

Impact of Yoga on Haemodynamic Function in Healthy Medical Students

O Parshad¹, A Richards¹, M Asnani²

ABSTRACT

Objectives: Yoga improves cardiovascular health in both healthy individuals and those with diagnosed heart disease. This study compares changes in some cardiovascular parameters before and after the practice of Yoga in healthy medical students.

Methods: Sixty-four healthy medical students (57 females and 7 males), mean age 21.3 ± 2.6 years, attending a Special Study Module 'Role of Dhyana Yoga in Stress Management', participated in this study. Systolic (SYS) and Diastolic (DIA) blood pressure, Heart Rate (HR), Stroke Volume (SV), Cardiac output (CO), Total Peripheral Resistance (TPR), Interbeat Interval (IBI), Left Ventricular Ejection Time (LVET), Arterial Compliance (Cwk) and Ascending Aorta Impedance (Zao) were measured before and after six weeks of yogic exercises. Various exercises included asanas (Postures), pranayama (Breathing), and dhyana (Meditation). Data were analyzed using Stata for WindowsTM.

Results: Two-tailed paired *t*-test revealed that practice of yoga caused significant increases in HR ($p < 0.05$), SV ($p < 0.01$), CO ($p < 0.001$) and Cwk ($p < 0.01$) and decreases in TPR ($p < 0.001$), IBI ($p < 0.05$) and Zao ($p < 0.001$) after practising yoga for 6 weeks as compared to before yoga practice. No significant differences were, however, observed in SYS, DIA, Mean arterial blood pressure (MAP) and LVET.

Conclusions: Practice of yoga even for a short period showed ability to improve most of the cardiovascular functions. Regular practice of yoga for a longer period may further improve these functions and possibly result in improved management of their daily stress.

Keywords: Healthy adults, haemodynamics, yoga

Impacto del Yoga en la Función Hemodinámica de Estudiantes de Medicina Saludables

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RESUMEN

Objetivos: El yoga mejora la salud cardiovascular tanto en individuos sanos como aquellos con diagnóstico de enfermedad cardíaca. Este estudio compara cambios en algunos parámetros cardiovasculares antes y después de la práctica del yoga en estudiantes de medicina saludables.

Métodos: Sesenta y cuatro estudiantes de medicina saludables (57 mujeres y 7 hombres), con una edad promedio de $21,3 \pm 2,6$ años, que asistían a un módulo especial de estudio "Papel de DhyanaYoga en el manejo del estrés", participaron en este estudio. Antes y después de seis semanas de ejercicios yoga, se midieron la presión arterial sistólica (SIS) y diastólica (DIA), ritmo cardíaco (RC), volumen sistólico de eyección (VS), gasto cardíaco (GC), resistencia periférica total (RPT), tiempo de intervalos interpalpos o interlatidos cardíacos (IBI), tiempo de eyección ventricular izquierda (TEVI), distensibilidad arterial Windkessel (Cwk) y la impedancia de la aorta ascendente (Zao). Los diversos ejercicios incluyeron asanas (posturas), pranayama (respiración) y dhyana (meditación). Se analizaron los datos usando Stata de Windows.

Resultados: La prueba *T* pareado de dos colas, reveló que la práctica del yoga causaba importantes aumentos del RC ($p < 0,05$), VS ($p < 0,01$), GC ($p < 0,001$) y Cwk ($p < 0,01$) y disminuciones de RTP

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($p < 0,001$), IBI ($p < 0,05$) y Zao ($p < 0,001$), tras la práctica de yoga durante seis semanas, en comparación con la situación antes de la práctica de yoga. Sin embargo, no se observaron diferencias significativas en SIS, DIA, MAP y TEVI.

Conclusiones: La práctica del yoga incluso durante un corto periodo mostró capacidad para mejorar la mayoría de las funciones cardiovasculares. La práctica regular del yoga por un periodo más largo puede mejorar aún más estas funciones, y posiblemente traer como resultado una mejoría en el manejo del estrés cotidiano.

Palabras claves: Adultos sanos, hemodinámica, yoga

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INTRODUCTION

Essential hypertension continues to be a significant health problem globally. Environmental conditions and a variety of behavioural factors such as stress, anxiety, affective and attitudinal dispositions of the individual influence the cardiovascular response (1). Interventions including lifestyle modification and pharmacologic treatment have been shown in clinical trials to produce major reductions in blood pressure (2).

Yoga is said to be a healing system of theory and practice utilized for more than 5000 years. Yoga, a form of physical activity consisting of various postures (Asanas), breathing (Pranayama) and meditation (Dhyana) techniques, has been shown to have therapeutic benefits for individuals with a wide range of health conditions, including hypertension and diabetes mellitus (3–6). Studies have demonstrated that Transcendental Meditation, Zen Meditation, Om Meditation and Yogic Relaxation reduce the resting oxygen consumption rate, respiratory rate and heart rate. These changes are thought to be due to decreased arousal as well as decreased mental and muscular activity (7, 8). Relaxation by yoga training is associated with a significant increase of cardiac vagal modulation and decreasing sympathetic activity (9, 10). Maintenance of a normal blood pressure is dependent on the balance between the cardiac output and peripheral vascular resistance. Most patients with essential hypertension have a normal cardiac output but a raised peripheral resistance (11). Few studies have shown a decrease in peripheral vascular resistance and improved cardiac output in individuals who practice yoga and transcendental meditation (12–14). This study is a further attempt to verify those reports.

SUBJECTS AND METHODS

Sixty-four medical students of both genders (57 Females, 7 Males), mean age 21.3 ± 2.6 years, mean body mass index of 22.4 ± 3.2 kg/m², attending Special Study Module 'Role of Dhyana Yoga in Stress Management', participated in this study. This module is an optional course that is approved by the Faculty of Medical Sciences of the University of the West Indies. The aims and objectives of the study were explained to each of them. All the students who consented for this module were healthy, did not have any cardio-respiratory diseases and were not on any medications. Most of these students were being exposed to yoga exercises for the first

time. The students attended a total of six yoga sessions and practised at each session (II-VI), once a week for one hour duration. The students were asked to practise each session at least for 10 minutes every day at their residence for the next six days before coming to the next session. The details of six sessions were as follows:

Session I: Lecture on yoga and its benefits to increase awareness among students about philosophy and benefits of Yoga. At the end of the lecture, their baseline data for various cardiovascular parameters were recorded.

Sessions II: Demonstration *cum* practice of *Bhujangasana* (Cobra pose), *Halasana* (Plough pose), *Gomukhasana* (Cow-Face Pose) and *Shavasana* (Corpse pose).

Session III: Demonstration *cum* practice of *Padamasana* (Lotus pose).

Session IV: Demonstration *cum* practice of *Pranayama* – single and alternate nostril breathing and breathing with a pause.

Session V: Demonstration *cum* practice of *Dhyana* yoga – fixing the mind between the two eye brows or at the tip of the nose and reciting the Mantra (syllable) "SOHUM".

Session VI: The participants were asked to close their eyes and practise *Dhyana* yoga while they were being tested for cardiovascular functions.

Measurements: Various cardiovascular parameters were recorded using a non-invasive device, Finapres (FMS, Finapres Medical Systems BV Arnhem, The Netherlands), before the start and after five weeks of yoga practice. The definitions of various functions studied were:

- * Systolic blood pressure (SYS): the maximum pressure in arterial systole.
- * Diastolic blood pressure (DIA): the lowest pressure just before the next upstroke.
- * Mean arterial blood pressure (MAP): the true integrated mean between upstrokes.
- * Heart Rate (HR): the pulse rate derived from interbeat interval.
- * Interbeat Interval (IBI): the time between two consecutive upstrokes.
- * Left ventricular ejection time (LVET): the time between upstroke and dicrotic notch.
- * Stroke volume (SV): is from Model flow simulation.

- * Cardiac output (CO): the product of stroke volume and heart rate.
- * Total peripheral resistance (TPR): As the ratio of mean pressure to cardiac output, thus assuming zero venous pressure (at the right atrium).
- * Ascending aorta characteristic impedance (Zao): at the current diastolic pressure.
- * Total arterial compliance (Cwk): at the current diastolic pressure.

Statistical Analysis

Descriptive statistics were performed and results were expressed as mean scores with Standard Deviations (SD). Differences between means were determined using t-test and a p-value of less than 0.05 was accepted as indicating significant differences between the values obtained before and after five weeks of yogic exercises.

Data were analysed using Stata Software version 10.0 for Windows™ (StataCorp, College Station, TX).

RESULTS

Table 1 shows Mean \pm SE of various cardiovascular functions before and after five weeks of yogic practice in 64

maintain arterial and venous blood pressure readings within a narrow range. Among various factors, changes in vessel diameter are most important quantitatively for regulating blood flow within an organ, as well as for regulating arterial pressure. Changes in vessel diameter, particularly in small arteries and arterioles, enable organs to adjust their own blood flow to meet the metabolic requirements of the tissue.

A second type of extrinsic influence on the vasculature is circulating vasoactive hormones such as angiotensin II, epinephrine, norepinephrine and endothelin. Both the neural and humoral factors, while affecting organ blood flow, primarily serve the function of regulating arterial pressure by altering systemic vascular resistance.

This study reports on changes in haemodynamic functioning before and after five weeks of practising yogic exercises in medical students. Yogic training for five weeks exhibited significant decreases ($p < 0.005$) in total peripheral resistance indicating increase in the diameter of the blood vessels. This in turn resulted in significant increase ($p < 0.0024$) in arterial compliance (Cwk). Besides intrinsic regulatory mechanisms such as release of vasoactive metabolites and myogenic mechanism, there is an extrinsic mechanism *viz* sympathetic vascular tone and vasoactive

Table: Mean \pm SE of the various cardiovascular functions before and after 6 weeks of Yogic practice in 64 healthy medical students

Functions	Before	After	t value	p value
Systolic Pressure, mmHg	115.5 \pm 1.6	116.4 \pm 1.8	-0.8074	0.42
Diastolic Pressure, mmHg	72.0 \pm 1.2	70.6 \pm 1.1	1.2809	0.21
Mean Arterial Pressure, mmHg	90.6 \pm 1.2	89.9 \pm 1.3	0.6528	0.52
Heart Rate, beats/min	77.6 \pm 1.4	80.9 \pm 1.5	-2.1502	0.04*
Stroke Volume, ml	67.4 \pm 2.5	73.3 \pm 2.1	-2.8374	0.006**
Cardiac Output, L/min	5.14 \pm 0.18	5.84 \pm 0.17	-4.0873	0.0001***
Total Peripheral Resistance, mmHg.s/ml	1.15 \pm 0.05	1.00 \pm 0.04	3.6787	0.0005***
Inter Beat Interval, s	0.80 \pm 0.15	0.76 \pm 0.02	2.3942	0.02*
Left ventricular ejection time, s	0.31 \pm 0.00	0.33 \pm 0.03	-0.8402	0.40
Ascending aorta characteristic impedance, milli-mmHg.s/ml	66.99 \pm 0.98	64.92 \pm 1.11	3.4918	0.0009***
Total arterial compliance, ml/mmHg	1.99 \pm 0.03	2.08 \pm 0.03	-3.1695	0.002**

* $p < 0.05$; ** $p < 0.01$; *** $p < 0.001$

healthy medical students. The results revealed significant increases in HR ($p < 0.05$), SV ($p < 0.01$), CO ($p < 0.001$) and Cwk ($p < 0.01$) and decreases in TPR ($p < 0.001$), IBI ($p < 0.05$) and Zao ($p < 0.001$) after practising yoga for five weeks as compared to before yoga practice. No significant differences were, however, observed in SYS, DIA, MAP and LVET.

DISCUSSION

Haemodynamics can be defined as the physical factors that govern blood flow. These factors include the changes in blood pressure and the resistance. Changes in resistance are the primary means by which blood flow is regulated within organs because control mechanisms in the body generally

hormones acting on the vasculature and which can regulate vessel diameter.

The research conducted thus far proves that yoga relaxes muscles and mind and in turn reduces stress and anxiety (15, 16). Practice of yoga has demonstrated decreases in respiration rate by decreasing the sympathetic activity (17, 18) and cortisol levels (19, 20). Yoga and meditation appear to improve endothelial function in subjects with coronary artery disease (21). Decreases observed in TPR during the present study may be due to the effect of yogic training in reducing the sympathetic vascular tone (13, 14, 17, 22).

Blood pressure is a product of Cardiac output (CO) and Total Peripheral Resistance (TPR). Cardiac output is a product of Stroke Volume (SV) and Heart Rate (HR). Signi-

ificantly higher ($p < 0.0001$) cardiac output observed in the present study is most likely due to higher per cent increases in SV (8.69%) as compared to lower per cent increases in the heart rate (4.21%) in students practising yoga. Increases in both SV and CO suggest improved dilated systolic function in subjects after six weeks of yoga training. Both stroke volume and cardiac output are controlled by venous return. Increase in stroke volume may be attributed to increase in venous return due to vasodilatation caused by a fall in TPR. In addition, practice of asanas in yoga causes contraction of active skeletal muscles that may increase the venous return by compressing the veins. Furthermore, inter-pleural pressure becomes progressively more negative by deep and slow inspiration during Pranayama that can also increase the venous return.

Interbeat interval (IBI) is a beat to beat variation in the heart rate and is an indicator of autonomic function and physiological coherence. It is affected by emotions, thoughts and physical exercise. It is a powerful tool to explore the dynamic interaction between physiological, mental and behavioural processes. Significant increases in the heart rate ($p < 0.0354$) may be attributed to significant decreases in IBI ($p < 0.0196$) after yoga training. Previous studies have shown decreases in blood pressure in subjects practising yogic exercises (4, 21, 23, 24). Increases in CO and decreases in TPR in Yoga and/or Transcendental Meditation (TM) practitioners have been reported earlier (12, 14).

The present study did not reveal any significant changes in the mean arterial blood pressure in the students after yoga training. Cardiac Output and TPR are the two main factors that could have altered the mean arterial pressure. Significant increases in CO ($p < 0.0001$; 13.69%) and simultaneous decreases in TPR ($p < 0.0005$; 12.69%) might have compensated for bringing about any change in the mean arterial blood pressure. Furthermore, systolic blood pressure was slightly higher than slightly lower diastolic blood pressure that may have helped to maintain the mean arterial blood pressure. It is also not surprising that the blood pressure did not decrease because the subjects in the present study were young and healthy and the mean blood pressure was already low for their age indicating a possible "physiological floor effect" (14).

CONCLUSIONS

Yoga is at the core of alternative systems that have an important role in both the primary prevention of cardiovascular diseases as well as hindering the progress of heart diseases. Practice of yogic asanas has been found to improve cardiovascular efficiency even in a diseased person. Conscious breathing, as in pranayama, strengthens heart muscles and improves the oxygen carrying capacity of the blood vessels. In addition, the relaxation induced by meditation helps to stabilize the autonomic nervous system with a tendency towards parasympathetic dominance. Physiological benefits which follow help yoga practitioners become

more resilient to stressful conditions and reduce a variety of risk factors for various diseases, especially cardio-respiratory diseases (25).

The results of the present study demonstrated that practice of yoga, even for a short period, is able to reduce TPR, increase Cwk, SV and CO. These changes suggest improved cardiac pump functions and vessel compliance in amateur medical students. Regular practice of yoga for a longer period may further improve these functions. The results of this study provide a preliminary contribution to understanding the underlying haemodynamic mechanisms responsible for beneficial influence of yoga on cardiovascular risk factors.

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