OXYGEN CONSUMPTION AT REST AND AFTER MODERATE AEROBIC EXERCISE IN SPORTSMEN*

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ABSTRACT

The oxygen consumption at rest and after moderate aerobic exercise on a treadmill was estimated in 20 sportsmen of Loyola College, Madras. The mean oxygen consumption index at rest was 118 ml/min/m^2 end there was a three-fold increase in oxygen consumption after walking at 5 k.m. per hour for five minutes on the treadmill. The rise in pulse rate and the rise in systolic blood pressure after the exercise did not have any significant correlation with the excess oxygen consumption. However. the product of the rise in pulse rate end the rise in systolic blood pressure (double product) showed a significant correlation with the excess oxygen consumed. The excess minute ventilation showed a positive correlation with the excess oxygen consumed, whereas the PO_2 difference between the inspired and expired air showed a negative correlation. It is suggested that after moderate aerobic exercise in sportsmen, the initial responses are more on the respiratory system rather on the cardiovascular system.

Introduction

Maximal oxygen uptake is the greatest amount of oxygen a person can take in during physical work and is a measure of his maximal capacity to transport oxygen to the tissues of the body. The combined cardiovascular and respiratory systems function as one unit for the transport of oxygen from the ambient air to the tissue ceils of the body (Mitchell and Blomqvist, 1971[1]). The WHO (1968[2]) defined physical fitness as the ability to perform muscular work satisfactorily under specific conditions. For assessing the physical fitness in general and the cardio-respiratory functions in particular, the most important criteria are the maximum work output and the maximum oxygen uptake (W.H.O., 1971[3]). Moderately trained non-atheletic Indian soldiers aged 20-30 years had a maximum oxygen uptake of 41.62 ± 3.71 ml/kg/mt (Malhotra *et al,* 1972a[4]; 1972b[5]). The corresponding data for 25 Indian athletes of similar age undergoing pre-selection training for different events for the Olympics varies from 38.9 ± 2.61 to 55.2 ± 7.65 ml/kg/mt. The maximum oxygen uptake of the world class athletes was 75.1 ± 3.40 ml/kg/mt showing that our athletes have much lower aerobic capacity in comparison to world class athletes. Because of the paucity of data for oxygen consumption in Southern Indian subjects, a study was undertaken to assess the oxygen consumption at rest. and after moderate aerobic exercise in sportsmen and also to evaluate the cardiac and respiratory responses to aerobic exercise.

Material end Methods

Twenty sportsmen of Loyola College. Madras, who were active participants of various games and athletics conducted at inter-university and inter-state competitions were studied. All of them were non-smokers. To exclude any cardio-vascular or respiratory disease, a thorough clinical examination, a 12 lead electro-cardiogram and pulmonary function tests such as FVC, FEV, FEV_1% and single-breath diffusing capacity for carbon monoxide were carried out.

The pulse rate and the blood pressure were recorded in the standing position before and after exercise. The pulse rate was counted manually immediately after exercise for one minute. The pulse rate counted was compared with the heart rate displayed on the Rigel ECG monitor and was found equal. The oxygen consumption was measured on Morgan Oxylog at rest and after exercise. The oxylog was provided with Beckman polarographic oxygen sensor to measure PO_2 differences between the inspired and expired air. It was also provided with a flow transducer to measure inspiratory volume in range $6.80L_1$/ minute ventilation. In the performance of aerobic exercise, the aim is to attain a steady state performance and the time required to achieve a steady level of O_2

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consumption ranges from three to six minutes (Chung, 1979[6]) Hence the exercise was performed on Morgan motorised treadmill at 5 k.m. per hour for five minutes in order to achieve aerobic exercise. The athletes were, however, not exercised to sub-maximal level to achieve 85% of predicted heart rate. The PO_2 difference between the inspired and expired air, the minute ventilation and the oxygen consumption per minute were recorded before and after exercise.

Results

The physical characteristics of the subjects studied are shown in Table-1. The mean age was 19.9 ± 0.40 years, the mean body surface area was 1.691 ± 0.0365 m^2 and the mean height was 172.1 ± 1.70 cms.

TABLE–1

PHYSICAL CHARACTERISTICS OF THE SUBJECTS

	Mean ± S.E.
Age (years)	19.9 ± 0.40
Height (cms)	172.1 ± 1.70
Weight (kg)	58.78 ± 2.21
B.S.A. (m^2)	1.691 ± 0.0365

The cardio-pulmonary responses at rest and after exorcise are shown in Table-2.

TABLE–2

CARDIO-PULMONARY RESPONSES TO AEROBIC EXERCISE

	Rest	Exorcise	p value
O_2 Consumption (ml/kg/mt)	3.349 ± 0.140	10.54 ± 0.704	<0.01
Pulse rate (beats/mt)	73.6 ± 2.63	88.9 ± 3.703	<0.001
Blood Pressure Systolic (mm.Hg)	112.1 ± 2.85	120.3 ± 2.974	<0.001
Blood Pressure Diastolic (mm. Hg)	78.7 ± 2.17	81.4 ± 1.661	<0.05
PO_2 difference (mm. Hg)	23.34 ± 1.006	30.89 ± 1.20	<0.001
Minute ventilations (L/mt)	6.015 ± 0.552	15.84 ± 1.813	<0.001

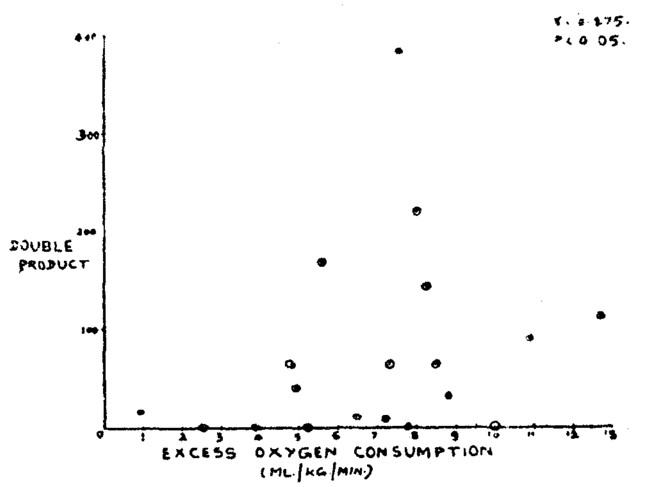
The mean oxygen consumption was 3.35 ± 1.14ml/kg/mt. at rest and 10.54 ± 0.70 ml/kg/mt. after exercise. The difference was significant statistically (p <0.01). Similarly pulse rate, blood pressure, PO_2 difference and minute ventilation showed a significant rise after exercise.

Discussion

The mean minute oxygen consumption in these subjects was 3.35 ± 0.14 ml/kg/mt and this is equivalent to a mean oxygen consumption index of 118 ml/min/mz. The normal oxygen consumption index in a western population is 110 to 150 ml/min/m^2 (Barry and Grossman, 1980[7]). This shows that the oxygen consumption at rest of a Southern Indian college sportsmen is similar to that of a normal population of a western country. The pulse rate and the blood pressure are the two important non-invasive parameters for assessment of cardiac responses to exercise. When the rise in pulse rate and the rise in systolic blood pressure after the exercise were correlated with the excess oxygen consumed after exercise, it was observed that there was no significant correlation with any of these parameters. However, when the product of the pulse rate and the systolic blood pressure (double product) which is used to assess the myocardial oxygen demand (Scheuer *et al.* 1978[8]) was correlated (Fig. 1) with the oxygen

FIG. 1.

DOUBLE PRODUCT VS EXCESS OXYGEN CONSUMPTION



consumed, there was a significant correlation (r=0.475, P<0.05). These data show that the cardiac response after moderate aerobic exercise were not as expected as in the case of maximal exercise.

The minute ventilation and the PO_2 difference between the inspired and expired air are two important parameters for the assessment of respiratory responses to exercise. The normal inspired PO_2 is about 150 and expired PO_2 at rest is about 116 mm/Hg. However, in a large number of subjects in the authors laboratory where inspired and expired O_2 concentration by different methods have been measured the values obtained at BTPS were as follows:-

Inspired O_2 = 713 x 0.209 = 149.02 mm. Hg.

Expired O_2= 17.5% (average) = 713 x 0.175 = 124.7 mm. Hg. The PO_2 difference between inspired and expired air at BTPS was 149.02-124.78 = 24.24 mm. Hg. The PO_2 difference in subjects of this study at BTPS was 23.34 ± 1.006. This value was found to be very close to earlier findings. It is presumed that these values are correct at BTPS. The excess ventilation per ml per kg per minute after the exercise showed a positive correlation (r=0.883) with the excess oxygen consumed ($P<0.001$) (Fig. 2). However, the PO_2 difference showed a negative correlation (r=0.526) with the oxygen consumed and it was significant statistically ($P<0.05$). (Fig, 3).

FIG. 2

EXCESS VENTILATION VS EXCESS OXYGEN CONSUMPTION.

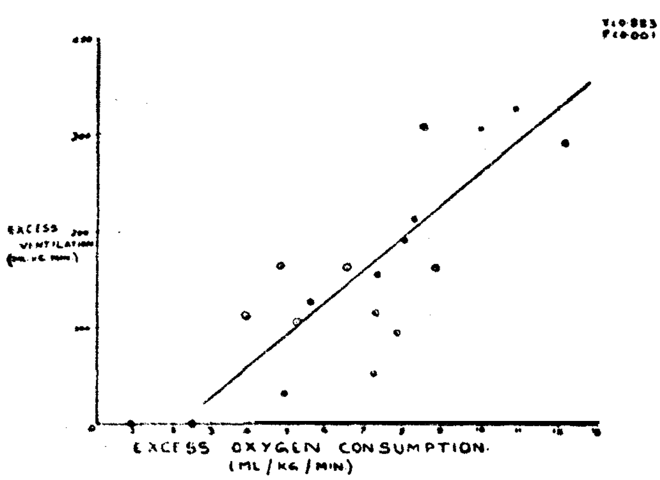


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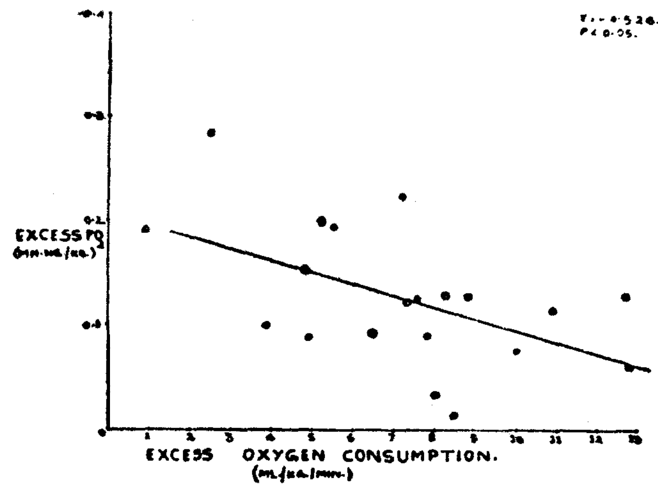
FIG. 3.

EXCESS PO_2 VS EXCESS OXYGEN CONSUMPTION.



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