NJPPP National Journal of Physiology, Pharmacy & Pharmacology

DOI: 10.5455/njppp.2015.5.191020142
http://www.njppp.com/

RESEARCH ARTICLE

EFFECT OF YOGA ON INDICES OF CARDIOVASCULAR SYSTEM IN MAHARASHTRIAN ADOLESCENT GIRLS

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Received
07.07.2014
Accepted
14.10.2014

Key Words
Double Product; Rate Pressure Product; Step Test; Yoga

Background: Yogic exercises are scientifically observable physiological and biochemical activities. Certain yogasanas decrease the sympathetic tone, rate pressure product (RPP), and double product (DoP) and improve cardiovascular endurance and anaerobic threshold.
Aims and Objectives: The objective of this study was to determine the effect of yoga training on cardiovascular response to step test and its time course after exercise in normal adolescent girls.
Materials and Methods: This study was conducted on 200 adolescent school-going girls and mainly focused on assessing the effect of yoga training on improvement of heart rate (HR) by using parameters such as RPP and DoP. Change in the HR with response to exercise was determined by using two constructed staircases, each of 9 inch (22.5 cm) in height. HR and blood pressure response to exercise were measured in when the subject were in supine position before exercise and at 1, 3, 5, 7, and 10 min after the exercise. Rate pressure product [RPP = (HR × SP)/100] and double product (DoP = HR × MP), which are indices of work performed by the heart, were calculated.
Results: After 6 months of yoga training, exercise-induced changes on these parameters were found to be reduced significantly.
Conclusion: It is concluded that after yoga training a given amount of exercise leads to a milder cardiovascular response, suggesting better exercise tolerance. Exercise produced a significant increase in HR, systolic pressure, RPP, and DoP, and a significant decrease in diastolic pressure.

INTRODUCTION

Yoga is a science that is practiced for thousands of years. It produces physiological changes and has sound scientific basis.[1–4] Throughout the world, scientists have extensively studied yogasanas and have claimed that yoga increases longevity of life and has therapeutic and rehabilitative effects.[1–3] Various ancient Indian literatures such as *Grantha Samitha* and *Bhagwad Gita* have mentioned about various yogic practices. The scientific approach toward yoga was adopted in the second half of the 19th century.[3–5] Specific yogasanas are recommended for various systems and organs of our body.[1] Asanas fulfill various needs of musculoskeletal, digestive, circulatory, respiratory, and nervous system. [1,3,4] Regular practice of yogic exercises helps in reducing the incidence and controlling highly prevalent diseases such as diabetes, hypertension, digestive, and endocrinal disorders. Arthritis, asthma, and chronic fatigue can also reduced.[3–6,8] The relaxation and exercise component of yoga has a major role in the treatment and prevention of high blood pressure.[3–5,10] The combination of biofeedback, yogic breathing, and relaxation techniques lowers the blood pressure.[5,6,14] The asanas decrease the sympathetic tone, rate pressure product (RPP) and double product (DoP), and improve cardiovascular endurance and anaerobic threshold.[1,3,4,8,9]

In 1924, Swami Kuvalayananda of KaivalyaDham observed that the amounts of oxygen consumption and carbon dioxide production during pranayam are comparatively less during normal breathing.[1–3,12] A study conducted by Kaviraja Udupa *et al.*[8] in 2003 on 24 healthy young subjects showed significant reduction in basal heart rate (HR) and systolic and diastolic blood pressure following 3 months of yoga training. Murlidhara and Ranganathan[15] reported an improvement in cardiac recovery index after 10 weeks of yoga training in 50 young subjects. Raju *et*

al.[16] found a significant increase in maximal work output and oxygen consumption per unit work done after yoga training. Bera and Rajapurkar[17] have reported a significant improvement in cardiovascular endurance and aerobic power as a result of yoga training. A study carried out by Ray *et al*.[20] on the effect of yogic exercises on physical and mental health of 54 young fellowship course trainees showed significant reduction in HR and systolic and diastolic blood pressure after 5 months of yoga training. Joshi and colleagues[20] studied the effect of shavasana on 12 subjects who performed shavasana daily for 20 min. After 7 months, the results indicated that there was decrease in pulse rate as well as systolic and diastolic blood pressure in 11 subjects. Tulpule & Tulpule[27] also considered yoga as a method of relaxation after myocardial infarction. In 1973, Nayar *et al*. (http://www.svyasa.org/research_papers/psif/om.asp) conducted experiments on NDA cadets and observed decrease in pulse rate and blood pressure, and increase in vital capacity maximal voluntary ventilation and forced expiratory volume after 6 months of yogic practices. On the basis of above-mentioned historical background, one can get an idea of importance of yoga in improving endurance and exercise tolerance. Madanmohan *et al*.[8] studied modulation of cardiovascular response to exercise by yoga training, showing significant reduction in HR as well as systolic and diastolic blood pressure following 2 months of yoga training. Madanmohan *et al*.[10] further studied the effect of 6-week yoga training on weight loss following step test, respiratory pressures, handgrips strength, and handgrip endurance in young healthy subjects, showing highly significant changes in HR.[10]

However, studies on the effect of yoga training on cardiovascular response to stress are limited. In view of this, the present study was planned with an objective to determine the effect of yoga training on cardiovascular response to step test and its time course after exercise in normal adolescent girls.

MATERIALS AND METHODS

Study Design: A prospective interventional study was carried out in Pravara Kanya Vidya Mandir, Loni.

Study Population: Girls studying in class 8th to class 12th were included in this study.

Sample Size: This study was carried out on 200 girls.

Study Period: The study was carried out from August 2008 to February 2009 considering the academic year and examinations of the students.

Exclusion Criteria: Girls who practice yoga regularly and those who routinely do any form of physical exercise were excluded from the study.

Materials Used: (i) Mercury sphygmomanometer; (ii) Stethoscope; (iii) Weighing machine; (iv) Measuring tape; (v) 2 staircase steps , each of 9 inch (22.5 cm); (vi) Metronome; (vii) Predesigned questionnaire.

Methodology: The cardiovascular response to exercise was determined by using two constructed staircases, each of 9 inch (22.5 cm) in height. Before conducting the step test, basal HR and systolic blood pressure as well as diastolic blood pressure were recorded. Then, the subjects were individually asked to step up and down the two stairs at the rate of 30 steps per minute for 4 min or until exertion. HR and blood pressure were measured in supine position, immediately after exercise and later after the intervals of 1, 3, 5, 7, and 10 min. Later, the rate pressure product (RPP) = (Heart rate × Systolic blood pressure/100) and double product (DoP) = (Heart rate × Mean pressure), which are indices of work done by the heart, were calculated before yoga training and after 6 months of interventional yoga training. A trained yoga teacher taught the subjects yogasanas and pranayam for 1 week. The asanas taught were Swastikasana, Virasana, Padmasana, Gomukhasanae, Paschimothan asana, Baddh Konasana, Janusirsasana, Trikonasana, Ardhachandrasana, Setubandhasana, Suptavajrasana, Shavasana, and Pranayam (Ujjayi Viloma Pranayama in Shavasana). The students were divided according to their classes and were instructed to practice the same asanas and pranayam daily for 45 min (excluding Sundays) for 6 months. Visits were paid once a week to assess their compliance and communicate with the subjects undergoing yoga training. After 6 months of yoga, training the cardiovascular response to exercise was noted in the same questionnaire format. The data were analyzed by applying statistical test (standard error of difference between two mean) and by applying *Z* test to compare pre- and post-yoga

Table 1: Cardiovascular changes before and after yoga training (heart rate, systolic BP, diastolic BP)

	Heart Rate (beats/min)		*Z* value	Systolic Blood Pressure (mm Hg)		*Z* value	Diastolic Blood Pressure (mm Hg)		*Z* value
	Before	After		Before	After		Before	After	
Basal	71.07 ± 2.81	66.96 ± 2.82	17.12 **	114.08 ± 7.53	115.22 ± 70.31***	**0.23**	69.31 ± 6.14	66.49 ± 5.14	4.27 **
After step test	154.86 ± 5.69	144.07 ± 84.59	**1.82**	161.42 ± 11.37	149.56 ± 10.42	10.98 **	70.95 ± 6.55	68.52 ± 5.27	4.11 **
1 min	129.34 ± 9.43	123.4 ± 71.16	**0.68**	152.07 ± 10.80	136.13 ± 9.21	15.94 **	70.64 ± 6.52	66.11 ± 5.04	2.12 *
3 min	116.91 ± 7.14	109.27 ± 7.65	10.46 **	139.86 ± 8.52	126.48 ± 6.53	**1.77**	69.95 ± 5.92	65.02 ± 4.65	4.93 **
5 min	110.26 ± 6.49	102.35 ± 6.15	12.7 **	127.29 ± 9.91	118.1 ± 5.95	11.34 **	69.09 ± 5.87	63.9 ± 4.64	10.38 **
7 min	103.74 ± 2.57	96.48 ± 5.04	19.10 **	120.715 ± 7.00	113.05 ± 5.63	12.35 **	68.5 ± 5.75	63.01 ± 4.39	10.98 **
10 min	99.22 ± 1.30	94.86 ± 63.79	**0.99**	115.43 ± 6.14	108.98 ± 5.39	11.51 **	67.89 ± 5.96	62.39 ± 4.29	11 **

**Values are expressed mean+standard error of difference between two mean (SEM).*
**Significant (1.96–2.51); **highly significant (>2.58); not significant (<1.96).*

Table 2: Cardiovascular changes before and after yoga training (pulse pressure, mean pressure)

	Pulse Pressure (mm Hg)		*Z* value	Mean Pressure (mm Hg)		*Z* value
	Before	After		Before	After	
Basal	45.12 ± 7.60	44.12 ± 7.25	**1.36**	84.48 ± 5.78	81.09 ± 5.08	6.51 **
After step test	90.33 ± 13.12	81.02 ± 10.65	8.46 **	100.88 ± 6.74	95.42 ± 5.48	9.1 **
1 min	81.41 ± 11.89	69.72 ± 10.83	13.72 **	97.76 ± 6.11	89.44 ± 5.04	15.12 **
3 min	69.87 ± 9.09	61.47 ± 7.50	10.12 **	93.23 ± 5.41	85.51 ± 4.04	1.90 **
5 min	58.04 ± 9.80	54.25 ± 6.79	3.79 **	88.38 ± 5.65	81.95 ± 3.99	13.97 **
7 min	52.37 ± 7.34	50.04 ± 5.91	3.58 **	85.87 ± 5.18	79.68 ± 3.98	13.75 **
10 min	47.61 ± 6.60	46.64 ± 5.78	**1.61**	83.77 ± 5.25	77.86 ± 3.77	13.43 **

**Values are expressed mean+standard error of difference between two mean (SEM).*
**Significant (1.96–2.51); **highly significant (>2.58); not significant (<1.96).*

Table 3: Cardiovascular changes before and after yoga training (rate pressure product, double product)

	Rate Pressure Product (mm Hg)		*Z* value	Double Product (beats/min)		*Z* value
	Before	After		Before	After	
Basal	80.65 ± 8.15	73.72 ± 5.46	10.19 **	5992.23 ± 526.35	5433.14 ± 430.02	11.63 **
After step test	250.44 ± 23.37	206.58 ± 20.38	19.93 **	15620.63 ± 1249.5	13118.07 ± 1394.78	2.25 *
1 min	195.38 ± 22.50	161.01 ± 17.06	18.08 **	12687.63 ± 1496.37	10582.64 ± 1049.73	16.28 **
3 min	163.74 ± 15.44	138.115 ± 12.59	18.30 **	10916 ± 1437.63	9255.369 ± 1211.71	12.49 **
5 min	139.95 ± 12.84	120.86 ± 9.66	15.90 **	9719.87 ± 818.21	8352.06 ± 863.86	16.25 **
7 min	125.35 ± 8.49	109.00 ± 8.28	19.69 **	8884.99 ± 876.54	7659.04 ± 772.98	14.83 **
10 min	114.41 ± 6.53	98.31 ± 7.46	29.3 **	8357.45 ± 654.79	7036.65 ± 548.88	21.86 **

**Values are expressed mean+standard error of difference between two mean (SEM).*
**Significant (1.96–2.51); **highly significant (>2.58); not significant (<1.96).*

training values. *Z* value between and above 1.96 and 2.51 was considered statistically significant, showing difference between the compared values.

RESULTS

After 6 months of yoga training, the exercise-induced changes in these parameters were significantly less as compared to their pre-yoga training response. Before yoga training, systolic blood pressure and mean pressure values returned almost to their pre-exercise basal values, whereas other parameters continued to be significantly different from their basal values 10 min after exercise period. After 6 months of yoga training, although there was significant reduction in all parameters, the values continued to be significantly different from the pre-yoga training values.

DISCUSSION

According to WHO, health is a state of complete physical, mental and social well-being, and not merely the absence of disease.[1,2]

As health is a dynamic equilibrium between man and his environment, it can be modified by many factors such as heredity, pattern of behavior, work, rest, food habits, personal hygiene, exercise, and yoga.[2–4,8] The purpose of the present study was to determine if yoga training modulates the cardiovascular response to exercise and its time course after the exercise. Yoga training for 6 months resulted in a significant decrease in basal HR and blood pressure, and a significant reduction in post-exercise values. This study findings are much more significant than those reported by Madanmohan *et al*., who revealed that yoga training for 2 months resulted in a significant decrease in basal HR and blood pressure.[8,20] Calculated RPP and DoP values also decreased significantly.[19] As RPP is an index of myocardial oxygen consumption and load on heart, study results indicate that after yoga training, a given level of exercise is less taxing for the heart.[16] This study also revealed a significant reduction in diastolic blood pressure values after yoga training.

Similar decrease in diastolic blood pressure was reported by Ray *et al*.,[20] who attributed this to a reduction in sympathetic activity. Exercise produced a marked and significant increase in the parameters measured except diastolic blood pressure, which showed significant decrease in response to exercise stress. After yoga training, the exercise-induced changes (i.e., decrease in diastolic pressure and increase in other parameters) were significantly reduced.[8,10] Study results also showed significant and faster recovery except that the values remained different from the pre-yoga training values. Our findings are similar to those reported by Madanmohan *et al*. and O'Sullivan and Bell,[5] who have reported that physical training blunts the pressor, tachycardiac and vasodilator responses, and attributed this to blunting of sympathetic vasodilator activation. Study findings of lesser increase in blood pressure, HR, and RPP are consistent with those reported by Madanmohan *et al*. and Ray *et al*., showing that yoga training increases muscular endurance, delays onset of fatigue, and enables one to perform work at lesser Vo_2 max.[8,10] This study also reported lesser increase in pulse pressure, mean pressure, and DoP values following 6 months of yoga training, showing that, after yoga training, a given level of exercise is less taxing for heart and concluding that reduction in exercise-induced stress on cardiovascular system by yoga training has physiological significance and clinical application.[16]

CONCLUSION

It is concluded that after yoga training a given level of exercise leads to a milder cardiovascular response, suggesting better exercise tolerance. Exercise produced a significant increase in HR, systolic pressure, RPP and DoP, and a significant decrease in diastolic pressure.

ACKNOWLEDGMENTS

We thank Mrs. LB Sarode, Principal, Pravara Kanya Vidya Mandir, Loni, Ahmednagar, for understanding the concept of our research and allowing us to do the research work on the students. We also thank the enthusiastic participants without whose participation we would not have been able to conduct the research work.

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Cite this article as: Parkhad SB, Palve SB, Chandrashekar M. Effect of yoga on indices of cardiovascular system in Maharashtrian adolescent girls. Natl J Physiol Pharm Pharmacol 2015;5:129-133.
Source of Support: Nil
Conflict of interest: None declared