[16] in a study had shown that during short-term (3 months) yoga training, significant reduction of $\dot{V}_E$ and oxygen uptake during sub-maximal exercise test occurred in normal healthy volunteers. Ross *et al*.[17] suggested that yogic practice render benefits of physical and mental health via down regulation of the hypothalamic–pituitary–adrenal axis and the sympathetic nervous system. HR reduction was significant in our trainees from 2nd phase to 3rd phase (P < 0.001). Participants recruited in the present study were army soldiers and they were highly active individuals. They were also involved in regular PT and other physical activity program as per the army protocol. The cardiorespiratory effect observed in trainees in the present study may be attributed to their high level of training status in addition to yogic training. Study by Bowman *et al*.[18] suggested that HR was decreased following yoga (69 ± 8 beats/min vs. 61 ± 7 beats/min, P < 0.05) training, but not due to aerobic training (66 ± 8 beats/min vs. 63 ± 9 beats/min, P = 0.29).

CONCLUSION

The effect of yogic training on various cardiorespiratory responses during the practice of SN was observed in 9 healthy male volunteers after 3 months (1st phase), 6 months (2nd phase), and 11 months (3rd phase) months of training. The yogic schedule consisted of a battery of yogic exercise, pranayama, and meditation. The physiological parameters such as $\dot{V}O_2$, HR, $\dot{V}CO_2$, $\dot{V}_E$, and V_T showed a significant fall in the 3rd phase as compared to the previous phases. O_2P, an indicator of myocardial oxygen carriage, showed a significant decrease in the 3rd phase when compared to 1st phase of the training. This might have happened because of dissimilar reduction of $\dot{V}O_2$ and HR during training. The respiratory parameters f_R did not show any significant fall in the 3rd phase from 1st phase. The derived ventilatory parameters EQO_2 and $EQCO_2$ showed a significant increase in the 3rd phase from 1st phase, which is commensurate with disproportionate reduction of $\dot{V}O_2$ and $\dot{V}_E$.

ACKNOWLEDGMENTS

The author puts on record the sincere thanks to participants who voluntarily took part in the present study, without their wholehearted co-operation, the study would not have been possible. The author sincerely thanks Mrs. Anjana Pathak for her help in collecting the data. The author also acknowledges the help received from Mr. OS Tomer for his technical help while collecting the data.

REFERENCES

1. Sinha B, Ray US, Pathak A, Selvamurthy W. Energy cost and cardiorespiratory changes during the practice of Surya Namaskar. Indian J Physiol Pharmacol 2004;48:184-90.
2. Sinha B, Ray US, Sinha TD. Physiological study of Surya Namaskar, a yogic practice. Altern Ther Health Med 2011;17:62-3.
3. Mody BS. Acute effects of Surya Namaskar on the cardiovascular and metabolic system. J Bodyw Mov Ther 2011;15:343-7.
4. Bhavanani AB, Udupa K, Madanmohan, Ravindra P. A comparative study of slow and fast suryanamaskar on physiological function. Int J Yoga 2011;4:71-6.
5. Hagins M, Moore W, Rundle A. Does practicing hatha yoga satisfy recommendations for intensity of physical activity which improves and maintains health and cardiovascular fitness? BMC Complement Altern Med 2007;7:40.
6. Bhutkar PM, Bhutkar MV, Taware GB, Vinayak D, Doddamani BR. Effect of suryanamaskar practice on cardio-respiratory fitness parameters: A pilot study. Al Ameen J Med Sci 2008;1:126-9.
7. Sasi AK, Sivapriya DV, Thirumeni S. Effects of surya namaskar on cardiovascular and respiratory parameters in school students. Recent Res Sci Tech 2011;3:19-24.
8. Chaya MS, Nagendra HR. Long-term effect of yogic practices on diurnal metabolic rates of healthy subjects. Int J Yoga 2008;1:27-32.
9. Ray US, Pathak A, Tomer OS. Hatha yoga practices: Energy expenditure, respiratory changes and intensity of exercise. Evid Based Complement Alternat Med 2011;2011:241294.
10. Raju PS, Prasad KV, Venkata RY, Murthy KJ, Reddy MV. Influence of intensive yoga training on physiological changes in 6 adult women: A case report. J Altern Complement Med 1997;3:291-5.
11. Blank SE. Physiological responses to iyengar yoga performed by trained practitioners. J Exerc Physiol Online 2006;9:7-23.
12. 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;47:235-8.
13. 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;45:37-53.
14. Harinath K, Malhotra AS, Pal K, Prasad R, Kumar R, Kain TC, *et al*. Effects of Hatha yoga and Omkar meditation on cardiorespiratory performance, psychologic profile, and melatonin secretion. J Altern Complement Med 2004;10:261-8.
15. Raub JA. Psychophysiologic effects of Hatha Yoga on musculoskeletal and cardiopulmonary function: A literature review. J Altern Complement Med 2002;8:797-812.
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 1986;30:121-32.
17. Ross A, Thomas S. The health benefits of yoga and exercise: A review of comparison studies. J Altern Complement Med 2010;16:3-12.
18. Bowman AJ, Clayton RH, Murray A, Reed JW, Subhan MM, Ford GA. Effects of aerobic exercise training and yoga on the baroreflex in healthy elderly persons. Eur J Clin Invest 1997;27:443-9.

How to cite this article: Sinha B, Sinha TD. Effect of 11 months of yoga training on cardiorespiratory responses during the actual practice of Surya Namaskar. Int J Yoga 2014;7:72-5.

Source of Support: Defense Institute of Physiology and Allied Sciences, Defense Research and Development Organization, Ministry of Defense, Delhi - 110 054, India, **Conflict of Interest:** None declared