EFFECT OF YOGA ON EXERCISE TOLERANCE IN NORMAL HEALTHY VOLUNTEERS

P. S. RAJU, K. ANIL KUMAR, S. S. REDDY, S. MADHAVI, K. GNANAKUMARI, C. BHASKARACHARYULU, M. V. REDDY, N. ANNAPURNA, M. E. REDDY, D. GIRIJAKUMARI, B. K. SAHAY AND K. J. R. MURTHY*

Vemana Yoga Research Institute,
8-1-14 Market Street, Secunderabad - 500 003

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Summary : Twelve normal healthy volunteers (6 males and 6 females) undergoing yoga training for 90 days were studied for the effect of yoga on exercise tolerance. Their ages ranged from 18 to 28 years. The volunteers were taught only Pranayama for the first 20 days and later on yogic asanas were added. Sub-maximal exercise tolerance test was done on a motorised treadmill by using Balke's modified protocol, initially, after 20 days (Phase-I) and after 90 days of yoga training (Phase-II). Pyruvate and lactate in venous blood and blood gases in capillary blood were estimated immediately before and after the exercise. Minute ventilation and oxygen consumption were estimated before and during the test. Post exercise blood lactate was elevated significantly during initial and Phase-I, but not in Phase-II. There was significant reduction of minute ventilation and oxygen consumption only in males in Phase-I and II at the time when the volunteers reached their 80% of the predicted heart rate. Female volunteers were able to go to higher loads of exercise in Phase-I and II.

Key words : pranayama, exercise tolerance, lactate, pyruvate, minute ventilation, oxygen consumption

INTRODUCTION

Oxygen consumption after yoga was noted differently by different workers; increased oxygen consumption (7, 15) decreased oxygen consumption (1, 11, 14) and no change (8, 13).

The present study was undertaken to study the effect of yoga on sub-maximal exercise tolerance in normal healthy volunteers.

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MATERIAL AND METHODS

Subjects : Twelve normal healthy volunteers of comparable age (6 males and 6 females) undergoing yoga training certificate course for 90 days were studied. The volunteers were students and office going executives from middle-income group. Sportsmen and athletes were excluded from the study. None of the female volunteers were lactating.

Yoga training: Initially Pranayama was taught for 40 min (Rechaka-Puraka, Rechaka-Puraka with Kumbhaka, Suryabedha Chandrabedha, Suryabedha Chandrabedha with Kumbhaka, for 10 minutes each) and later Shavasana was practised for 20 minutes. At the end of 20 days Kapalabhati, Shashankasana, Bhujangasana, Shalabhasana, Matsyendrasana, Sarvangasana, Vipareetakarni, Halasana, Chakrasana, Dhanurasana, Mayurasana, Sirsasana, Yoga Mudra and Makarasana were added on and the practice of Pranayama was reduced to 15 min.

Methods of study : Sub-maximal exercise was carried out on a motorised treadmill (Venky-Madras) by using Balke's modified protocol (2) in the morning on empty stomach in an air-conditioned room. All parameters initially were recorded in standing position at rest. Continuous heart rate and Electrocardiogram were monitored on a cardiac monitor (OLLI-FINLAND). Blood pressure was recorded by Sphygmomanometer. Minute ventilation ($\dot{V}E$) and fractional oxygen in expired air ($F_E O_2$) were estimated by Morgan Transfer Test (P. K. Morgan Ltd, Chatham, Kent-England) and fractional expired CO_2 ($F_E CO_2$) was measured by Haldane's apparatus. The expired air was collected into the bags during the 4th minute after every 3 minutes of exercise. All the parameters, blood pressure, heart rate, $\dot{V}E$ and $\dot{V}O_2$ were recorded and estimated at rest in standing position and during the 4th minute after every 3 minutes of exercise Oxygen consumption ($\dot{V}O_2$) was estimated from the $\dot{V}_E$, $F_E CO_2$ and F O_2 and was expressed in STPD.

Venous blood was drawn from antecubital vein before and immediately after the exercise to estimate lactate and pyruvate. Urinary lactate was also estimated before and after the exercise. Lactate was estimated by the method of Barker and Summerson (3). Pyruvate was estimated by Friedemann and Haugen method (4). Urinary lactate was estimated by method of Barker and Summerson modified by Huckabee, W.E. (9).

PO_2 and SaO_2 were estimated from capillary blood by Blood Gas Analyser (AVL-Micro Blood Gas Analyser-Switzerland) immediately before and after the exercise. The exercise test was carried initially, at the end of 20 days (Phase-I) and at the end of 90 days (Phase-II).

Assessment : All parameters were expressed as mean with ±1SD. Statistical analysis was done using Student's paired 't' test of each value between initial and Phase I and Phase II respectively. The results between Phase I and II were not compared as Pranayama was practised from the beginning to the end of study. The level of significance (P value) was expressed at less than 0.05.

RESULTS

The physical characteristics of both males and females were shown in Table I.

TABLE I : Physical characteristics of subjects.

	Males (6) $\bar{X} \pm 1SD$	*Females (6)* $\bar{X} \pm 1SD$
Age (years)	25.83 ± 2.64	21.50 ± 2.51
Height (cms)	167.12 ± 4.81	159.67 ± 3.27
Weight (kgs)	54.08 ± 9.17	45.83 ± 6.59

Responses in males : All the parameters in resting stage in all the Phases were comparable.

PO_2 increased significantly immediately after the exercise in Phase I and II. Post exercise PO_2 increased significantly in Phase II as compared to that of initial Phase. SaO_2 increased significantly immediately after the exercise in Phase I. There was no significant change in Post exercise SaO_2 in between any Phase (Table II).

At the end of the exercise there was significant reduction in $\dot{V}E$ and $\dot{V}O_2$ between initial and Phase I and initial and Phase II (Table IV).

Blood lactate increased significantly immediately after the exercise in initial Phase and Phase I but not in Phase II. Urine lactate increased significantly immediately after the exercise in initial Phase but not in Phase I and II. Post exercise blood lactate reduced significantly in Phase II as compared to that of initial Phase. Post exercise urine lactate reduced significantly in Phase I and II as compared to that of initial Phase. There was no significant change in pyruvate levels in all Phases (Table VI). There was no significant change in blood pyruvate/lactate and urine lactate/blood lactate ratio (Table VIII and IX).

TABLE II : Changes in blood gases (capillary blood) in males (n=6.)

		PO_2 (mm Hg)		*SaO_2 (%)*	
		Before exercise	*After exercise*	*Before exercise*	*After exercise*
		a	b	l	m
Initial	$\bar{X}$	58.06	67.81	88.32	93.00
	± 1SD	12.97	30.53	4.47	8.07
		a1	b1	l1	m1
Phase I	$\bar{X}$	49.43	73.74	81.30	93.08
	± 1SD	6.37	17.62	2.65	3.86
		a2	b2	l2	m2
Phase II	$\bar{X}$	64.14	88.59	90.59	95.75
	± 1SD	13.65	23.55	5.00	2.74

avsb	>0.05	a1vsb1	<0.05*	a2vsb2	<0.05*		
avsa1	>0.05	avsa2	>0.05	bvsb1	>0.05	bvsb2	<0.05*
lvsm	>0.05	l1vsm1	<0.05*	l2vsm2	>0.05		
lvsl1	>0.05	lvsl2	>0.05	mvsm1	>0.05	mvsm2	>0.05

*Significant

Responses in females : All the parameters in resting stage in all the Phases were comparable.

PO_2 and SaO_2 increased significantly immediately after the exercise in all three Phases. The post exercise PO_2 increased significantly in Phase I and II as compared to that of initial Phase. Post exercise SaO_2 between any Phase did not change significantly (Table III).

TABLE III : Changes in blood gases (capillary blood) in females (n=6).

		PO_2 (mm Hg)		SaO_2 (%)	
		Before exercise	*After exercise*	*Before exercise*	*After exercise*
		a	b	l	m
Initial	$\bar{X}$	47.33	62.26	88.37	90.45
	± 1SD	4.65	9.60	4.41	4.22
		a1	b1	l1	m1
Phase i	$\bar{X}$	56.18	80.49	86.78	93.94
	± 1SD	9.15	29.03	4.80	4.18
		a2	b2	l2	m2
Phase II	$\bar{X}$	59.56	88.74	87.28	96.01
	± 1SD	9.22	12.22	2.86	0.92

avsb	<0.05*	a1vsb1	<0.05*	a2vsb2	<0.05*		
avsa1	>0.05	avsa2	>0.05	bvsb1	<0.05*	bvsb2	<0.05*
lvsm	<0.05*	l1vsm1	<0.05*	l2vsm2	<0.05*		
lvsl1	>0.05	lvsl2	>0.05	mvsm1	>0.05	mvsm2	>0.05

Post exercise $\dot{V}E$ and $\dot{V}O_2$ did not show significant change in between any Phase. Volunteers were able to go to higher loads of exercise in Phase I and II (Table V).

TABLE IV : Physiological responses to submaximal exercise in males (n=6).

		Initial		*Phase I*		*Phase II*	
		Rest	*VI Stage*	*Rest*	*VI Stage*	*Rest*	*VI Stage*
		a	b	a1	b1	a2	b2
Minute	$\bar{X}$	13.33	83.00	10.42	48.95	11.35	45.00
Expired volume	± 1SD	5.56	2.83	3.16	11.24	5.38	11.98
($\dot{V}E$) L/min.							
O_2 consumption	$\bar{X}$	6.06	49.08	5.26	28.96	6.93	31.18
($\dot{V}O_2$) *ml/kg*/min.[2]	±	1.54	7.59	1.00	5.57	3.04	3.03
Heart rate	$\bar{X}$	69.83	175.00	69.00	166.00	68.50	158.67
(bpm)	± 1SD	10.96	25.21	10.24	18.38	6.19	2.31
$\dot{V}$	avsa1	>0.05	avsa2 >0.05		bvsb1 <0.05*		bvsb2 <0.05*
$\dot{V}O_2$	avsa1	>0.05	avsa2 >0.05		bvsb1 <0.05*		bvsb2 <0.05*
HR	avsa1	>0.05	avsa2 >0.05		bvsb1 >0.05		bvsb2 >0.05

*=Significant

Blood lactate increased significantly immediately after the exercise in initial and Phase I but not in Phase II. Post exercise blood lactate did not reduce significantly in Phase II as compared to that of initial Phase. No significant change was seen in blood pyruvate and urine lactate at any level in ail the Phases (Table VII). There was no significant change in blood pyruvate/blood lactate ratio and urine lactate/blood lactate ratio (Table VIII and IX).

DISCUSSION

Miles (7) reported an increase in the oxygen consumption of yogi during the yogic practice than during relaxed state. Shanker Rao (15) also found an increase in the oxygen consumption in normal subjects during yoga type breathing when compared to relaxed breathing at different altitudes. Anand *et al.* (1) observed that yogis can reduce their oxygen utilization. Selvamurthy *et al.* (14) reported significant reduction in oxygen consumption and pulmonary ventilation with a concommitant increase in the net mechanical efficiency during sub-maximal exercise after yoga training. Salgar *et al.* (11) reported volunteers practising yoga utilised less oxygen at sub-maximal exercise. Nayar *et al.* (8) reported that there was no change in oxygen uptake in volunteers after 6 and 12 months of yoga training.

TABLE V : Physiological responses to submaximal exercise in females (N=6).

		Initial		*Phase I*		*Phase II*	
		Rest	*II Stage*	*Rest*	*III Stage*	*Rest*	*III Stage*
		a	b	a1	b1	a2	b2
Minute Ventilation	$\bar{X}$	8.10	35.24	8.27	28.80	8.52	30.33
($\dot{V}E$) *L/min.*)	± 1SD	2.44	7.11	1.79	2.84	1.95	5.69
Oxygen consumption	$\bar{X}$	4.82	22.99	4.92	24.22	6.55	22.26
($\dot{V}O_2$) *ml/kg/min.*	± 1SD	0.76	4.24	3.00	2.20	3.13	3.84
Heart rate	$\bar{X}$	80.50	166.33	80.12	156.00	76.00	140.50
(bpm)	± 1SD	8.98	14.79	6.15	8.20	5.80	2.12
$\dot{V}E$	avsa1 >0.05		avsa2 >0.05		bvsb1 >0.05	bvsb2 >0.05	
$\dot{V}O_2$	avsa1 >0.05		avsa2 >0.05		bvsb1 >0.05	bvsb2 >0.05	
HR	avsa1 >0.05		avsa1 >0.05		bvsb1 >0.05	bvsb2 >0.05	

Out of six females three were able to go IVth stage of the exercise after 3 months of yoga practice.

The present study has demonstrated (i) PO_2 increased significantly though there was no significant change in SaO_2 (none of the volunteers had desaturation of blood to start with) (ii) $\dot{V}E$ and $\dot{V}O_2$ were decreased significantly on exercise test in Phase I and

Phase II (the change was not observed in females) (iii) blood and urine lactate levels on exercise were reduced significantly for the same loads of work in Phase II. (No change was observed in urinary lactate in females) blood pyruvate/blood lactate ratio and urine lactate/blood lactate ratio did not show significant change.

TABLE VI : Blood lactate, pyruvate and urine lactate (*mg/dl*) in males (n=6).

		Blood lactate		*Blood pyruvate*		*Urine lactate*	
		Before exercise	*After exercise*	*Before exercise*	*After exercise*	*Before exercise*	*After exercise*
		a	b	l	m	x	y
Initial	$\bar{X}$	16.37	37.33	1.62	2.19	3.29	33.21
	± 1SD	8.08	20.28	0.43	1.85	3.30	8.08
		a1	b1	l1	m1	x1	y1
Phase I	$\bar{X}$	14.96	21.89	1.47	1.60	3.58	8.85
	± 1SD	3.17	2.95	0.66	0.73	1.59	4.64
		a2	b2	l2	m2	x2	y2
Phase II	$\bar{X}$	9.23	12.87	1.40	2.09	7.64	7.26
	± 1SD	7.53	11.48	0.32	0.07	5.42	8.73

avsb	<0.05*	a1vsb1	<0.05*	a2vsb2	>0.05		
lvsm	>0.05	l1vsm1	>0.05	l2vsm2	>0.05		
xvsy	<0.05*	x1vsy1	>0.05	x2vsy2	>0.05		
avsa1	>0.05	avsa2	>0.05	bvsb1	>0.05	bvsb2	<0.05*
lvsl1	>0.05	lvsl2	>0.05	mvsm1	>0.05	mvsm2	>0.05*
xvsx1	>0.05	xvsx2	>0.05	yvsy1	<0.05*	yvsy2	<0.05*

*Significant

TABLE VII : Blood lactate, pyruvate and urine lactate *(mg/dl)* in females (n=6).

		Blood lactate		*Blood pyruvate*		*Urine lactate*	
		Before exercise	*After exercise*	*Before exercise*	*After exercise*	*Before exercise*	*After exercise*
		a	b	l	m	x	y
Initial	$\bar{X}$	11.24	20.65	1.71	2.01	5.14	6.74
	± 1SD	5.73	6.00	0.61	0.33	4.35	5.85
		a1	b1	l1	m1	x1	y1
Phase I	$\bar{X}$	10.64	23.54	1.69	2.60	4.85	10.33
	± 1SD	5.05	11,87	0.62	0.82	9.00	16.70
		a2	b2	l2	m2	x2	y2
Phase II	$\bar{X}$	11.52	19.65	1.67	2.81	8.43	12.42
	± 1SD	8.21	10.97	0.65	1.12	4.78	8.70

avsb	<0.05*	avsb1	<0.05*	a2vsb2	>0.05		
lvsm	>0.05	l1sm1	>0.05	l2vsm2	>0.05		
xvsy	>0.05	x1vsy1	>0.05	x2vsy2	>0.05		
avsa1	>0.05	avsa2	>0.05	bvsb1	>0.05	bvsb2	>0.05
lvsl1	>0.05	lvsl2	>0.05	mvsm1	>0.05	mvsm2	>0.05
xvsx1	>0.05	xvsx2	>0.05	yvsy1	>0.05	yvsy2	>0.05

*Significant

The results indicate that volunteers were able to perform the same loads (higher in females) of work without getting exhausted. The exercise had brought out increased oxygen tension of blood with decreased oxygen consumption and also postponement of fatigue (anaerobic treshhold). The absence of increased execretion of lactate shows that the exercise could have brought forth the changes. Yoga trained persons seem to be

TABLE VIII : Pyruvate/Lactate ratio.

	Initial		Phase I		Phase II	
	Before exercise	*After exercise*	*Before exercise*	*After exercise*	*Before exercise*	*After exercise*
			IN MALES (n=6)			
	a	b	a1	b1	a2	b2
$\bar{X}$	0.1	0.13	0.10	0.07	0.29	0.28
± 1SD	0.04	0.06	0.05	0.03	0.32	0.25
avsb,	a1vsb1,	a2vsb2,	avsa1,	avsb2,	bvsb1,	bvsb2 >0.05
			IN FEMALES (n=6)			
$\bar{X}$	0.15	0.11	0.16	0.13	0.19	0.25
± 1SD	0.05	0.03	0.10	0.04	0.09	0.30
avsb,	a1vsb1,	a2vsb2,	avsa1,	avsa2,	bvsb1,	bvsb2 >0.05

TABLE IX : Urine lactate/blood lactate ratio.

	Initial		Phase I		Phase II	
	Before exercise	*After exercise*	*Beforc exercise*	*After exercise*	*Befote exercise*	*After exercise*
			IN MALES (n=6)			
	a	b	a1	b1	a2	b2
$\bar{X}$	0.28	1.22	0.29	0.38	1.74	1.53
± 1SD	0.26	1.88	0.17	0.35	2.03	1.57
avsb,	a1vsb1,	a2vsb2,	avsa1,	avsa2,	bvsb1,	bvsb2 >0.05
			IN FEMALES (n=6)			
$\bar{X}$	0.15	0.11	0.16	0.13	0.19	0.25
± 1SD	0.15	0.03	0.10	0.04	0.09	0.30
avsb,	a1vsb1,	a2vsb2,	avsa1,	avsa2,	bvsb1,	bvsb2 >0.05

able to utilise efficiently larger amount of liberated energy for work at the low level of exercise (11). Yoga practice is known to achieve a stable autonomic balance a relative hypo-metabolic state and also improvement in physical efficiency (14). Yoga trained volunteers showed elevation of serum creatinine phosphokinase and reduction in pyruvate and lactate ratio indicating increase muscular activity in the presence of anaerobiasis after yoga training (10). Muscular work utilise free energy available by hydrolysis of adenosine triphosphate (ATP). ATP regeneration by oxidative phosphorylation in aerobic conditions is dependent upon (i) adequate oxygen supply, (ii) sufficient mitochondrial density in working muscles, (iii) sufficient mitochondrial oxidative enzyme capacity. The absences of one or more of these conditions results in anaerobic metabolism. In every severe exercise some of fibres may be working aerobically while others anaerobically. In active muscles and in liver, lactate is being metabolised equal to the net production (6). Training increases the aerobic capacity of the fast twitch fibres than the slow twitch fibres and even leads to the conversion of one type fibres to the others (12). Studies have indicated that blood lactate accumulation decreased after training and anaerobic treshhold increased relative to $\dot{V}O_2$ max (5).

The yogic practices could have brought out changes in any one or many of the ways.

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