National Journal of Physiology, Pharmacy and Pharmacology

RESEARCH ARTICLE

Comparison of cardiac output between practitioners and nonpractitioners of yoga before and after physical stress intervention

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Received: November 20, 2016; **Accepted:** December 12, 2016

ABSTRACT

Background: Modern lifestyle and daily stress due to various causes have an adverse effect on cardiovascular health. Yoga modulates the sympathetic nervous system and hypothalamic-pituitary axis to decrease the effects of stress. Increase in cardiac output (CO) within physiological limits has health benefits. **Aims and Objective:** We compared the alteration in CO in subjects practicing yoga and those not practicing yoga before and after exposure to an exercise challenge. **Materials and Methods:** A total of 94 healthy male subjects in the age group 20 to 60 years were included in the study. Subjects were divided into two groups. Yoga group ($n = 47$, mean age: 43.95 ± 6.61 years, mean body mass index (BMI): 24.09 ± 4.19 kg/m^2) consisted of subjects who had practiced yoga (Asanas, Pranayama, and meditation) for over 2 years. Nonyoga group ($n = 47$, mean age: 44.17 ± 6.48 years, mean BMI: 24.33 ± 4.97 kg/m^2) did not perform yoga or any other form of regular physical activity for the same duration. CO was measured using non-invasive CO monitor of L and T systems. **Results:** CO before exercise in yoga and non-yoga groups was 4.21 ± 0.63 L/min and 4.08 ± 0.57 L/min, respectively. The values of CO after exercise in yoga and non-yoga groups were 5.71 ± 0.58 L/min and 4.94 ± 0.53 L/min, respectively. CO after exercise challenge and difference in change of CO was statistically significant ($P < 0.05$) between the two groups. CO was significantly increased in yoga group after exercise but not in nonyoga group. **Conclusion:** There was a significant increase in CO after exercise in practitioners of yoga indicating an increase in cardiovascular endurance in practitioners of yoga.

KEY WORDS: Yoga; Physical Stress; Exercise; Cardiac Output

INTRODUCTION

Cardiac output (CO) is basic yet extremely important parameter to assess heart function, as it determines the extent of tissue perfusion in every nook and corner of human body.[1] Studies have indicated that CO improves after different forms of exercises or physical activity.[2] Very few look into the CO soon after a physical stress challenge. Moreover, many of physical activity or exercise regimes are not suitable to practice in our daily lives. One of the reasons for this is that the exercise regimes themselves sometimes cause both physical and mental stress for the subjects taking them up.

Access this article online	
Website: www.njppp.com	Quick Response code
DOI: 10.5455/njppp.2017.7.1234112122016	

Despite the strong evidence base for the efficacy of physical activity in the management and preventions of lifestyle disorders, a limited number of physical activity interventions have been translated and evaluated in everyday practice. The effectiveness of all types of physical activity interventions is unclear. Although there is evidence that physical activity can be useful, overall the results are inconclusive.[3] The efficacy of the physical activity depends on the reach of the physical activity. It also depends on the effectiveness of the intervention in achieving desired positive outcomes, adoption of intervention by the individuals on daily basis and maintenance of practice of exercise over a period of time. If one of the above fails, the benefits of exercise are lost. There is a need for well-designed studies to be carried out to evaluate the effectiveness of physical activity and to identify the types of interventions that show the most promise.[4]

The main barriers to daily exercise are work related factors; access to facilities; lack of motivation; embarrassment and body image; weather, low levels of knowledge about beneficial effects of exercise. Motivational factors for exercising are physical benefits from exercise; improvements in body image; enjoyment and the social interaction of exercising in groups. The main facilitator to exercise was free or reduced admission to gyms and swimming pools and constant encouragement. Since yoga does not involve any cost and can be done in groups, our study is of relevance in the present era where lifestyle disorders are a major problem.[5] Self-confidence in and value of physical activity/exercise are not primary motivators to action. In general, physicians fail to provide details regarding exercise length, warm-up, cool-down expectations, and common adverse effects. Patient perceptions of what physical activity/exercise means are multidimensional; fears, emotions, priority, and participatory social support contribute to adherence. Yoga has a potential to nullify all these adverse effects related to other forms of exercise.[6]

In this day, there is both physical stress and psychological stress. Psychological stress is a feeling of being overwhelmed by the necessity of constant adjustment to an individual's changing environment. Stress affects people of all ages. Major changes can cause anxiety leading to feelings of insecurity and/or loss of self-esteem and depression. The cellular mechanisms underlying psychological stress are poorly understood. The molecular consequences of stress are linked to aging processes. The molecular changes induced by psychological stress can compromise healthy aging. There is a need to concentrate our efforts in simulating the routine physical activities of our ancestors whose genome we largely share. In an inactive person, daily physical activity will optimize gene expression and confers the good health that was enjoyed by our ancestors. Nonpharmacological techniques such as yoga are becoming very popular as a stress-relieving therapy because of its greater effectiveness and no associated side effects. Yoga focuses on body, breathing and mind.[7] This is accomplished by Asanas (exercise postures), pranayama (breathing techniques), and meditation.[8] Both physical and mental stresses are associated with increased abnormalities of cardiovascular and immune systems.

Therefore, it is a priority to include a focus on stress management and reduction of negative emotional states to reduce the burden of disease. Viewed as a holistic approach in stress management technique, yoga is a form of complementary and alternative medicine (CAM) that produces a physiological sequence of events in the body that act toward reducing the stress response.[9]

Cardiovascular diseases are the leading cause of morbidity and mortality in developed and developing countries. Cardiac autonomic balance has a pivotal role in morbidity and mortality of a person. Increase in parasympathetic activity in cardiac autonomic balance decreases the morbidity and mortality.[10]

CO is defined as the volume of blood ejected by each ventricle per minute and is the product of stroke volume (SV) and heart rate (HR). The total amount of blood flow circulating through the heart, lungs and all the tissues of the body represents the CO. Most individual tissues determine their own flow in proportion to their metabolic rate. Brain, heart, skeletal muscle, and the splanchnic area all vary their blood flows according to local tissue metabolic rate. Summation of peripheral blood flows constitutes venous return and hence CO. CO is therefore, largely, determined by the metabolic rate of the peripheral tissues.[11]

Noninvasive measurement of CO is an emergent technique in recent days which is more cost-effective and patient friendly as compared to other invasive and minimally invasive techniques of measuring CO.[12]

It is important to assess the practical significance and the suitability of incorporating yoga into the comprehensive cardiac rehabilitation program. The majority of the rehabilitation workers believe that incorporating nonconventional forms of physical exercise such as yoga definitely would enhance efficacy and quality of life and add value to the same.

CO can be changed by altering HR or rhythm, preload, contractility, and afterload. It also gives important information about tissue perfusion and oxygen delivery.[11] The assessment of cardiac function, particularly CO, during exercise is essential for the evaluation of cardiovascular factors that may limit oxygen transport. Measures of CO enable researchers to develop insight into the physiological responses and mechanisms of adaptation induced by physical training, sedentary lifestyle, or chronic disease. CO - the product of SV and HR - represents the body's ability to meet the metabolic demands of exercise and it may increase by five- to six-fold when an individual is exerting maximal effort during exercise.[13] Coordinated autonomic nervous system function (characterized by rapid and sustained parasympathetic withdrawal coupled with sympathetic activation) is required for this to occur.[14] Maximal HR varies innately among individuals and decreases with age. The increase in HR and/or SV is responsible for the majority of the augmentation of CO during exercise, and peak HR is a fundamentally limiting factor of peak exercise capacity in healthy individuals.[13,14]

CO can be measured by various methods and thermodilution method using pulmonary artery catheter (PAC) is till date considered as the gold standard method. Complications associated with PAC led to development of newer methods which are minimally or noninvasive. Newer methods fulfill other properties such as continuous and reproducible reading, cost-effective, reliable during various physiological states, and have fast response time.[15]

Advances in the computer software and hardware have led to development of newer methods of CO monitoring with no vascular access.[16]

MATERIALS AND METHODS

A total of 94 healthy male subjects in age group of 20 to 60 not currently on any medication were recruited for the study. A detailed clinical examination and routine investigations were carried out as a part of screening to rule out cardiopulmonary and metabolic disorders. 47 healthy male volunteers practicing yoga for minimum 1 year duration were taken as controls. A similar number of anthropometrically, age and gender matched subjects not practicing yoga were taken as controls, all subjects chosen were age, gender and body mass index (BMI) matched, who satisfy the inclusion and the exclusion criteria.

An informed written consent was obtained from the volunteers who agreed to participate in the study. The ethical clearance was obtained from institutional scientific and ethical committee.

Inclusion Criteria

Males between 20 and 60 years age, performing yoga for a minimum period of 2-year for half an hour each day, nonsmokers, nonalcoholics.

Exclusion Criteria

Any history of long-term illnesses and disorders, long-term drug (medicine) intake, respiratory diseases. Renal disease and persons performing any form of physical activity on a regular basis.

Study Design

Measurement of CO

CO was measured using the noninvasive continuous CO monitor (NICOMON). It works on the principle of impendence plethysmography. Both the cases and controls were administered a physical stress intervention in the form of 10 m shuttle walk test, and the recordings were taken. Subjects were abstained from practicing yoga or any other physical exercise on the day of recording.

Impedance measurements were obtained with the NICOMON model 3, revision 7 (NICOMON, Larsen and Toubro Ltd.).[17]

The exercise regime chosen was the standardized 10 m Shuttle Walking Test regime.[18] The requirements for this exercise regime are: Flat surface at least 10 m in length, audio signal, measuring tape to measure 10 m course and marker cones. The marker cones are placed 0.5 m within each end avoiding the need for any abrupt change in direction. A calibration period of 1-min is present at the beginning of the tape which was checked regularly to maintain the accuracy of the test. Instructions are given to each of the subjects at the beginning of the exercise. The audio signal was played once the subject was ready.

- There is a triple bleep to start. Thereafter, the tape emits a single bleep at regular intervals. The subject should aim to be at the opposite end to the start by the time the bleep sounds.
- After every minute the speed of the walking is increased by a small increment, so the subject walks progressively faster; this is indicated by a triple bleep.
- The first speed of walking is referred to as "level-1," the second as "level-2" and so on. Each level lasts for 1 min and the tape continues for 12 levels. Each level contains a number of "shuttles" (10 m lengths), the number of which is dictated by the speed of that level.
- To help the subject establish the first very slow speed of walking, the operator walks alongside for the first minute.

The level of exercise is graded as moderate when there is a 50% increase in HR soon after the exercise. It is graded as strenuous when there is a cent percent increase in HR.

Indications for discontinuation of the test are (1) subject becomes too breathless to maintain the required speed and (2) failure of the subject to complete the shuttle in the time allowed, i.e., is more than 0.5 m away from the cone.

Determination of sample size

The sample size was determined using n-master software from the cited study.[19] The study was utilized to check for equivalence in 2 groups. It was estimated that at a power of 80% and an alpha error of 5%, 40 persons in each group was sufficient to be included in each group.

Statistical Analysis

The coefficient of variation was assessed for all the parameters. The data following normal distribution was expressed as averaged (mean ± standard deviation). Student *t*-test was used to determine the statistical significance between controls for parametric data. Paired *t*-test was used to determine the statistical difference in pre and post-exercise values for parametric data. The level of significance was fixed at $P < 0.05$.

Data analysis was performed using Statistical Package for Social Science (SPSS Software, Version 16) package.

RESULTS

About 94 healthy male subjects satisfying the inclusion and exclusion criteria were recruited for the study. The subjects were divided into two groups.

Age of cases was 43.95 ± 6.619 years and that of controls was 44.17 ± 6.48 years, height in meters in cases was1.64 ± 0.06 and controls was 1.64 ± 0.06, weight in Kg in cases was 70.59 ± 10.35 and in controls was 70.60 ± 10.46 and the BMI in cases was 26.09 ± 4.19 and in controls was 26.33 ± 4.97 kg/m^2.

The value of CO before exercise in cases was 4.21 ± 0.63 and in controls was 4.08 ± 0.57. The value of CO after exercise in cases was 5.71 ± 0.58 and in controls 4.94 ± 0.53. The value of the difference in CO before and after exercise in cases was 1.50 ± 0.46 and in controls was 0.85 ± 0.25. The value of CO before exercise in cases and controls was not statistically significant, whereas values of CO after exercise and difference in change of CO was statistically significant $P < 0.05$ (Table 1).

DISCUSSION

Cardiovascular diseases are the main contributors of mortality and morbidity in modern world.[20] This is due to lifestyle changes, food habits, decreased physical activity, mental stress, environmental pollution, smoking, and alcohol consumption. The majority of risk factors associated with cardiovascular diseases can be modified at initial levels which reduce morbidity and suffering in general population.[21]

To modulate these factors lifestyle modifications like physical exercise and CAM forms like yoga have gained a lot of importance and attention of researchers and doctors alike.[22] Yoga is reported to promote physical and mental health by performance of postures (asanas), regulated breathing (Pranayama), and meditation (dhyana).[23] Over the last 10 years, a growing number of research studies have shown that the practice of yoga can improve strength and flexibility and may help control physiological variables such as blood pressure, respiration and HR, and metabolic rate to improve overall exercise capacity.[24] There is a need to objectively evaluate perceived or reported benefits of yogic practice. There are different tools to quantify the benefits of yoga on cardiovascular system.

The objective of this study was to evaluate the effect of yoga practice on CO. CO - the product of SV and HR - represents the body's ability to meet the metabolic demands of exercise; it may increase by five- to six-fold when an individual is exerting maximal effort during exercise. In this study, CO was measured using NICOMON which is a non-invasive method of measuring and has fewer side effects compared to invasive and minimally invasive method. CO was measured before and after shuttle walk test which is a kind of endurance training and also a physical stress intervention in the subject.

The CO increased in both practitioners and non-practitioners of yoga after exercise, but the increase in CO in yoga practitioners was significantly more compared to nonpractitioners. This suggests that yoga practitioners are able to combat the stress in the form of exercise more efficiently compared to non-practitioners and thereby increasing the blood flow to exercising muscles.

The increase in CO may be due to regular practice of yoga. In addition to this prolonged flexibility of muscles operating during exercise also led to an improvement in heart muscle and increased the efficiency of pumping action of heart. This, in turn, led to an increase in cardiac micropayment, which had a positive impact in the flow of blood in the coronary artery, and this gives the heart a rest enough between each pulse or systole and thus the impact of a decline in pulse rate.[25]

yoga training would have led to the revitalization of the venous return and increased blood to the heart. This is in addition to the increase of blood capillaries in the open cells and tissue blood flow easily inside the arteries and capillaries of blood during systole. This led to a decrease in systolic blood pressure and increase in the number of capillaries open and during extended cardiovascular activity. This leads to reduced external resistance to the flow of blood outside the artery.[26]

A number of published studies have reported significant improvement in overall cardiovascular endurance of young subjects who were given varying periods of yoga training (months to years), and they compared it with a similar group who performed other types of exercises The parameters measured were oxygen consumption and other measures of endurance (e.g., work output, anaerobic threshold, blood lactate) during submaximal and maximal exercise tests.[27]

Cardiovascular endurance is known to improve after regular yoga practice for long durations.[28] Tilting of the sympathovagal balance more toward the parasympathetic side within limits and increase in vagal tone may also have contributed to increase in CO in practitioners of yoga.[29] Hence, the practice of yoga which involves lifestyle

Table 1: Cardiac output before and after exercise in yoga and nonyoga group

Cardiac output parameters	Yoga	Non-Yoga	*P*
Cardiac output before exercise	4.21±0.63	4.08±0.57	0.328
Cardiac output after exercise	5.71±0.58	4.94±0.53	<0.0001*
Difference in cardiac output	1.50±0.46	0.85±0.25	0<0.0001*

*$P<0.05$

modification can be used as a nonpharmacological technique to prevent cardiovascular complications.

Limitations of Study

CO with various grades of exercise was not taken up in this study. Females were excluded as the electrodes of NICOMON had to be placed over the chest region and it was difficult to get consent from female subjects for the same.

CONCLUSION

CO increases significantly after physical stress intervention in the form of endurance exercise in practitioners of yoga compared to nonpractitioners indicating more efficient cardiovascular endurance in subjects practicing yoga.

ACKNOWLEDGMENTS

The authors wish to acknowledge the Department of Science and Technology, Government of India for providing the funds for equipment for this study. The authors are thankful to the subjects and Mrs. Alka Vishwanath of Omkar Yoga Mandir, Bengaluru, for taking part in the study and for the assistance during the study, respectively. Authors are thankful to Dr. Murthy. N. S of Department of Community Medicine and Dr. Raviprakash who was Resident in Physiology Department of Ramaiah Medical College, Bengaluru, for statistical help.

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How to cite this article: Madhu DR, Vijayaraghava A, Doreswamy V, Narasipur OS. Comparison of cardiac output between practitioners and nonpractitioners of yoga before and after physical stress intervention. Natl J Physiol Pharm Pharmacol 2017;7(3):317-322.

Source of Support: Nil, **Conflict of Interest:** None declared.