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RESEARCH ARTICLE

A study of cardiorespiratory efficiency following yoga in healthy Indian medical students

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ABSTRACT

Background: Medical students are confronted with many life stressors from both college and home. Unmanaged stress is now believed to be a contributing and/or causal factor in the development of many physical and mental health problems. Yoga is an ancient Indian philosophic system to reduce stress and achieve psychosomatic harmony through a combination of postural exercises (Asanas), voluntary breathing exercises (Pranayamas), and meditations. **Aims and Objectives:** The aims and objectives of this study were to better understand the effects of Yoga on healthy individuals and to provide the scientific basis for the possible use of Yoga as preventive and/or alternative therapy for health disorders; the present study was planned. The primary objective was to investigate the effects of Yoga on cardiorespiratory efficiency parameters of healthy Indian medical students. **Materials and Methods:** A total of 300 medical students were randomly divided into intervention group and control group using simple random sampling. Intervention group was subjected to 4 weeks' Yoga training by a certified Yoga teacher. Height, weight, resting pulse rate (RPR), systolic blood pressure (SBP), diastolic blood pressure (DBP), fitness index (FI), tidal volume (TV), vital capacity (VC), breath holding time (BHT), maximum expiratory pressure (MEP), and 40 mmHg endurance test (40 mmHg ET) were measured in both the groups before and after intervention. **Results:** In the intervention group, RPR, SBP, and DBP decreased significantly, whereas FI, TV, VC, BHT, MEP, and 40 mmHg ET increased significantly following Yoga. TV increased after Yoga, but the change was not significant. **Conclusion:** Yoga improves cardiorespiratory efficiency in healthy individuals and can be recommended for patients as well.

KEY WORDS: Yoga; Students; Cardiovascular; Respiratory; Efficiency

INTRODUCTION

Medical students are confronted with a variety of life stressors from both college and home. Unmanaged stress is now considered to be an important contributing and/or causal factor in the development of numerous physical and mental health problems that are prevalent in adolescents, including anxiety, depression, and other behavioral problems.[1]

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Yoga is an ancient philosophic system that originated in India, with the primary objective of development of the union of mind and body through a combination of exercise, respiration, and meditation to achieve psychosomatic harmony.[2-3] Yoga consists of a holistic combination of postural exercises (Asanas), relaxation, and voluntary breathing exercises (Pranayamas). All over the world, Yoga has gained popularity as an alternative form of physical activity since it offers a different experience when compared to traditional physical exercise training and is less strenuous and more enjoyable.[4]

Hence, it is pertinent to study the effects of Yoga on cardiorespiratory efficiency of medical students to better understand its effects on healthy individuals and to provide the scientific basis for the possible use of Yoga techniques as preventive and/or alternative therapy for health disorders. Supporting the rationale of addressing the health needs of medical students, the present study intended to investigate the effects of Yoga on cardiorespiratory efficiency parameters of medical students.

MATERIALS AND METHODS

It was an interventional study conducted on 300 Indian medical students in the Department of Physiology, Gujarat Adani Institute of Medical Sciences (GAIMS), Bhuj – 370 001, Gujarat, India. After obtaining ethical permission from the Institutional Ethics Committee (IEC) of GAIMS (letter No. GAIMS/IEC/Approval-11/Res. Pro./2015), medical students of GAIMS were invited to participate in this study. A total of 321 students volunteered for the study.

Inclusion and Exclusion Criteria

Students >18 years of age who gave a valid consent for participation were included in the study. While students with <18 years of age ($n = 7$), body mass index (BMI) < 18.5 ($n = 5$) or > 24.99 ($n = 4$), following any Yoga/diet/exercise regimens ($n = 4$), taking any drugs that may affect psychophysiological functions, suffering from any disease/disorder that can affect psychophysiological functions, for example, thyroid disorders, diabetes mellitus, bronchial asthma ($n = 1$), any acute illness, any other respiratory, and cardiovascular or neuropsychiatric disorders, who were smokers and/or alcoholics, were excluded from the study.

Then, participants were allotted to intervention group ($n = 150$) and control group ($n = 150$) using simple random sampling. The intervention group was subjected to 4 weeks' Yoga training by a certified Yoga teacher as per Table 1. Following four Pranayams, Suryanamaskar[5] (SN) and Shavasan[6] were included in the training:

Anulom Vilom Pranayam

Also called "alternate nostril breathing," it begins from the left nostril. Close the right nostril with the right thumb. Inspire slowly from the left nostril until the lungs are fully filled (Puraka). Then, close the left nostril using the second and third fingers. Opening the right nostril, expire slowly (Rechaka) until the lungs are fully empty. until the lungs are fully empty. This process of "inspire with left nostril and expire with right" nostril is considered "one cycle." Then, alternate the nostrils and "inspire with right nostril and expire with left nostril" which is considered second cycle and so on.[7]

Bhramari Pranayam

In Bhramari (Sanskrit word meaning a female bee) Pranayam, one produces a low pitched humming but audible sound resembling that of a female bee during exhalation, as long as possible.[8]

Shitali Pranayam

Slightly lower your chin. Make a "straw" of your tongue curling it lengthwise and project it out of the mouth to a comfortable distance. Gently inhaling through this "straw" elevate your chin toward ceiling as far as the neck is comfortable. With your chin raised comfortably, retract the tongue and close the mouth at the peak of the inhalation. Exhale through the nostrils slowly, gently lowering back your chin to a neutral position.[9]

Shitkari Pranayama

Keeping the tongue just behind the teeth, slightly open your mouth. Inhale gently through the area between the higher and lower teeth, allowing the air to wash over your tongue while raising your chin toward the ceiling. Close your mouth at the end of inhalation, and expire through the nostrils, gently lowering back your chin to a neutral position.[9]

Following parameters were measured in both the groups before and after intervention:

Table 1: Graded Yoga training (6 days a week, 1-day rest) in intervention group

Week No	Yoga training	Total daily duration
1	Joint relaxation exercises (JREs) followed by Shavasan	15+5 = 20 min
Weekly medical examination-1		
2	JREs followed by Pranayams (4 in number) followed by Shavasan	5+10+5 = 20 min
Weekly medical examination-2		
3	JREs followed by Pranayams (4 in number) followed by Suryanamaskar followed by Shavasan	5+10+5 + 5=25 min
Weekly medical examination-3		
4	JREs followed by Pranayams (4 in number) followed by Surya Namaskar followed by Shavasan	5+10+10+5 = 30 min
Weekly medical examination-4		

JREs: Joint relaxation exercises

Height

Height was recorded during inspiration using a stadiometer. The subject was asked to stand erect on the stadiometer with barefoot. The horizontal bar of the stadiometer was placed on the vertex of the subject, and the readings were recorded.

Weight

Weight was measured by a digital standing scale. The subject was asked to stand erect on the scale with barefoot and the readings were recorded.

BMI

BMI was calculated using the Quetelet's[10] formula:

$$\text{BMI} = \text{Weight (kg)}/\text{Height}^2\ \text{(m)}$$

Resting Pulse Rate (RPR)

The subject was seated quietly for at least 5 min in a chair with feet on the floor and arm supported at heart level. Pulse rate was examined using three-finger method and a stopwatch.

Resting Blood Pressure

The subject was seated quietly for at least 5 min in a chair with feet on the floor and arm supported at heart level. Systolic blood pressure (SBP) and diastolic blood pressure (DBP) were measured with the help of a mercury sphygmomanometer. An average of three such measurements was taken as the blood pressure.[11]

Fitness Index (FI)

FI was calculated using the Harvard step test. Participants were asked to step on and off a bench of 50 cm height, 30 times/min for 5 min. Recovery pulse rate was counted between 1 and 1.5 min, 2 and 2.5 min, and 3 and 3.5 min. FI was calculated using the following formula:

FI (%) = Duration of exercise in seconds × 100/2 (Sum of recovery pulse rate counts)[12]

Tidal Volume (TV) and Vital Capacity (VC)

These were measured using a computerized spirometer (SpiroTech 1.0, Clarity Medicals Pvt. Ltd., Mohali, India; calibrated before each testing session) in sitting position.

Breath Holding Time (BHT)

Procedure ◊ After deep inspiration, hold your breath for as long as you can. The maximum time (up to the breaking point) up to which breath can be held was recorded using a stopwatch. The participant was continuously motivated to increase the BHT. Three such trials were given with a rest period of 3 min in between. Maximum reading of the three was taken for statistical analysis.[13,14]

Maximum Expiratory Pressure (MEP)

Procedure ◊ Connect a rubber tube and mouthpiece to a mercury sphygmomanometer. Apply a noseclip, and after a deep inspiration, blow into the tube pushing the mercury column up. The maximum reading up to which the mercury column can be raised is recorded as the MEP in mmHg.

40 mm Hg Endurance Test (40 mmHg ET)

Participants were asked to inspire deeply, and then with the nose-clip attached, blow into the tube of mercury sphygmomanometer to take the mercury column up to 40 mmHg mark. Maximum time (s) up to which the level of mercury column could be held steady at 40 mmHg by the participant was recorded using a stopwatch. Pulse rate was counted along with the procedure, so that when the pulse rate increases, the procedure can be stopped. The participant was continuously motivated to maintain the mercury level. Furthermore, the participant was instructed not to blow cheeks, not to use tongue or oral muscles to create pressure, and not to block the tubing. Maximum reading of three such trials (with a rest period of 3 min in between) was taken for statistical analysis.[13,14]

Statistical analysis was performed using Microsoft Excel 2016 and Statistical Package for the Social Sciences version 21. Student's *t*-test was used to compare mean of different variables. The alpha level to determine significance was taken as $P < 0.05$. $P < 0.01$ was considered to be highly significant.

RESULTS

No significant change was found in age, height, weight, or BMI of the participants in either intervention or control group [Table 2 and 3]. In the intervention group, RPR, SBP, and DBP decreased significantly while FI increased significantly following Yoga [Table 4]. No significant change was detected in the cardiovascular efficiency parameters in the control group [Table 5]. In the intervention group, VC, BHT, MEP, and 40 mmHg ET increased significantly following Yoga while TV increased, but this change was not statistically significant. [Table 6]. No significant change was detected in the respiratory efficiency parameters in the Control Group [Table 7].

DISCUSSION

We found that RPR, SBP, and DBP decreased, while FI increased significantly after doing Yoga, indicating that Yoga

Table 2: Anthropometric parameters in intervention group (paired Student's *t*-test)

Gender	Parameter	Pre-Yoga Mean±SD	Post-Yoga Mean±SD	*P*-value
Female (*n*=72)	Age (years)	18.50±0.71	18.50±0.71	-
	Height (cm)	156.46±5.29	156.46±5.29	-
	Weight (kg)	52.00±6.44	52.03±6.39	0.32
	BMI (Kg/m^2)	21.22±2.26	21.24±2.25	0.39
Male (*n*=78)	Age (years)	18.60±0.62	18.60±0.62	-
	Height (cm)	170.72±7.64	170.72±7.64	-
	Weight (kg)	61.69±8.81	61.64±8.54	0.44
	BMI (Kg/m^2)	21.14±2.46	21.12±2.37	0.47
All (*n*=150)	Age (years)	18.43±0.67	18.43±0.67	-
	Height (cm)	163.87±9.73	163.87±9.73	-
	Weight (kg)	57.04±9.14	57.03±8.96	0.72
	BMI (Kg/m^2)	21.18±2.36	21.18±2.31	0.86

Table 3: Anthropometric parameters in control group (paired Student's *t*-test)

Gender	Parameter	Pre Mean±SD	Post Mean±SD	*P*-value
Female (*n*=64)	Age (years)	18.09±0.29	18.09±0.29	-
	Height (cm)	158.94±5.51	158.94±5.51	-
	Weight (kg)	53.16±7.29	53.13±7.22	0.57
	BMI (Kg/m^2	20.97±2.04	20.96±2.01	0.62
Male (*n*=86)	Age (years)	18.23±0.48	18.23±0.48	-
	Height (cm)	171.00±6.43	171.00±6.43	-
	Weight (kg)	62.20±8.64	62.13±8.50	0.13
	BMI (Kg/m^2	21.22±2.23	21.20±2.19	0.15
All (*n*=150)	Age (years)	18.17±0.41	18.17±0.41	-
	Height (cm)	165.85±8.50	165.85±8.50	-
	Weight (kg)	58.34±9.23	58.29±9.13	0.13
	BMI (Kg/m^2)	21.11±2.15	21.10±2.11	0.17

Table 4: Cardiovascular efficiency in intervention group

Gender	Parameter	Pre-Yoga Mean±SD	Post-Yoga Mean±SD	*P*-value
Female (*n*=72)	RPR (beats/min)	75.31±5.39	73.04±5.26	<0.01
	SBP (mmHg)	116.75±8.68	114.44±5.43	<0.01
	DBP (mmHg)	75.92±4.28	74.06±4.49	<0.01
	FI (%)	69.93±12.10	71.31±10.34	<0.05
Male (*n*=78)	RPR (beats/min)	79.31±8.14	77.15±6.24	<0.01
	SBP (mmHg)	123.64±7.6	121.03±6.51	<0.01
	DBP (mmHg)	78.26±6.51	76.64±4.96	<0.01
	FI (%)	75.78±9.03	77.30±7.14	<0.01
All (*n*=150)	RPR (beats/min)	77.39±7.22	75.18±6.13	<0.01
	SBP (mmHg)	120.33±8.81	117.87±6.84	<0.01
	DBP (mmHg)	77.13±5.65	75.40±4.90	<0.01
	FI (%)	72.97±10.98	74.42±9.29	<0.01

RPR: Resting pulse rate, SBP: Systolic blood pressure, DBP: Diastolic blood pressure, FI: Fitness index

Table 5: Cardiovascular efficiency in control group

Gender	Parameter	Pre	Post	*P*-value
		Mean±SD	Mean±SD	
Female (*n*=64)	RPR (beats/min)	76.16±5.35	76.67±4.50	0.11
	SBP (mmHg)	119.66±8.24	120.00±6.74	0.75
	DBP (mmHg)	77.25±4.21	77.03±3.80	0.77
	FI (%)	71.10±11.38	71.19±11.40	0.96
Male (*n*=86)	RPR (beats/min)	76.29±4.64	76.48±5.32	0.80
	SBP (mmHg)	120.95±6.54	119.16±5.93	0.07
	DBP (mmHg)	76.77±4.91	76.56±4.54	0.78
	FI (%)	77.05±7.32	75.06±10.63	0.12
All (*n*=150)	RPR (beats/min)	76.23±4.94	76.56±4.97	0.54
	SBP (mmHg)	120.40±7.32	119.52±6.28	0.23
	DBP (mmHg)	76.97±4.62	76.76±4.23	0.69
	FI (%)	74.51±9.70	73.41±11.09	0.31

RPR: Resting pulse rate, SBP: Systolic blood pressure, DBP: Diastolic blood pressure, FI: Fitness index

Table 6: Respiratory efficiency in intervention group

Gender	Parameter	Pre-Yoga	Post-Yoga	*P*-value
		Mean±SD	Mean±SD	
Female (*n*=72)	TV (ml)	359.88±25.31	361.83±25.40	0.64
	VC (L)	3.10±0.45	3.47±0.57	<0.01
	BHT (S)	37.22±5.06	39.65±4.83	<0.01
	MEP (mmHg)	64.11±11.24	65.31±11.58	<0.01
	40 mmHg ET (S)	28.04±9.57	30.40±10.21	<0.01
Male (*n*=78)	TV (ml)	409.96±62.36	412.92±62.41	0.77
	VC (L)	4.00±0.53	4.30±0.50	<0.01
	BHT (S)	41.77±9.08	45.01±9.54	<0.05
	MEP (mmHg)	74.95±19.26	76.12±19.60	<0.01
	40 mmHg ET (S)	34.68±13.07	37.15±13.49	<0.01
All (*n*=150)	TV (ml)	385.92±54.27	388.40±54.55	0.69
	VC (L)	3.57±0.60	3.90±0.68	<0.01
	BHT (S)	39.59±7.74	42.44±8.09	< 0.01
	TV (ml)	69.75±16.78	70.93±17.08	<0.01
	VC (L)	31.49±11.96	33.91±12.46	<0.01

TV: Tidal volume, VC: Vital capacity, BHT: Breath holding time, MEP: Maximum expiratory pressure

improves cardiovascular efficiency. Furthermore, VC, BHT, MEP, and 40 mmHg ET increased significantly following Yoga, suggesting that Yoga improves respiratory efficiency as well.

Cardiovascular Efficiency Parameters

In our study, RPR, SBP, and DBP reduced significantly, whereas FI increased significantly following Yoga training in normal healthy participants. A similar decrease in cardiovascular parameters was found by Kumar *et al*.,[9] and Bhavanani *et al*.[15] wherein participants practiced other Pranayams such as Sukha Pranayama and Chandra Nadi Pranayama. Many studies have reported that practice of Pranayams increases parasympathetic activity and decreases sympathetic activity, which may be responsible for this observed decrease in cardiovascular parameters.[16]

Furthermore, the slower rate of breathing in different Pranayams may have contributed to the favorable cardiovascular effects seen in this study. Previous studies have reported that slow and deep breathing decreases the heart rate and heart rate variability possibly due to enhanced vagal tone on sinoatrial node.[16] Such enhanced vagal modulation may be responsible for decreased heart rate and blood pressure observed following Yoga. Bernardi *et al*.[17] reported that slow and deep breathing combines RR interval fluctuations with the rate of respiration and significantly increases their

Table 7: Respiratory efficiency in control group

Gender	Parameter	Pre	Post	*P* value
		Mean±SD	Mean±SD	
Female (*n*=64)	TV (ml)	357.84±26.10	358.67±25.74	0.87
	VC (L)	3.54±0.54	3.55±0.59	0.94
	BHT (S)	37.27±5.33	37.36±4.98	0.88
	MEP (mmHg)	62.91±11.06	62.30±11.19	0.10
	40 mmHg ET (S)	27.05±9.72	27.39±10.28	0.35
Male (*n*=86)	TV (ml)	395.08±48.07	396.56±63.02	0.86
	VC (L)	3.76±0.64	3.84±0.53	0.32
	BHT (S)	41.97±9.06	42.29±9.13	0.67
	MEP (mmHg)	72.58±14.43	73.45±18.86	0.46
	40 mmHg ET (S)	35.20±12.86	34.95±13.32	0.68
All (*n*=150)	TV (ml)	379.19±44.13	380.39±53.84	0.82
	VC (L)	3.67±0.61	3.72±0.57	0.43
	BHT (S)	39.96±8.02	40.19±8.00	0.78
	MEP (mmHg)	68.45±13.91	68.69±16.93	0.64
	40 mmHg ET (S)	31.72±12.27	31.73±12.65	0.98

TV: Tidal volume, VC: Vital capacity, BHT: Breath holding time, MEP: Maximum expiratory pressure

amplitude and thereby enhances baroreflex competence. Such enhancement may have contributed to the lowering of blood pressure observed in our study. This finding may be utilized in routine clinical situations where blood pressure needs to be reduced. Thus, Yoga may serve as a simple and cost-effective adjunct in the management of hypertension, in addition to the regular antihypertensive management. Further studies may be necessary to uncover the detailed mechanisms involved.

The RPR and DBP were significantly lower post-Yoga in our study. A similar decrease in RPR and DBP was reported by Bhavanani *et al*.[18] and Bhutkar *et al*.[5] The main determining factor of DBP is peripheral vascular resistance, which is regulated by sympathetic tone. In the present study, the significant decrease of DBP and RPR in Yoga group may be attributed to a decrease in peripheral vascular resistance due to reduced sympathetic tone. The SBP was found to be significantly lower in Yoga group after the training. Bhutkar *et al*.[5] also reported a similar decrease in SBP. Interestingly, Bhavanani *et al*.[18] reported an increase in SBP following Fast SN practice which may be due to the speed of SN causing increasing venous return and cardiac output.

The observed cardiovascular changes may also be due to the Shavasan which is reported to reduce cardiac sympathetic modulation.[6] Yoga practices, including relaxation (such as Shavasan), improves autonomic modulation and enhances vagal dominance.[19] Hence, Shavasan may be included in the non-pharmacological management of hypertension.

Respiratory Efficiency Parameters

We found a significant increase in VC, BHT, MEP, and 40 mmHg ET following Yoga, while the change in TV was not statistically significant. Similar results were reported by Karmur *et al*.[20] and Mahajan *et al*.[21] Yoga postures (asanas), such as SN in our study, increase skeletal muscle strength including that of respiratory muscles. Hence, lungs and thorax expand and collapse to the fullest possible. Such strengthening of the respiratory musculature contributes to the increased respiratory efficiency evidenced in our study.[22-24]

Limitations and Directions for Future Research

We did not investigate whether these cardiorespiratory changes persisted even after stopping Yoga practice and whether long-term Yoga practice can cause stable improvements in cardiorespiratory efficiency. Research studies may be planned in this direction to get better perspective on Yoga.

CONCLUSION

Yoga improves cardiorespiratory efficiency in healthy individuals, and hence, it should be included in daily life. Yoga may be extremely helpful as an alternative/adjunct therapy in patients to improve cardiorespiratory efficiency.

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