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EFFECT OF SIX WEEKS YOGA TRAINING ON WEIGHT LOSS FOLLOWING STEP TEST, RESPIRATORY PRESSURES, HANDGRIP STRENGTH AND HANDGRIP ENDURANCE IN YOUNG HEALTHY SUBJECTS

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Abstract : The present study was designed to test whether yoga training of six weeks duration modulates sweating response to dynamic exercise and improves respiratory pressures, handgrip strength and handgrip endurance. Out of 46 healthy subjects (30 males and 16 females, aged 17–20 yr), 23 motivated subjects (15 male and 8 female) were given yoga training and the remaining 23 subjects served as controls. Weight loss following Harvard step test (an index of sweat loss), maximum inspiratory pressure, maximum expiratory pressure, 40 mm endurance, handgrip strength and handgrip endurance were determined before and after the six week study period. In the yoga group, weight loss in response to Harvard step test was 64±30 g after yoga training as compared to 161±133 g before the training and the difference was significant (n = 15 male subjects, $P<0.0001$). In contrast, weight loss following step test was not significantly different in the control group at the end of the study period. Yoga training produced a marked increase in respiratory pressures and endurance in 40 mm Hg test in both male and female subjects ($P<0.05$ for all comparisons). In conclusion, the present study demonstrates attenuation of the sweating response to step test by yoga training. Further, yoga training for a short period of six weeks can produce significant improvements in respiratory muscle strength and endurance.

Key words : asans pranayams shavasan step test

INTRODUCTION

The effect of yoga training on exercise tolerance has been reported earlier (1, 2). The beneficial effects of yoga training on exercise tolerance might include decreased

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sweating in response to exercise. There is only one report on the effect of yoga training on thermoregulation measured by sweating response to exercise (3). The present study was specifically an attempt to determine whether yoga training of short duration (six weeks) modifies the sweating response to dynamic exercise in a hot and humid environment. The effect of training on sweating response to dynamic exercise was studied using Harvard step test (4).

The effects of yoga training on pulmonary function have been previously studied (5, 6). These studies have mainly investigated the effects of yoga training on indices of airway resistance such as peak expiratory flow rate and forced vital capacity. However, it is likely that some of the beneficial effects of yoga training are mediated through improvements in respiratory muscle strength, which can be determined readily. Maximal inspiratory pressure (MIP) and maximal expiratory pressure (MEP) are useful and sensitive indices of the strength of inspiratory and expiratory muscles respectively (7, 8). Indeed, in a previous study from our laboratory, we have shown that yoga training is associated with improvements in respiratory muscle strength and 40 mm Hg endurance but this study lacked a control group (7). We planned to undertake the present study with the objectives to determine whether six weeks yoga training produces improvements in handgrip strength, handgrip endurance, and respiratory pressures in young healthy subjects, and alters weight loss response (an indicator of the sweating response) to dynamic exercise.

MATERIAL AND METHODS

Forty six (30 male and 16 female) healthy subjects between 17-20 years consented to participate in the present study. Of these, 23 (15 males and 8 females) motivated subjects volunteered to receive yoga training (yoga group) and the remaining 23 (15 males and 8 females) served as controls (control group). Written informed consent was obtained from the participants after explaining the purpose of the study, testing procedures and yoga training schedule. The Institute Research Council and Ethics Committee approved the study protocol.

Experimental protocol: Tests were done under standard laboratory conditions after familiarising the subjects with the testing procedure and the study protocol. Height and weight were measured and body mass index (BMI) was calculated [weight (kg) divided by square of height (m^2)]. In both groups, the parameters described below were recorded before and at the end of six week study period.

Resting heart rate (HR) and blood pressure (BP) : Baseline HR and BP values were obtained after five minutes rest in the sitting position. BP was recorded using Colins automated BP monitor (COLIN Press-Mate, COLIN Corporation, Japan) which measures BP by the oscillometric method. Pulse pressure (PP) was calculated as the difference between systolic pressure (SP) and diastolic pressure (DP). Mean arterial pressure (MAP) was calculated as DP + 1/3 PP.

Maximum inspiratory pressure (MIP), maximum expiratory pressure (MEP) and 40 mm Hg endurance : MIP was obtained by asking the subject to breathe out fully and then inhale maximally from the mouthpiece connected to a mercury manometer. MEP was determined by asking the subject to take in a full breath and blow forcefully into the mouthpiece of the mercury manometer. The maximum pressure that was maintained for at least 3 seconds was noted in both the cases. Respiratory pressures depend on lung volumes; the highest MIP is obtained near residual volume while the highest MEP is obtained near total lung capacity (7, 8). For determining 40 mm Hg endurance, the subject was asked to take in a full breath and blow into the mouthpiece of a mercury manometer and raise the pressure to 40 mm Hg. The maximum time for which the subject could maintain this pressure was recorded as 40 mm Hg endurance. It was ensured that the subjects did not use oral muscles or tongue to develop pressure or block the tubings.

Handgrip strength (HGS) and handgrip endurance (HGE) : HGS was determined using a handgrip dynamometer (INCO, Ambala, India) by asking the subject to maintain a maximal voluntary contraction (MVC) for at least 3 seconds with the dominant arm outstretched in front and parallel to the ground. HGE was determined by noting the maximum time (seconds) for which the subject could maintain 1/3 of MVC.

Step test : Female subjects opted out of the step test. Male subjects (n = 15 in each group) were familiarized with the procedure 2–3 days before the actual recording was done. Weight prior to exercise was measured using a weighing machine (TESTUT, France), having a precision of 20 g. The study was done at a laboratory temperature of 32 ±1°C and humidity of 60–70%. The Harvard step test was done by asking the subject to step up and down a wooden platform of 45 cm height at the rate of 30 times per minute for a duration of 2 mins. After the exercise, the subject was wiped dry with a clean dry towel and weighed again. The difference between the weight before and immediately after the step test was taken as weight loss as a result of exercise-induced sweating.

Yoga training : Yoga training including asans, pranayams and shavasan was imparted to the yoga group by one of the authors (Madanmohan), who is a trained yoga instructor. Practice sessions were held between 4.30 and 6.00 PM, Monday through Saturday, for a duration of six weeks in a pleasant lawn. Sessions began with a brief prayer. The sequence and duration of the yogic techniques practised by the yoga group are summarized in Table I.

Statistical analysis : Data are expressed as mean±SD. Intergroup comparisons were done using Student's unpaired *t*-test and within group comparisons by Student's paired *t*-test. Where compared variances were unequal, Welch's correction was applied. Differences in means were considered statistically significant when the two-tailed P value <0.05.

RESULTS

The results are given in Tables II and III. The height (m), weight (kg) and body mass index in (kg/m^2) in male yoga group were 1.7±0.07, 64.4±11.4, and 22±3.14, respectively. In the female yoga group, the

TABLE I : The yogic techniques, their sequence, duration and the number of repetitions practiced by the yoga group.

S.No.	Yogic technique	Duration and number of repetition
1.	Prayer	5 min
2.	Mukh-bhastrika in vajrasan	12 sec × 3
3.	Tribandh (mool+uddiyan +jalandhar bandh)	20 sec × 2
4.	Talasan (with breath control)	6: 6: 6 sec × 2
5.	Trikonasan (with breath control)	6: 6: 6 sec × 2
6.	Navasan	6: 6: 6 sec × 2
7.	Naukasan	6: 6: 6 sec × 2
8.	Brahm mudra (with Aum chant)	48 sec × 2
9.	Ardh-matsyendrasan	6: 6: 6 sec × 2
10.	Bhujangasan (with breath control)	6: 6: 6 sec × 2
11.	Bakasan	20 sec × 2
12.	Viparitakarani	20 sec × 2
13.	Dharmikasan (with jyoti darshan)	20 sec × 2
14.	Nadi shuddhi pranayam	24 sec × 5
15.	Pranav pranayam with mahat yoga breathing	12 sec × 5
16.	Shavasan	10 min

corresponding values were 1.59±0.06, 55.8±9, and 22.4±4.5, respectively. In the male control group the corresponding values were 1.7±0.1, 63.6±10.9 and 21.9±2.7, respectively. In the female control group they were 1.58±0.04, 58.8±8.4 and 23.5±3.2, respectively. The baseline parameters were comparable between the yoga and the control groups (P>0.05 for all). In each group, cardiovascular, respiratory and handgrip parameters were recorded in 20 (12 male and 8 female) subjects. Weight loss response to step test was recorded for male subjects only (n=15 in each group).

HR and BP: There was no significant change in HR or SP in any of the study groups. However, six weeks of yoga training produced a significant decrease in DP in males (P=0.002) as well as females (P=0.03). Yoga training increased the PP in males as well as females (P=0.02 in each case). Yoga training produced a decrease in MAP which was significant (P=0.005) in males but not in females (Tables II and III). In contrast,

TABLE II : Effect of yoga training on various parameters in males. Data are given as the mean±SD for 12 subjects except for the weight before step test and weight loss following step test (n=15).

	Yoga group			*Controls*		
	Before	*After*	*P value*	*Before*	*After*	*P value*
Resting systolic pressure (mm Hg)	118±9	117±8	0.53	118±9	122±13	0.11
Resting diastolic pressure (mm Hg)	74±9	62±7	0.002	69±7	69±7	1
Resting pulse pressure (mm Hg)	44±10	54±10	0.02	49±9	52±10	0.11
Resting mean pressure (mm Hg)	89±8	80±5	0.005	86±6	87±8	0.55
Resting heart rate (beats per minute)	70±14	67±14	0.36	75±10	73±14	0.68
Maximum inspiratory pressure (mm Hg)	124±28	160±23	0.001	120±30	138±28	0.01
Maximum expiratory pressure (mm Hg)	88±16	107±20	<0.0001	85±15	94±29	0.23
Endurance in the 40 mm Hg test (s)	44±9	72±13	<0.0001	46±11	56±12	0.04
Handgrip strength (kg)	35±5	36±9	0.15	32±7	32±9	0.82
Handgrip endurance (s)	76±34	88±48	0.43	86±47	86±53	0.67
Weight before step test (kg)	64±11.7	64±11	0.64	63.1±11	63±11	0.51
Weight loss following step test (g)	161±133	64±30	0.0001	133±109	131±52	0.79

Note: P values for comparisons at baseline between yoga and control groups was > 0.05 for all parameters.

TABLE III : Effect of yoga training on various parameters in females. Data are given as the mean±SD for 8 subjects.

	Yoga group			*Controls*		
	Before	*After*	*P value*	*Before*	*After*	*P value*
Resting systolic pressure (mm Hg)	99±13	103±13	0.30	102±10	109±8	0.11
Resting diastolic pressure (mm Hg)	69±9	62±6	0.03	67±8	67±10	0.90
Resting pulse pressure (mm Hg)	30±6	41±12	0.02	35±7	43±6	0.06
Resting mean pressure (mm Hg)	79±10	76±7	0.30	79±8	81±9	0.58
Resting heart rate (beats per minute)	79±8	77±6	0.35	79±8	79±8	0.87
Maximum inspiratory pressure (mm Hg)	96±17	123±14	<0.0001	109±18	110±19	0.74
Maximum expiratory pressure (mm Hg)	61±17	69±20	0.003	70±12	73±14	0.27
Endurance in 40 mm Hg test (s)	33±14	55±18	0.0002	38±14	50±16	0.03
Handgrip strength (kg)	18±4	20±4	0.46	18±3	18±4	0.90
Handgrip endurance (s)	36±10	55±36	0.03	49±23	49±30	0.96

Note: P values for comparisons at baseline between yoga and control groups was > 0.05 for all parameters.

the changes in the above parameters were not significant in the control group.

Respiratory pressures, HGS and HGE: In male as well as female subjects, yoga training produced a marked and highly significant increase in MIP as well as MEP in males as well as females (P<0.001). However in the control group, there were no significant changes in the above parameters except in MIP in males (Tables II and III). 40 mm Hg endurance showed a highly significant increase after yoga training (P<0.0001 in males and 0.0002 in females). In contrast, the increase in this parameter was less in controls. There were no significant changes in HGS in either group. Yoga training produced an increase in HGE which was statistically significant in females (P=0.03) but not in males.

Sweating response to step test: In the male subjects (n=15 in both groups), the weight loss in response to 2 min Harvard step test was 161±133 g before yoga training. After yoga training, the weight loss was significantly reduced to 64±30 g (P=0.0001). In contrast, there was no significant change in the controls.

DISCUSSION

The physiologic responses to physical training have been well studied by many investigators (9). The effect of yoga training on physiologic response to cold stress has been reported (10). Exercise tolerance is an index of physical fitness (11). An important finding in the present study is that yoga training is associated with a significant decrease in exercise-induced sweating, an index of heat generated during dynamic exercise. Cutaneous vasodilation and increase in blood flow are important determinants of sweating when core body temperature increases during exercise (12). However, it is possible that yoga training may have had a favorable effect on energy metabolism in skeletal muscle; i.e., the same workload would generate less heat with less utilization of energy substrate and oxygen thereby decreasing sweating.

Our results clearly indicate that yoga training of six weeks is associated with a decrease in DP in males as well as females. This may be due to a decrease in baseline sympathetic nerve activity. It is worth noting that yoga training produced a significant increase in PP, a parameter that is influenced by stroke volume and compliance of large arteries. Changes in arterial compliance over the six week study period might have been insignificant. Thus, the only other explanation is that the hemodynamic effect of yoga training was to increase the stroke volume through the arterial baroreflex mechanism. The decrease in MAP was statistically significant in males but not in females possibly because the baseline MAP was lower in females. Indeed, it is well established that women have lower tonic sympathetic support of arterial blood pressure (13).

Maximum respiratory pressures are simple and accurate indices of strength of respiratory muscles and their values are altered even in early states of respiratory diseases (8, 14). The increase in MIP and MEP following yoga training of six weeks duration suggests that yoga training has a favorable effect on respiratory muscle strength. This can be attributed to a combination of deep breathing and yoga postures of our training programme. In earlier studies also, we have found that yoga training of longer duration improves respiratory pressures, HGS and HGE (7, 14). Endurance in the 40 mm Hg test is influenced by strength and endurance of respiratory muscles. In addition, it is influenced by breath holding time, a parameter that is complexly affected by several factors including mechanisms that regulate respiration. It is clear from our data that increases in endurance are far greater and significant in the yoga group as compared to the control group. This suggests that the effect of yoga training might have increased the strength and endurance of respiratory muscles and may contribute to enhanced voluntary control of breathing.

HGS is influenced by effort, integrity of motor neuronal pathways, muscle bulk and contractility. Yoga training-induced increase in HGS was not significant in male as well as female subjects suggesting that yoga training given for a short period of six weeks does not influence it. When effort is maximal, HGE is influenced by the strength and metabolic capacity of exercising skeletal muscles. A significant increase in HGE in female subjects may reflect the fact that, in females the baseline endurance is less and training readily enhances it. On the other hand, in males, the increase in HGE brought about by training was less possibly because they were physically more active than females at baseline. In light of our observations, it can be inferred that yoga training might be more beneficial in physically less active individuals.

In the present study we could not determine the effect of yoga on sweating response to step test in female subjects as they opted out of the step test. In conclusion, the present study suggests that short-term yoga training improves the thermoregulatory efficiency as measured by the weight loss response to muscular exercise. Further, six weeks yoga training improves respiratory muscle strength and endurance, a finding previously reported by us to have occurred with longer durations of training (7).

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REFERENCES

1. Madanmohan, Udupa K, Bhavanani AB, Shatapathy CS, Sahai A. Modulation of cardiovascular response to exercise by yoga training. *Indian J Physiol Pharmacol* 2004; 48: 461–465.
2. Bera TK, Rajapurkar MV. Body composition, cardiovascular endurance and anerobic power of yogic practitioner. *Indian J Physiol Pharmacol* 1993; 37: 225–228.
3. Bhatnagar OP, Ganguly NK, Anantharaman V. Effect of yoga training on thermoregulation. *Indian J Med Res* 1978; 67: 844–847.
4. Ganeriwal SK, Sen SC, Khandare SS. Test of physical fitness (Harvard step test) in Indian females. *Indian J Med Res* 1968; 56: 845–849.
5. Bhole MV, Karambelkar PV, Gharote ML. Effect of yoga practices on vital capacity. *Ind J Chest Dis* 1970; 12: 32–35.
6. Birkel DA, Edgren L. Hatha yoga: improved vital capacity of college students. *Altern Ther Health Med* 2000; 6: 55–63.
7. Madanmohan, Thombre DP, Balakumar B et al. Effect of yoga training on reaction time, respiratory endurance and muscle strength. *Indian J Physiol Pharmacol* 1992; 36: 229–233.
8. Black LF, Hyatt RE. Maximal respiratory pressures: normal values and relationship to age and sex. *Am Rev Respir Dis* 1969; 99: 696–702.
9. O'Sullivan SE, Bell C. The effects of exercise and training on human cardiovascular reflex control. *J Auton Nerv Syst* 2000; 81: 16–24.
10. Selwamurthy W, Ray US, Hegde KS et al. Physiological response to cold (10°C) in men after six months' practice of yoga. *Indian J Biometeorol* 1988; 32: 188–193.
11. Raju PS, Kumar KA, Reddy SS et al. Effect of yoga on exercise tolerance in normal healthy volunteers. *Indian J Physiol Pharmacol* 1986; 30: 121–132.
12. Ganong WF Cardiovascular homeostasis in health and disease. In: *Review of Medical Physiology*. 21st ed. New York, Mc Graw Hill 2002: 633–648.
13. Christou DD, Jones PP, Jordan J et al. Women have lower tonic autonomic support of arterial blood pressure and less effective baroreflex buffering than men. *Circulation* 2005; 111: 494–498.
14. Madanmohan, Jatiya L, Udupa K, Bhavanani AB. Effect of yoga training on handgrip, respiratory pressures and pulmonary function. *Indian J Physiol Pharmacol* 2003; 47: 387–392.