Original Article

Effects of yoga training on blood pressure response during surya namaskar following eleven months of yoga practice in army men and yoga-trained individuals

Biswajit Sinha, Tulika Dasgupta Sinha[1], Anjana Pathak[2], Omveer Singh Tomer[2]

Department of Physiology, Institute of Aerospace Medicine, Indian Air Force, Bangalore, [1]Department of Physiology, Nadgir Institute of Paramedical Sciences, Bangalore, Karnataka, [2]Department of Work Physiology, Defence Institute of Physiology and Allied Sciences, Defence Research and Development Organization, Ministry of Defence, Timarpur, Delhi, India

Abstract

Background and Aim: Surya namaskar (SN), a popular traditional Indian yogic practice, called sun salutations, is a series of 12 physical postures performed with controlled breathing. The present study was carried out to investigate the blood pressure (BP) response i.e., sympathetic reactivity during actual performance of SN at three different phases of yoga training for 11 months.

Methods: It was an interventional study design where nine healthy, male, army volunteers were selected and imparted training in various yogic practices for 11 months. Their systolic blood pressure (SBP), diastolic blood pressure (DBP) and mean arterial pressure (MAP) during actual performance of SN were measured after 3, 6 and 11 months of training. BP responses of army personnel were compared with those of yoga proficient (*n* = 10) and semi-proficient (*n* = 9) individuals.

Results: Average SBP during SN in trainees (at different phases of the training), proficient and semi-proficient was 158.2, 141.3, 138.7, 152.4 and 155.9 mmHg, respectively. DBP and MAP during SN in trainees, proficient and semi-proficient were 98.9, 92.9, 86.9, 106.7 and 96 mmHg and 117.3, 105.7, 101.8, 122 and 115.9 mmHg, respectively.

Conclusion: Training in yogic practices for 11 months brought about a substantial reduction of BP response i.e., sympathetic reactivity during actual performance of SN in a group of army soldiers. The training helped them to achieve the same level of proficiency with those of yoga proficient and semi-proficient individuals.

Key words: Blood pressure, surya namaskar, yoga proficient, yoga training

Received: 18th October, 2013; ***Revised:*** 20th December, 2013; ***Accepted:*** 4th January, 2014

INTRODUCTION

Surya namaskar (SN), a popular traditional Indian yogic practice called "Sun Salutations", is a series of 12 physical postures that are performed by moving various body parts in synchrony with alternate backward and forward bending postures in standing and sitting on the floor. Performing 12 postures in succession makes one round of SN practice [Figure 1].[1] Practice of each forward and backward bending posture is accompanied by deep exhalation and inhalation respectively. During SN practice, duration of isometric and isotonic contraction of muscles vary according to the rate at which practitioners move from one posture to succeeding posture. Rapid transition makes muscle to contract more dynamically and the slower transition makes muscle to contract more isometrically. The practice of SN has gained wide popularity in recent times amongst people due to its beneficial effects and gradual acceptance by the scientific community.[1]

Access this article online	
Quick Response Code:	Website: www.ijcep.org
	DOI: 10.4103/2348-8093.129738

Studies from our laboratory and other investigators reported the energy cost and cardiorespiratory responses of practicing SN.[2-5] It is also reported that regular SN practice improves cardiopulmonary efficiency in healthy adolescents, reduces resting pulse rate and blood pressure (BP) in both males and females.[6] Sasi *et al*., has reported increase of systolic blood pressure (SBP), peak

Address for correspondence: Dr. Biswajit Sinha, Department of Physiology, Institute of Aerospace Medicine, IAF, Old Airport Road, Vimanapura, Bangalore - 560 017, Karnataka, India. E-mail: bsinha2001@yahoo.co.in

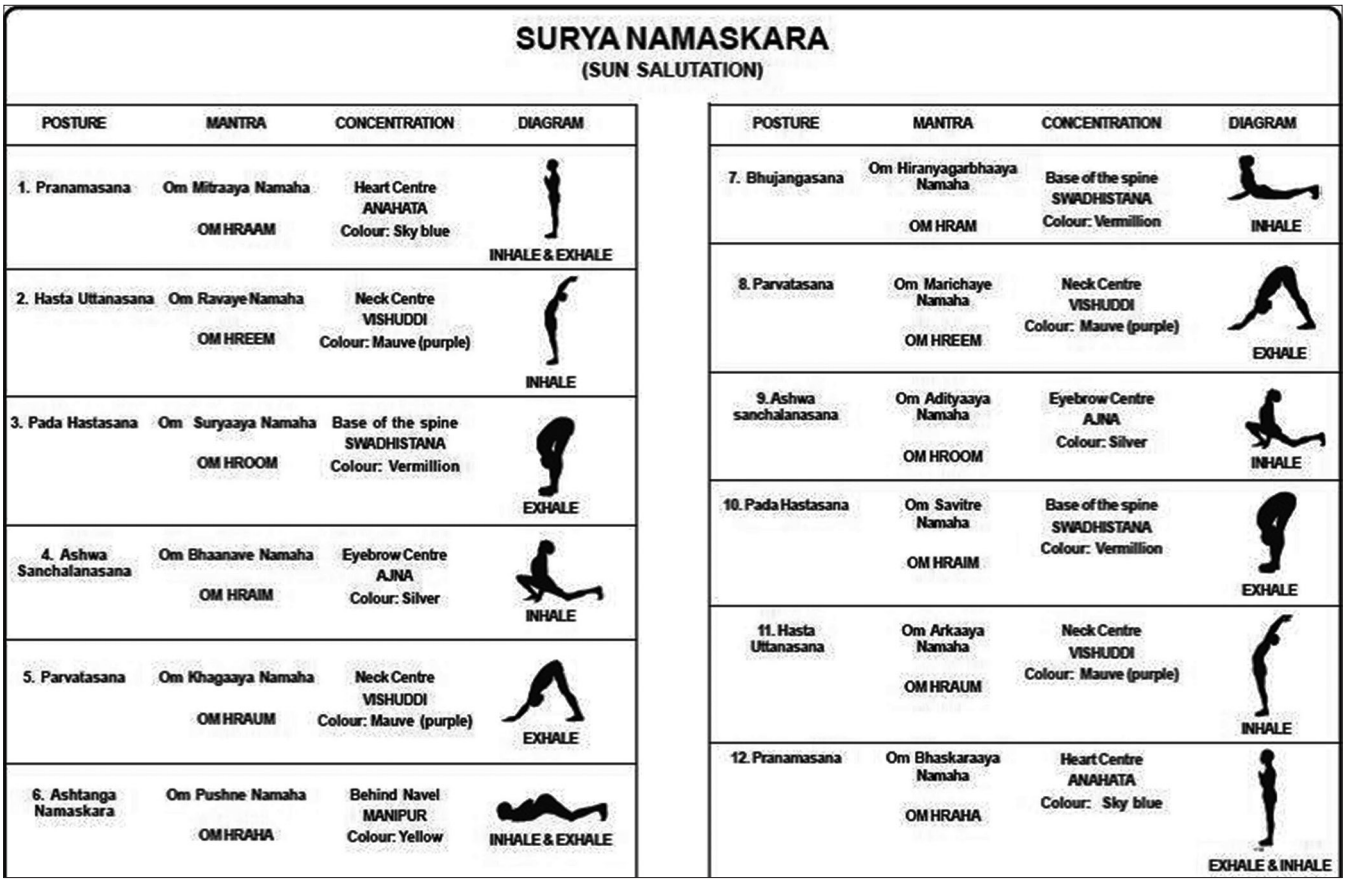

Figure 1: Twelve postures of Surya namaskar in a series

expiratory flow rate, forced vital capacity and reduction of respiratory rate, heart rate (HR) and diastolic blood pressure (DBP) in 115 school children aged 10-14 years after practising 30-40 minutes of SN daily for 45 days.[7] Number of reports have demonstrated that yogic practices for few weeks or months lead to relative vagal dominance, reduced sympathetic tone, HR, BP and improvement in other cardiovascular (CV) functions.[8-12] Ross *et al*., have suggested that yogic practice may render benefits of physical and mental health via down regulation of the hypothalamic–pituitary–adrenal axis and sympathetic nervous system.[13] Okonta in an integrated review have reported that yogic practices reduce BP in hypertensive patients.[14] Innes *et al*., in a systematic review have reported that yoga practice may reduce BP in healthy individuals and also in those with chronic illness.[15]

All the above-reported studies have measured the BP at rest, before and after commencement of yogic training, so as to measure the impact of yoga training on sympathetic activity. To date, no study has been carried out in which sympathetic reactivity has been tested during actual performance of a yogic practice following yoga training for certain duration. The present study was conducted with an aim to assess the sympathetic reactivity by measuring SBP, DBP and mean arterial pressure (MAP) during actual performance of SN by the army personnel, following 3, 6 and 11 months of yoga training and in a group of yoga-trained individuals. BP responses of army personnel were compared with those of yoga-trained proficient and semi-proficient subjects who performed SN for similar duration like army trainees.

MATERIALS AND METHODS

Nine normal healthy male volunteers from a regiment of army who were free from any clinical disorders were chosen for the present study. The participants were non-smokers, vegetarian and non-alcoholic. The small sample size (n = 9) was due to less availability of army men those who are not smoking and not taking alcohol. It is difficult to get a larger sample size of non-smoking and non-alcoholic armymen. Subjects with previous experience of yoga training, history of major medical illnesses such as tuberculosis, hypertension, diabetes mellitus, bronchial asthma, autonomic diseases or any other comorbidities that are likely to influence physiological parameters were excluded from the present study. However, being the army subjects, they used to practice their daily routine activity and exercise schedule before yoga training in the study. The subjects

underwent training daily in the morning at 0600 h for 5 days a week for 11 months in various yogic postures for 1 hour including SN for 3 min and 40 s along with other yogic postures, breathing maneuver (Pranayama) and meditation. The 1-hour yogic schedule consisted of various yogic asanas, mudra, meditation and pranayama in addition to SN for 3 min and 40 s. These included yogamudrasana (2 min), paschimottanasana (2 min), suptapavanmuktasana (1 min), pavanmuktasana (1 min), dhanurasana (2 min), matsyasana (2 min), vajrasana (1 min), suptavajrasana (1 min), gomukhasana 1 and 2 (2 min), sarvangasana (1 min), halasana 1 and 2 (2 min), karnapeedasana (1 min), bhujangasana (2 min), utthanpadasana (2 min) and shavasana was performed after every asana until the cardiorespiratory parameters returned to baseline resting level, kapalbhati (2 min), bhastrika (2 min), kakimudra (1 min), yoni mudra (1 min), bhramari pranayama (2 min), omkar meditation (3 min), meditation (2 min) and sukhasana was performed after pranayama and mudra.

Another 19 age-matched, healthy, vegetarian, non-smokers, non-alcoholic, male yoga instructors and yoga practitioners were recruited in the present study. Detailed questionnaire assessing their daily yogic practice schedule and other activities were carried out. They were divided into yoga proficient (n = 10) and semi-proficient (n = 9) subjects based on their years of experience of practicing various yogic exercises. Yoga proficient had experience of yogic practices for more than 4 years, whereas semi-proficient had an experience for 2-4 years.

All participants gave their voluntary informed written consent to participate in the study and to undertake physiological monitoring on them during the actual performance of SN in the laboratory. They were being familiarized with experimental set up and protocol before carrying out any physiological recording on them. The Institute Ethical Committee approved the protocol of this study.

First, second and third phases of the study were conducted after completion of 3, 6, and 11 months of yoga training i.e., on commencement of the 4th month, 7th month and 12th month, respectively. All the participants performed SN after 3, 6, and 11 months of yogic training in the laboratory of Department of Exercise Physiology, Defence Institute of Physiology and Allied Sciences, Delhi, India. They performed SN for 3 min and 40 s in a dimly lit, sound attenuated and thermoneutral room along with other yogic practices at the same time in the morning. A special blood pressure cuff of an electro-sphygmomanometer (Propaq, USA) was attached to the individuals to measure their BP during the yogic practice. The cardio-respiratory parameters of these individuals were monitored throughout and adequate rest period was provided in between two yogic practices until the cardio-respiratory parameters returned to pre-yoga baseline resting values. Data on BP during SN of proficient and semi-proficient was recorded after trainees and they performed SN for the same time duration like army trainees to keep the uniformity in the study.

The BP was recorded in all practitioners during the performance of SN at 3rd and 11th posture. These two particular postures were chosen because of convenience for recording BP, as manometer cuff was not compressed externally by contraction of the muscles due to arm movement. SBP and DBP were measured and MAP was calculated by adding 1/3rd of pulse pressure (SBP-DBP) with DBP. BP values were expressed as mmHg.

Statistical analysis

All the data were expressed as Mean ± standard error of mean (SEM). The data were analysed by using statistical software Statistica 9.0. The data were first checked for normality of distribution by Shapiro Wilks 'W' statistics. One-way ANOVA was carried out for data analysis, followed by post-hoc analyses using Tukey HSD (Honestly Significant Difference) for inter-group comparison.

RESULTS

The mean age (years), height (cm), body weight (kg) and body mass index (BMI) (kg/m^2) of yoga trainees, proficient and semi-proficient were shown in Table 1. The BP data of trainees at resting supine and during actual performance (11th posture of SN) at three different phases of the training was shown in Table 2. Comparison of BP data of trainees, yoga proficient and yoga semi-proficient at resting supine and during actual performance (11th posture of SN) at three different phases of the training was shown in Table 3.

It was observed from Table 2, SBP was increased significantly in trainees (by 25-45 mmHg) during SN from baseline resting supine. SBP was increased by 4-7 mm Hg from 3rd posture to 11th posture. SBP was reduced significantly in 2nd phase (P < 0.01) and in 3rd phase (P < 0.001) when compared with 1st phase.

Table 1: Physical characteristics of trainees (n=9), yoga proficient (n=10) and semi-proficient (n=9). Values are given as mean±SEM

Parameters	Trainees	Yoga proficient	Yoga semi-proficient
Age (years)	22.3±1.31	26.2±3.15	23.1±3.33
Height (cm)	172.8±4.60	167.0±6.14	167.0±5.94
Body weight (Kg)	62.5±4.10	56.8±10.1	56.6±7.05
BMI (Kg/m^2)	20.9±3.29	20.4±4.24	20.3±3.89

Values are mean±SEM. BMI: Body mass index, SEM: Standard error of mean

DBP in trainees was increased by 17-32 mmHg during SN from baseline resting and by about 2-8 mmHg from 3rd posture to 11th posture. DBP did not show any significant reduction in 2nd phase when compared with 1st phase; however, it registered a significant fall in 3rd phase ($P < 0.001$) from 1st phase. MAP in trainees was increased by 17-34 mmHg during SN from baseline resting and about 2-7 mmHg from 3rd to 11th posture. MAP showed a significant attenuation during SN in 2nd phase ($P < 0.01$) and in 3rd phase ($P < 0.001$) from 1st phase.

As noted in Table 3, it was observed that the average increase of SBP and DBP in proficient and semi-proficient was about 35-40 mmHg and 25-30 mmHg, respectively, during SN performance from baseline resting. Postural variation for SBP was found to be around 7 mmHg and for DBP as 6 mmHg between 3rd and 11th posture in case of proficient, but semi-proficient did not exhibit any postural variation. Average increase of MAP in proficient and semi-proficient was noticed to be about 30-32 mmHg during SN from resting supine. Proficient individuals showed a postural variation of about 7 mmHg between 3rd and 11th posture, whereas semi-proficient did not show this postural variation. From Table 2, it also evident that the proficient and semi-proficient exhibited a higher SBP, DBP, MAP and HR during SN practice from trainees.

Table 2: Blood pressure data of trainees at resting supine and during actual performance (11th posture of SN) at three different phases of the training

Parameters	Phase I	Phase II	Phase III
SBP			
Resting	110.8±1.95	113.4±2.65	111.5±2.55
SN 11th posture	158.2±4.12	141.3±3.80##	138.7±4.96***
DBP			
Resting	66.9±1.92	63.7±2.01	65.8±0.99
SN 11th posture	98.9±1.95	92.9±2.44	86.9±1.77***
MBP			
Resting	81.6±1.48	80.3±2.09	80.9±1.16
SN 11th posture	117.3±2.34	105.7±3.35##	101.8±3.15***

Values are mean±SEM. SEM: Standard error of mean, SBP: Systolic blood pressure, DBP: Diastolic blood pressure, MAP: Mean arterial blood pressure, I phase: After 3 months of yoga training, II phase: After 6 months of yoga training, III phase: After 11 months of yoga training. The (#) depicts comparison between Phase I and Phase II, # (P<0.05), ##(P<0.01), ###(P<0.001). The (*) depicts comparison between Phase I and Phase III, *(P<0.05), **(P<0.01), ***(P<0.001), SN: Suryanamaskar

DISCUSSION

The present study has examined the sympathetic reactivity during SN in army personnel following training in yoga practice and in a group of yoga trained proficient and semi-proficient individuals. Sympathetic reactivity during SN was tested by measuring their SBP, DBP and MAP during the practice. Earlier, many studies have reported improvement of CV parameters following yoga training. But, these studies have compared baseline resting CV responses before and after yoga training. Recording of CV response at rest is a way to test the sympathetic activity whereas in the present study, sympathetic reactivity during the actual performance of SN has been tested, which has not been done by other investigators. Therefore, the novelty of the present study is in determination of sympathetic reactivity during SN in three groups of subjects.

SBP during SN practice was increased significantly from baseline resting supine by about 35 mmHg in army trainees and by about the similar extent in proficient and semi-proficient individuals. DBP and MAP during SN practice increased by about 17-34 mmHg in trainees and by about 30-40 mmHg in proficient and semi-proficient from baseline resting values. The pressor response during exercise depends on many factors like type of exercise i.e., whether the exercise is isometric or isotonic in nature, intensity of muscle contraction, status of training and body muscles involved in the exercise.[16] The large increase in BP during SN practice may be due to its nature of muscle contraction which is predominantly isometric. The imposition of dynamic component into isometric component during SN practice causes BP response to be heightened from baseline resting supine posture to a great extent. Coupled with this, orthostatic stress occurs on standing during SN practice, can also be responsible for increased pressor response during its practice. Study by Miles *et al*., had shown that

Table 3: Comparison of blood pressure data of trainees at three different phases of the training, yoga proficient, yoga semi-proficient at resting supine and during actual performance of SN (11th posture)

Parameters	Group I		Group II		Group III	
	Resting	11th posture	Resting	11th posture	Resting	11th posture
HR (beats/min)	65.0±1.604	114.3±4.958	69.6±1.458	113.6±5.542	62.0±1.529##	86.5±6.320***###
SBP (mm/Hg)	111.8±0.963	152.4±4.112	119.6±1.863	155.9±4.11	111.9±2.384###	146.01±4.293**###
DBP (mm/Hg)	70.3±1.383	106.7±2.401	74.0±1.032	96.0±1.954	65.5±1.642###	92.9±2.054***
MAP (mm/Hg)	84.1±0.944	122.0±3.101	89.2±1.372	115.9±2.498	80.9±1.577###	108.3±2.949***###

Values are mean±SEM. SEM: Standard error of mean, HR: Heart rate, SBP: Systolic blood pressure, DBP: Diastolic blood pressure, MAP: Mean arterial blood pressure, Group I: Yoga proficient, Group II: Yoga semi-proficient; Group III: Army men undergoing yoga training. Statistical analysis was done by one-way ANOVA test followed by post-hoc Tukey test among 3 groups. The (*) depicts comparison between group I and group III, *(P<0.05), **(P<0.01), ***(P<0.001). The (#) depicts comparison between group II and group III, #(P<0.05), ##(P<0.01), ###(P<0.001), SN: Suryanamaskar

increase of SBP, MAP and DBP during actual yoga practice was greatest with standing postures as compared to yogic inversion and floor postures.[17]

However, the pressor response in army trainees was found to be attenuated during SN practice when compared to yoga trained proficient and semi-proficient individuals. The reason for this attenuation was perhaps due to attainment of better autonomic balance by the trainees. It was reported that exercise training reduces resting and exercise BP in normotensive and hypertensive individuals.[18] Another important factor associated with this training is an increase in arterial distensibility on which SBP and DBP depends. Seals and Hagberg had stated that a modest decrease in BP (less than or equal to 10 mmHg) occurrs following submaximal exercise after training.[19] It was reported by Morgan *et al*., that aerobic conditioning can modify hemodynamic response to isometric exercise.[20] Army trainees in the present study, in addition to yoga practice were also involved in various structured physical activity schedule like playing various outdoor games that are predominantly aerobic in nature. Yogic practice is a mixture of aerobic and anaerobic activities. Therefore, the greater reduction of sympathetic reactivity during SN in army trainees could be due to their well-maintained aerobic fitness level.

The primary finding of the present study was that the army personnel could achieve the similar level of proficiency following 3 months of yoga training with those of yoga proficient and semi-proficient individuals. Further, the actual decrease in sympathetic reactivity during SN was more pronounced in army personnel compared to those of yoga proficient and semi-proficient individuals. A better attainment of autonomic balance in armymen could be due to practice of a very structured and disciplined physical activity schedule in the army, which is not seen in any other group of people in general population. Also, it is not known, to what extent the yoga proficient and semi-proficient practiced yoga regularly, whereas army people had performed regular physical exercise and yoga. Yoga has added beneficial effects to the routine physical practices in army-men.

Limitations of the study

The sample size is small in the present study; especially the sample size is inadequate for extrapolating the application of these findings to the general population. Only BP response during SN has been studied to assess their sympathetic reactivity in these subjects. Though, BP change has been studied during SN, its response has not been correlated with the other sympathetic function tests such as heart rate variability (HRV) analysis, isometric hand grip test or cold pressor test. Therefore, future studies with a larger sample size are warranted for detailed assessment of autonomic function testing during SN practice following yoga training.

CONCLUSION

To conclude, army personnel could achieve the similar level of proficiency with those of yoga proficient and semi-proficient individuals. Further, the actual decrease in sympathetic reactivity was more in army trainees. The reason for attenuated pressor response during SN practice by the trainees could be due to practice of a very structured and disciplined activity schedule of the army, which was not imparted in other two groups of yoga proficient and semi-proficient subjects. Yoga has added beneficial effects to the routine physical practices in army personnel.

ACKNOWLEDGMENTS

The authors put on record the sincere thanks to the subjects who voluntarily participated in the study. The authors express their sincere thanks to Dr. US Ray, Scientist 'F' (Retd.) for his support, inspiration and valuable advice during the study. The author sincerely acknowledge Dr. SB Singh, Director, DIPAS, DRDO, Ministry of Defence, Delhi, for her support and encouragement.

REFERENCES

1. Swami Saraswati S. Surya namaskar. In: Asana, pranayama mudra bandha. Munger: Yoga Publication; 2005. p. 45-64.
2. Sinha B, Ray US, Dasgupta Sinha T. Physiological study of Surya Namaskar, a yogic practice (research letter). Altern Ther Health Med 2011;17:62-4.
3. 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.
4. Sinha B, Sinha TD, Pathak A, Tomer OS. Comparison of cardiorespiratory responses between Surya Namaskar and bicycle exercise at similar energy expenditure level. Indian J Physiol Pharmacol 2013;57:169-76.
5. Mody BS. Acute effects of Surya Namaskar on the cardiovascular and metabolic system. J Bodyw Mov Ther 2011;15:343-7.
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. 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.
9. Selvamurthy W, Nayar HS, Joseph NT, Joseph S. Physiological effects of yogic practice. Nimhans J 1983;1:71-80.
10. Damodaran A, Malathi A, Patil N, Shah N, Suryavansihi, Marathe S. Therapeutic potential of yoga practices in modifying cardiovascular risk profile in middle aged men and women. J Assoc Physicians India 2002;50:633-40.
11. Devasana I, Nahare P. Effect of yoga on heart rate and blood

pressure and its clinical significance. Int J Biol Med Res 2011;2:466-71.
12. Raub JA. Psychophysiologic effects of hatha Yoga on musculoskeletal and cardiopulmonary function: A literature review. J Altern Complement Med 2002;8:797-812.
13. Ross A, Thomas S. The health benefits of yoga and exercise: A review of comparison studies. J Altern Complement Med 2010;16:3-12.
14. Okonta NR. Does yoga therapy reduce blood pressure in patients with hypertension?: An integrative review. Holist Nurs Pract 2012;26:137-41.
15. Innes KE, Bourguignon, 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.
16. McArdle WD, Katch FI, Katch VL. The cardiovascular system. In: Exercise Physiology. 6th ed. Philadelphia: Lippincott Williams and Wilkins; 2007. p. 313-32.
17. Miles SC, Chun-Chung C, Hsin-Fu L, Hunter SD, Dhindsa M, Nualnim N, *et al*. Arterial blood pressure and cardiovascular responses to yoga practice. Altern Ther Health Med 2013;19:38-45.
18. Cornelissen VA, Fagard RH. Effects of resistance training on resting blood pressure: A meta-analysis of randomized controlled trials. J Hypertens 2005;23:251-9.
19. Seals DR, Hagberg JM. The effect of exercise training on human hypertension: A review. Med Sci Sports Exerc 1984;16:207-15.
20. Morgan BJ, Brammell HL, Sable DL, Morton ML, Horowitz LD. Effect of aerobic conditioning on cardiovascular response to isometric exercise. J Appl Physiol Respir Environ Exerc Physiol 1982;52:1257-60.

How to cite this article: Sinha B, Sinha TD, Pathak A, Tomer OS. Effects of yoga training on blood pressure response during surya namaskar following eleven months of yoga practice in army men and yoga-trained individuals. Int J Clin Exp Physiol 2014;1:51-6.
Source of Support: [DRDO, Ministry of Defence, Government of India] Ministry of Defence, Government of India, **Conflict of Interest:** Nil.