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

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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.

The energy cost and other cardiorespiratory responses during the practice of SN were first reported from our laboratory. The author also compared physiological responses of performing SN at two different paces in another study. Mody measured the average energy expenditure for practicing one round of SN in trainees. Bhavanani et al. 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 cardiopulmonary 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 4th, 7th, and 12th 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 (\([\text{VO}_2]\) in L/min), carbon dioxide output (\([\text{VCO}_2]\) in L/min), minute ventilation (\([\text{VE}]\) in L/min), volume tidal (\([\text{VT}]\) 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 (\([\text{EQO}_2]\) was calculated by dividing \(\text{VE}\) by \([\text{VO}_2]\), ventilatory equivalent for carbon dioxide (\([\text{EQCO}_2]\) was calculated by dividing \(\text{VE}\) by \([\text{VCO}_2]\) and oxygen pulse (\([\text{OP}]\) was calculated by dividing \([\text{VO}_2]\) by HR from main parameters \(\text{VE}\), \([\text{VO}_2]\), \([\text{VCO}_2]\) and HR. \([\text{EQO}_2]\) and \([\text{EQCO}_2]\) are measures of pulmonary ventilation required to transfer 1 L of \(\text{O}_2\) and 1 L of \(\text{CO}_2\) across the alveolo-capillary membrane in the lungs. \([\text{OP}]\) is a measure of cardiopulmonary oxygen transport and determines the amount of \(\text{O}_2\) 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 repeated 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. \([\text{VO}_2]\) decreased significantly in 3rd phase as compared to 1st phase and 2nd phase (\(P < 0.001\) in both the case). HR reduced significantly only in 3rd phase (\(P < 0.001\)) from 2nd phase. HR did not decrease in 2nd phase as compared to 1st phase. \([\text{OP}]\) decreased significantly in 3rd phase from 1st phase (\(P < 0.05\)). \([\text{VCO}_2]\) reduced significantly in 2nd phase (\(P < 0.001\)) and 3rd phase (\(P < 0.001\)) as compared to 1st phase. It also reduced in 3rd phase from 2nd phase (\(P < 0.001\)).

The ventilatory parameters like \([\text{Vr}]\) reduced significantly in 3rd phase from 1st phase (\(P < 0.001\)) as well as from 2nd phase (\(P < 0.001\)). \([\text{Vr}]\) did not reduce significantly across three phases of yoga training. \([\text{Vr}]\) reduced significantly in 3rd phase as compared to 1st phase (\(P < 0.001\)) and 2nd phase (\(P < 0.01\)).

\([\text{EQO}_2]\) increased significantly in 3rd phase from 1st phase (\(P < 0.001\)) and from 2nd 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 |
|------------|-----------|-----------|-----------|--------------|
| VO₂ (L/min) | 0.794±0.252 | 0.738±0.229 | 0.560±0.165***+++ | F=20.800, P=0.00001 |
| HR (beats/min) | 92.1±11.6 | 97.9±7.3 | 87.4±9.2*** | F=7.9063, P=0.00259 |
| O₂P (ml/beat) | 8.62±2.52 | 7.54±3.83 | 6.46±1.78* | F=4.0754, P=0.0312 |
| V̇CO₂ (L/min) | 0.650±0.199 | 0.550±0.177*** | 0.471±0.136***+++ | F=36.7268, P=0.0000 |
| VE (L/min) | 19.9±4.65 | 19.98±5.06 | 17.8±4.41***+++ | F=10.2225, P=0.0007 |
| f (breaths/min) | 18.81±1.46 | 19.59±2.72 | 19.1±2.41 | F=0.928, P=0.4103 |
| VT (L/breath) | 1.091±0.021 | 1.038±0.213 | 0.952±0.180***+++ | F=9.6876, P=0.0009 |
| EQCO₂ | 27.05±4.049 | 28.09±4.235 | 32.56±1.580***+++ | F=22.6580, P=0.00000 |
| EQCO₂ | 32.07±3.971 | 37.73±4.062***+++ | 39.84±3.686***+++ | F=56.567, P=0.00000 |

SN=Surya Namaskar; VO₂=Oxygen consumption; HR=Heart rate; O₂P=Oxygen pulse; V̇CO₂=Carbon dioxide output; VE=Minute ventilation; f=Breathing rate; VT=Tidal volume; EQCO₂=Equivalent for oxygen; EQCO₂=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

EQCO₂ 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 VO₂ reduces progressively from 1st phase to 3rd phase of SN practice indicating trainees performed SN consuming lesser oxygen as training progressed. Chaya et al. 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. 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. 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. 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 VO₂ per unit work (P < 0.05) and VE (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. Trained practitioners had a lower HR and V̇̇E while performing yogic asanas than their untrained counterparts who performed similar poses. 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.

It was reported that regular asana and pranayama practice reduces HR and blood pressure in resting young males and resting elderly males and females. Raju et al. in a study had shown that during short-term (3 months) yoga training, significant reduction of V̇̇E and oxygen uptake during sub-maximal exercise test occurred in normal healthy volunteers. Ross et al. 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. 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 VO₂, HR, V̇̇CO₂, V̇̇E, and V̇̇E showed a significant fall in the 3rd phase as compared to the previous phases. O₂P 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 $V_e$.

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