Effects of Ageing on Cardiorespiratory Changes to Moderate Physical Exercise

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Thirty normal healthy male subjects, 10 each from 20-34, 35-40 and 41-50 years of age, performed bicycle ergometer exercise at a moderate work load of 75 watts. Heart rate, oxygen consumption and pulmonary ventilation measured during steady state of exercise did not show any age bound differences, whereas arterial blood pressure, both systolic, and diastolic showed significantly higher values for subjects in 41-50 years compared to those in younger age groups. Rate pressure product (heart rate x systolic blood pressure) during exercise was thus significantly higher in subjects of 41-50 years, indicating an increased myocardial work in them while performing a moderate physical exercise.

WITH advancing age, certain alterations occur in the cardiorespiratory adaptation to physical work, thereby leading to a progressive deterioration of ones physical work capacity. In many cross sectional as well as longitudinal studies[2,4,13], including that on aircrew[6] the maximal oxygen uptake capacity showed a progressive decline with age from its peak value at around 20 years. One of the most relevant cardiovascular changes with advancing age is that of reduction in ones maximal heart rate[3,6].

For the flier population, the demand of the occupational physical work load is relatively less and it hardly encroaches beyond 50% of their maximal work capacity. However, within the ranges of such moderate work load also, age bound differences in cardiorespiratory changes to exercise have been noticed by many[7,10,12].

The present cross sectional study was designed to determine the changes in a few circulo-respiratory functions, viz., oxygen consumption (VO2), pulmonary ventilation (VE), heart rate and arterial blood pressure in response to a standard submaximal exercise for normal healthy subjects of 3 specific age groups, 20-34, 35-40 and 41-50 years thereby observing and assessing the age bound differences.

Material and Methods

A total number of 30 clinically healthy subjects, 10 each in 20-34, 35-40 and 41-50 years of age, were randomly taken from the ground duty personnel (Administrative, Technical and Medical) of IAM, IAF, Bangalore.

Resting heart rate and blood pressure measurements were made following 30 minutes rest sitting on a chair. Then an exercise work load of 75 watts was imparted with the help of a Bicycle Ergometer, keeping the pedalling rate at 60 rpm. The duration of exercise was 8 min. Heart rate and blood pressure measurements were made at each min of exercise. Expired air collection was made in the last 2 min of exercise.

Heart rate measurements were made by counting the time taken for 30 apical beats. Arterial blood pressure was measured at brachial artery with the help of a mercury sphygmomanometer. For collecting expired air a metallic breathing valve was connected to a Douglas bag. Analysis of expired gas sample was made with the help of a Scholander microgas analysis apparatus. Gas volume was measured in a wet gasometer.

Pulmonary ventilation and oxygen consumption values were corrected to BTPS and STPD respectively.

Results

Table I presents the mean values with standard deviation (SD) of age, height, body weight and body surface area for the subjects in the 3 age groups. The mean values of age in the 3 groups differed highly significantly, while no differences were noted in the physical characteristics.

Table II shows the mean values with SD of $V O_2$, VE and VE per litre of $V O_2$ in the 3 age groups after exercise. It is seen that there were no significant age differences in these respiratory parameters.

TABLE - I

Age and physical characteristics of the subjects in three age groups. (m±SD)

Age groups (years)	Age (years)	Height (cm)	Body weight (kg)	Body surface area (m^2)
I : 20-34	26.4 ±4.8	168.5 ±4.9	60.9 ±8.3	1.68 ±0.13
II : 35-40	37.4 ±1.5	169.0 ±5.0	63.9 ±4.2	1.72 ±0.07
III : 41-50	43.6 ±2.5	169.8 ±5.0	66.5 ±6.8	1.76 ±0.10
I~II	***	N S	N S	N S
I~III	***	N S	N S	N S
II~III	***	N S	N S	N S

*** : P<0.001 N S : Not Significant

TABLE - II

Oxygen consumption and pulmonary ventliation for the 3 age groups at 75 watts of bicycle ergometer work (m±SD)

Age groups (years)	$V O_2$ (l/min, STPD)	V E (l/min, BTPS)	Respiratory equivalent (l of air/l of O_2)
I 20-34	1.14 ±0.10	32.5 ±6.4	28.5 ±5.4
II 35-40	1.09 ±0.13	30.2 ±7.6	27.5 ±3.5
III 41-50	1.13 ±0.07	32.4 ±5.2	23.6 ±3.6
I~II	N S	N S	N S
I~III	N S	N S	N S
II~III	N S	N S	N S

N S : Not Significant

Table III presents the heart rate and blood pressure response during rest (sitting) and the last min of exercise of 75 watts for the subjects in the 3 age groups. While the heart rate, both at rest or exercise, did not indicate any age difference, significant age variation was noted in the blood pressure response in 41-55 years age group. Even during rest, this age group showed significantly higher mean value of diastolic blood pressure and a slightly higher value of systolic blood pressure compared to those observed in the younger age groups. During exercise both systolic and diastolic blood pressure were found to be at highly significantly higher levels in 41-50 years (166.8/105.6 mm of Hg) than those observed in 20-34 (141.2/88.6 mm Hg) and 35-40 years (138.6/85.6 mm Hg). The rise in blood pressure during exercise is shown separately and it showed a highly significantly higher value in the oldest age groups compared to those observed in the younger age groups. The mean value of rate pressure product, as calculated from exercise heart rate x exercise systolic blood pressure x 10^{-2}, was also found to be significantly higher at 41-50 years than in the other age groups.

TABLE - III

Cardiovascular responses of the 3 age groups at 75 watts of bicycle ergometer work (m±SD)

Age groups (Years)	Heart rate response (beats/min)			Blood pressure response (mm Hg)						Rate pressure product during exercise
				Resting		Exercise		Rise		
	Resting	Exercise	Rise	Sys	Dias	Sys	Dias	Sys	Dias	
I : 20-34	72.6	127.8	55.2	118.0	78.2	141.2	88.6	23.2	10.0	180.7
	±14.0	±18.3	±11.6	±8.3	±3.7	±7.5	±4.7	±8.3	±3.1	±29.8
II : 35-40	70.2	128.0	57.8	113.4	76.0	138.6	85.4	25.2	9.4	176.9
	±9.8	±9.4	±9.8	±8.7	±3.9	±13.2	±4.8	±14.2	±5.1	±15.6
III : 41-50	75.2	131.2	56.0	122.8	85.2	166.8	105.6	44.0	20.4	218.6
	±5.2	±7.7	±9.9	±9.1	±6.1	±12.8	±11.1	±11.7	±10.7	±18.8
I~II	N S	N S	N S	N S	N S	N S	N S	N S	N S	N S
I~III	N S	N S	N S	N S	**	**	**	**	**	**
I~III	N S	N S	N S	*	**	**	**	**	**	**

*: P<0.05, **: P<0.01, ***: P<0.001, N S : Not Significant

In none of these cardiovascular parameters, there were any significant differences between 20-34 and 35-40 years age groups.

Discussion

The exercise work load, employed in the present study, elicited mean V O_2 values ranging from 1.09 to 1.14 l/min for the 3 age groups without any significant age difference. The observed mean oxygen consumption rates correspond to about 50% of the maximal oxygen uptake capacity of untrained Indian male adults as reported elsewhere [14,15].

The present observation that there were no age differences in the oxygen consumption against a standard submaximal work load corroborates earlier findings by Becklake *et al*[5] on general population and by Grimby *et al*[8] on middle aged athletes.

The present study also indicated similar exercise ventilatory characteristics for the 3 age groups with no significant age differences in exercise VE, either in absolute or per litre of oxygen consumption. While Grimby *et al*[8] observed a definite tendency for the pulmonary ventilation per litre of oxygen intake to increase with age, Becklake *et al*[5] found no such age induced change in a general population of a wide age range (20-85 years).

In terms of heart rate response also, no significant differences were found in the 3 age groups, subjects showed similar mean values of exercise heart rate or rise in heart rate irrespective of increasing age (Table III). This corroborates the earlier findings reported in cross sectional[5,16] as well as longitudinal studies[1,10].

The only age bound difference in the presently studied circulorespiratory functions was that observed in respect of arterial blood pressure response during exercise (Table III). While there were no differences between 20-34 years and 35-40 years, subjects in 41-50 years age group showed significantly higher values of both systolic and diastolic blood pressure during exercise compared to those observed in the younger age groups. Even during rest, subjects in 41-50 years showed significantly higher mean values of diastolic blood pressure over other age groups. The systolic blood pressure in this age group also showed a slightly higher mean value during rest itself however, it was only during exercise that the age bound variation became assertive and highly significant ($P < 0.001$). The effect of exercise work stress on arterial blood pressure, as visualized in the rise of blood pressure during work, was very significantly higher in the age group 41-50 years both in terms of systolic and diastolic values.

Reindell *et al*[12] and Hollman[9] reported consistently higher systolic and diastolic arterial blood pressure during exercise in the older men than in the younger ones. In a recent longitudinal study[18] on 13 years of aging, from a mean age of 23.3 (21-29) years to 36.3 (34-42) years, subjects have shown significant increase in exercise arterial blood pressure, both in systolic and diastolic values.

As seen in Table III, the present study indicated a change in the exercise cardiovascular adaptation only beyond 40 years of age, subjects in 35-40 years age group showing no change over those observed in 20-34 years age groups. Structural changes that might be taking place in the walls of the blood vessels thus decreasing their distensibility, appeared to assert only since fifth decade of life.

The resultant effect of the increased exercise arterial blood pressure in 41-50 years age group led to an increased myocardial work as indicated in a significantly higher rate pressure product, which has been well established as an index of myocardial oxygen consumption during exercise[11].

To summarize, people in 35-40 and 41-50 years responded to a standard submaximal work load with similar ventilatory characteristics as those in 20-34 years. Heart rate responses at submaximal work also did not show any age bound differences. However, definite age bound change was noticed in respect of arterial blood pressure responses to submaximal exercise, which led to a significantly higher levels of both systolic and diastolic blood pressure in 41-50 years age group compared to those observed in the younger groups. This indicated an altered circulatory adaptation to exercise since fifth decade of life, leading to an increased myocardial work while performing a moderate physical exercise.

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